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Standard Guide for Climate Resiliency Planning and Strategy[1]

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ε[1] NOTE—5.9.1, 6.3.4.4, 6.3.4.5, and X4.2.1 were editorially corrected in May 2016.

INTRODUCTION

This guide provides a set of options for planning climate resiliency management. This includes adapting local business and government infrastructure to chronic, extreme weather events and sea level rise. It may not apply to entities where such assessment and risk management is already widely available through standard sets of guidance, such as the construction of green buildings. This guide provides a voluntary framework of the risk management options and steps that may be beneficial to evaluate climate resiliency solutions. It provides strategies for existing organizations, even those currently operating outside of various voluntary and regulatory schemes. The environmental assessment and risk management strategies contained in this guide recognize the overall value of existing responses. This guide references and blends similar, effective programs and extends them to provide a consistent approach that will facilitate communication and preparation for extreme weather events.

Background—This guide presents a series of options for an individual, group or entity to use. The goal is a strategy or plan to address extreme weather.

1. Scope

1.1 *Overview*—For the purposes of this guide, 'resiliency' refers to efforts by entities, organizations, or individuals to prepare for or adjust to future extreme weather and related physical conditions. The primary purpose is to reduce negative economic impacts associated with extreme weather.

1.1.1 This guide presents a generalized, systematic approach to voluntary assessment and risk management of extreme climate related events and conditions. It helps the user structure their understanding of the climate related vulnerabilities and consequences they seek to manage. It helps the user identify adaptive actions of both an institutional (legal), as well as engineering (physical) nature. Options for analysis provide a priority ranking system to address the "worst first" risks of a municipality, local area or facility, addressing practicality and cost-benefit. Users may approach this analysis having initially undertaken a risk assessment to determine what they are seeking to manage, or use the guide to help determine the likely areas of greatest need.

1.1.2 These climate adaptations or adjustments may be either protective (that is, guarding against negative impacts of extreme weather), or opportunistic (that is, taking advantage of any beneficial effects of extreme weather).

1.1.3 This guide addresses adaptation strategies and planning in response to various impacts that may occur to individuals, organizations, human settlements or ecosystems in a broad variety of ways. For example, extreme weather might increase or decrease rainfall, influence agricultural crop yields, affect human health, cause changes to forests and other ecosystems, or impact energy supply or infrastructure.

1.1.4 Climate-related impacts may occur locally within a region or across a country and may affect many sectors of the economy. In order to meet these challenges, this guide provides an organized, uniform approach to prepare for the impacts of extreme weather through planned "resiliency" strategies.

1.1.5 This guide addresses options to deal with risk factors that may be key drivers for the economy, human health, the environment, or ecosystems. The guide is aimed at helping users understand risks and potential losses, and offers options and a generalized approach to bolster human and ecosystem resiliency to a changing climate. This includes sustainability concepts such as support of economic stability and a good quality of life.

1.1.6 Adaptation can involve responses to extreme weather and long-term preparation for future events. Local conditions will require risk evaluation and analysis of both likely weather events and/or extreme weather trends.

[1] This guide is under the jurisdiction of ASTM Committee E50 on Environmental Assessment, Risk Management and Corrective Action and is the direct responsibility of Subcommittee E50.05 on Environmental Risk Management.

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1.1.7 This guide does not address the causes of extreme weather.

1.2 *Purpose*—The purpose of this guide is to provide a series of options consistent with preparing for extreme weather events. This guide encourages consistent management of climate exposures and risks. The guide presents practices and recommendations for regions, zones, and planning horizons to address institutional and engineering actions for reduction of physical and financial vulnerability attributable to extreme weather. It reviews available technologies, institutional practices, and engineering actions that can be implemented by individuals and organizations seeking to increase their adaptive capacity.

1.2.1 The guide also provides some high-level options for the monitoring and tracking of performance of an individual or organization's chosen strategy in order to evaluate its effectiveness and ensure that the approach continues to be reasonable.

1.2.2 This guide ties into the ASTM E50 standards series related to environmental risk assessment and management.

1.3 *Objectives*—The objectives of this guide are to determine the conditions of the community, facility and or/property with regard to risks of extreme weather events and actions to be taken to manage those risks.

1.3.1 The guide presents information on planning and strategies for response to extreme weather events such as: drought, flood, fire, storms, landslides, tidal surge, and extreme temperatures.

1.3.2 The guide encourages users to set priorities, using a matrix based upon regions in the United States. For each region the guide identifies key climate vulnerabilities, requiring preparation for future events. These could be extrapolated to other regions if there are similar conditions.

1.4 *Limitations of this Guide*—Given the different types of organizations that may wish to use this guide, as well as variations in State and Local regulations, it is not possible to address all the relevant circumstances that might apply to a particular facility. This guide uses generalized language and examples to guide the user. If it is not clear to the user how to apply standards to their specific circumstances, it is recommended that users seek assistance from qualified professionals.

1.4.1 The guide assumes risks are already identified and is not intended to provide assistance with identifying or evaluating risks.

1.4.2 *Insurance Industry*—The effects of climate extremes on insurers are not clear. The definition of an insurable occurrence and a commencement point for when insurable claims are made, along with when conditions were discovered and the actionable information leading to an insurable loss is not clear. It may be inappropriate to speculate on climate effects that are highly uncertain for purposes of insurance related to specific events. While there are exclusions for "acts of God," for example, claims associated with increasing extreme weather events may still have serious impacts on the insurance industry.

1.4.3 This guide does not take a position on the causes or science of extreme weather.

1.5 The guide uses references and information on the control, management and reduction of impacts from many cited sources.

1.6 Several national and international agencies served as sources of information on existing and anticipated levels and management of climate risks including: the Australian Ministry of Environment; the Federal Emergency Management Agency; the National Oceanographic and Atmospheric Administration; the Securities and Exchange Commission; the U.S. Army Corps of Engineers; the U.S. Department of Agriculture; the U.S. Department of Energy; the U.S. Environmental Protection Agency; and, the U.S. Department of Defense.

1.7 This guide relies on current regulatory information about risks from various state agencies, including the California Air Resources Board, the Massachusetts and Connecticut Departments of Environmental Protection, the Western Climate Initiative, and other published high-level strategies and guidance. For example, the National Academy of Sciences guidance and the Climate and Risk section of the Envision rating system published by the Institute of Sustainable Infrastructure.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E2114 Terminology for Sustainability Relative to the Performance of Buildings

E2432 Guide for General Principles of Sustainability Relative to Buildings

E2718 Guide for Financial Disclosures Attributed to Climate Change

E2725 Guide for Basic Assessment and Management of Greenhouse Gases

2.2 *ISO Standards:*[3]

ISO 14001:1996 Environmental Management Systems – Specification with guidance for use [products of ISO/TC 207 for which ASTM E50 was a participant on behalf of ANSI]

ISO 14064-1: 2006-03-01 Greenhouse Gases – Part 1 Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

ISO 31000:2009, Risk management Principles and guidelines

ISO 14064-3: Part 3 Specification with guidance for the validation and verification of greenhouse gas assertions

ISO Guide 73 Risk management – Vocabulary

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

ISO Draft Standard on Asset Management: Overview, Principles and Terminology (56/1358/DC)

2.3 *Standards Australia:*[4]

AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach

3. Terminology

3.1 *Definitions:*

3.1.1 *adaptation, n*—risk treatment and mitigation actions undertaken to reduce the adverse consequences of extreme weather, as well as to harness any beneficial opportunities. Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.

3.1.2 *adaptive capacity, n*—the ability of a system to adjust to extreme weather (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Response to and attenuation of potential damages, to take advantage of opportunities, or to cope with the consequences.

3.1.3 *climate, n*—the average and range of weather conditions in an area. More rigorously, the statistical description in terms of the mean and variability of relevant weather parameters over a period of time long enough to ensure representative values for a month or season. These parameters are most often surface variables such as temperature, humidity, air pressure, precipitation, and wind.

3.1.4 *contingency plan, n*—any plan of action that allows an organization to respond to events should they occur, includes all plans that deal with stabilization, continuity of critical business functions and recovery, sometimes called a 'business continuity plan'.

3.1.5 *drought risk, n*—rating systems of USDA to determine appropriate planting, harvesting and water conservation activities, based upon region and expected weather events.

3.1.6 *ecosystem, n*—any natural unit or entity including living and non-living parts that interact to produce a system through cyclic exchange of materials and energy.

3.1.7 *extreme temperature risk, n*—rating systems for vulnerability, especially to high temperatures in urban heat sink areas.

3.1.8 *extreme weather, n*—significant change in physical, climactic events lasting for an extended period of time. Includes major changes in storm frequency, duration or intensity; temperature; precipitation patterns; or wind patterns, among others, that occur over several decades or longer.

3.1.9 *fire risk, n*—various rating systems to determine how likely a fire is, given weather and wind conditions. The National Fire Protection Association has a rating system

3.1.10 *flood risk, n*—various rating systems to determine the flood zone associated with flooding and water damage. Rating system terminology includes various flood zones as defined by FEMA and State agencies for rainfall and tidal events. This can include the 5, 10, 25, 50,100 and 500 year events). The 100-Year flood level and floodplain are the typical standard to define severe flood levels and flood extent. The 100 year event risk is also defined as a one-in-100 or 1% likelihood of occurring in any given year.

3.1.11 *green buildings, n*—as defined in ASTM E2114, Standard Terminology Relative to the Performance of Buildings and E2432, Guide for General Principles of Sustainability Relative to Buildings

3.1.12 *green roof, n*—construction of water retaining and heat lowering materials, especially plants, on the roofs of buildings to address storm-water flooding, extreme temperatures, and energy conservation. This includes systems with assemblies that support an area of planting/landscaping, built up on a waterproofed substrate at any level that is separated from the natural ground by a human-made structure. Also defined in Guide E2432.

3.1.13 *extreme weather event, n*—phenomena such as tropical storms, hurricanes, typhoons, nor'easters, blizzards, hail storms and floods. These phenomena are at the extremes of the historical distribution, including especially severe or unseasonal conditions.

3.1.14 *extreme conditions, n*—trends in climate and weather, over the long term that result in substantial impacts to the local built and natural environment, including financial impacts.

3.1.15 *land movement, n*—a threat to urban or natural systems expressed in terms of the combination of their likelihood of occurrence and their consequences. This includes soil accretion, erosion, subsidence, landslides, and uplifts.

3.1.16 *mitigation, n*—attempts to lower or compensate for risks from weather/climate related events including flood, fire, drought, extreme temperature, sea-level rise and storms.

3.1.17 *natural variability, n*—variations in the mean state and other statistics (such as standard deviations or statistics of extremes) of the climate on all time and space scales beyond that of individual weather events. Natural variations in climate over time are caused by internal processes of the climate system, such as El Niño or La Nina, as well as changes in external influences, such as volcanic activity and variations in the output of the sun.

3.1.18 *relative sea level rise, n*—the increase in ocean water levels at a specific location, taking into account both global and local factors, such as glacial ice melt (from land and in sea, with land melt having greater relative impact), local subsidence, thermal expansion, and/or continental uplift or subduction Measured with respect to a specified vertical datum relative to the land, which may also be changing elevation over time. Can include evaluation of flood risk to coastal areas, generally associated with flood insurance ratings and maps.

3.1.19 *resilience, n*—adaptive capacity of an organization in a complex and changing environment. A capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment.

3.1.20 *scenarios, n*—a plausible and often simplified description of how the future may develop based on a coherent

[4] Standards Australia Level 10, The Exchange Centre 20 Bridge Street, Sydney GPO Box 476 Sydney NSW 2001. http://www.standards.org.au/

and internally consistent set of assumptions about driving forces and key relationships.

3.1.21 *sensitivity, n*—the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (for example, a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (for example, damages caused by an increase in the frequency of coastal flooding due to sea level rise).

3.1.22 *storm risk, n*—rating systems for the likelihood of impacts from rainfall, snow, hail or wind from rainfall events, hurricanes and tropical storms, Nor'easters, tornadoes, blizzards and other types of storms. Can include surges or abnormal rise in sea level accompanying a hurricane, tropical storm, or other intense storm, whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm or hurricane.

3.1.23 *subsiding/subsidence, n*—the downward settling of soil layers and/or rock in the Earth's crust relative to its surroundings.

3.1.24 *thermal expansion, n*—the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume, which leads to an increase in sea level.

3.1.25 *tidal effects, n*—rising seas, extreme water levels, storm surges, rising sea levels, and frequent tidal events, from hurricanes, tropical storms, typhoons, and Nor'Easters

3.1.26 *vulnerability, n*—the degree to which a system is susceptible to, or unable to cope with, adverse effects of extreme weather, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed; its sensitivity; and its adaptive capacity.

3.1.27 *weather, n*—atmospheric condition at any given time or place. It is measured in terms of such parameters as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. [A simple way of remembering the difference is that climate is what you expect (for example, cold winters) and 'weather' is what you get (for example, a blizzard).]

4. Significance and Use

4.1 *The Use of this Standard Guide*—This guide addresses issues related solely to adaptation strategies and development of a plan to address extreme weather and related physical changes. This guide does not include specific guidance on risk assessment, however references are provided in Appendix X3. The matrix approach does reflect general risks for certain regions of the country, based upon the frequency of extreme weather and/or conditions such as fires, floods, storms, drought, and extreme temperatures. Adaptation strategies and planning may consist of a wide variety of actions by an individual, community, or organization to prepare for, or respond to, the impacts of extreme weather.

4.1.1 This guide does not address causes of extreme weather.

4.1.2 This guide addresses adjustment strategies and planning that a group of people or ecosystems make to limit negative effects of extreme weather. It also addresses taking advantage of opportunities that long term extreme weather patterns may present.

4.2 *Example Users:*

4.2.1 Small businesses or enterprises;

4.2.2 Service industries;

4.2.3 Federal, state or municipal facilities and regulators, including departments of health and fire departments;

4.2.4 Financial and insurance institutions;

4.2.5 Public works staff, including water system, stormwater system, wastewater system, solid waste, and other utilities (electrical, telephone, gas, et al) and other waste managers, including liquid and solid waste haulers, treatment, recycling, disposal and transfer;

4.2.6 Consultants, auditors, state, municipal and private inspectors and compliance assistance personnel;

4.2.7 Educational facilities;

4.2.8 Property, buildings and grounds management, including landscaping;

4.2.9 Non-regulatory government agencies, such as the military;

4.2.10 Wildlife management entities including government, tribal and NGOs.

4.3 This guide is a first step in crafting simplified goals for managing and communicating risks. The framework describes a process by which the user may categorize current climate risks and a priority approach to manage those risks. The technique classifies common responses for both mitigation and adaptation. The guide groups responses and examples into regions based on experience in responding to risks. The regional classifications found in this guide reflect the general structures of State, Federal and local response programs. These authorities generally classify groups of similar responses according to the timely availability and cost effectiveness of responses.

4.3.1 Adaptation strategies and planning may include actions by individuals and communities, for example, from reduced tree clearing for an individual lot, to a farmer planting more drought-resistant crops, or to a municipality protecting riparian and floodplain standards and buffers or ensuring that new coastal infrastructure can accommodate future sea level rise. However, building resilience across communities will require action at all levels; individual, business, town, county, state, and federal.

4.3.2 Some municipalities, for example Boston, Miami Beach, and Baltimore, corporate entities, and organizations have already begun taking action toward defining adaptation strategies and planning for extreme weather.

4.3.3 In an increasingly interdependent world, negative effects of extreme weather on one population or economic sector may have repercussions around the world. These effects have repercussions on populations and settlements in neighboring areas, within countries, or across the globe. They include economic disruption to productivity and the supply-chain, impacts to energy production and cascading impacts to users.

4.3.4 Many ecosystems will also be affected by extreme weather challenges and opportunities. Some species may be able to migrate or change their behavior to accommodate changes in the weather. Other species may decline or become extinct. Some species may increase in numbers. Managers of natural resources may anticipate some of the impacts of extreme weather on ecosystems. This offers one avenue in beginning to develop management programs that may help ecosystems adapt.

4.3.5 There are limits to the ability of human systems to adapt. For example, the relocation of cities and various communities or infrastructure may not be feasible in many locations, especially in a short period of time. Implementation timeframes could take 20, 50 and 100 years or longer.

4.3.6 Those communities or sections of communities that are most vulnerable, such as locations where the poor, disengaged, elderly or those in ill health live, are at greatest risk. Extreme weather may exacerbate existing issues. Addressing underlying issues that make communities or systems vulnerable will increase their resilience and support adaptation efforts.

4.3.7 The user should consider the most effective scale of adaptation, for example, site, town, catchment, watershed, City, State, or regional level. The scale will impact the relative direct and indirect costs and benefits of a solution. The guide may help users understand the most effective scale of adaptation and the appropriate level of action.

4.4 This guide defines good commercial and customary practice in the U.S. for conducting baseline assessment and reasonable mitigation/adaptation strategic options on a voluntary basis. The following principles apply to this priority system:

4.4.1 Ability to set specific goals for activities. This includes adopting a contingency plan for protection from weather related events using engineering changes while maintaining current operations. This includes “flood-proofing” “fire-proofing,” back-up energy generation, vegetation management around power lines and other measures to cope with extreme weather.

4.4.2 Marketing environmental awareness and sensitivity;

4.4.3 Assessing risks from future weather related events and extreme conditions. A compendium of applicable risk assessment tools that users may find useful are in Appendix X1.

4.4.4 Risk management, underwriting; loss control and history; premiums and claims;

4.4.5 Liability assessment and qualifications for loans;

4.4.6 Standardization, consistency and certification of facility specific evaluations;

4.4.7 Educating employees, clients and customers;

4.4.8 Generating multi media and cross medium information;

4.4.9 Evaluating vendors;

4.4.10 Reducing costs and preventing pollution.

4.5 Users may consider various benefits of assessment and response.

4.5.1 This guide is a basic primer on climate impacts and may serve to introduce the subject for organizations unfamiliar with the principles.

4.5.2 Some government agencies, fiduciaries and business organizations publish strategies for climate resiliency. The public has systematic ability to access or estimate information on individual businesses. Therefore, businesses need guidance on how to assess the nature and potential risks of climate risks, and a programmatic approach for reducing or eliminating those risks through protection, accommodation, retreat, and other proactive management systems.

4.5.3 Reduced operation, insurance and maintenance costs may be realized through a tiered evaluation of weather related response opportunities.

4.5.4 Responses may be streamlined and simplified so that all levels in an organization may participate.

4.5.5 Some enterprises may be more competitive in the marketplace with improved climate-related response programs.

4.5.6 Setting priorities can allow planning and evaluation of new adaptation and response requirements.

4.5.7 Different stakeholders, such as industries or governments, will have different interests and responsibilities for taking action. For example, retreat and relocation of populations will fall under the government scope rather than industry.

4.6 *Institutional Risks*—Some of the risks posed by weather related events include damage to residences, businesses, infrastructure and agriculture from fires, floods, drought, extreme temperature, storms, hail, winds, tidal surge and sea level rise. Early, voluntary actions, including the use of this guide, may also help organizations prepare for and reduce the impacts of future government regulations. Some of the possible government programs that may be used to address climate are described below.

4.6.1 Flood Insurance Maps;

4.6.2 Water conservation requirements;

4.6.3 Fire codes;

4.6.4 Emergency response;

4.6.5 Zoning regulations;

4.6.6 Building codes;

4.6.7 Wetlands and stream buffer regulations;

4.6.8 Stormwater standards and regulations for floodplains and floodways, planning, development requirements, and infrastructure design (MS4, flood control systems, floodplains and floodways);

4.6.9 Public Works Projects;

4.6.10 Hazard Mitigation Planning.

4.7 *Managing Risk Uncertainty:*

4.7.1 It appears that weather extremes will continue to present risks and uncertainty as to the effects they will have in different regions. The ability to predict future weather related

risks has improved, but efforts to understand the complete impact of those risks on society and analyze mitigation and adaptation strategies are still relatively immature.

4.7.2 The tiered analysis in this guide will help support decision-making, studying regional impacts, and communicating with wider group of stakeholders in the face of uncertainty.

4.7.3 The insurance industry has always played a role in risk management by insuring weather related risks, promoting stronger building codes, and better land-use decision-making.

5. Risk Management

5.1 This guide establishes a framework of common, climate risk management strategies in the United States. The same planning principles could be applied in other countries, depending upon priorities associated with climate risks. This general guide will allow the user to evaluate the category of risk from extreme weather related issues. Responses would then be evaluated for timeliness and availability in order to continually reduce the risks.

5.2 This guide outlines adaptation strategies and planning steps that may be taken to prepare for, and respond to, the impacts of extreme weather. The guide addresses a series of adaptation and planning options for managing environmental and human risks associated with extreme weather. The guide addresses potential ways to approach managing risks. This may include adoption of regional priorities for adaptation. Strategies for preparedness for a weather event may be different than reactions to post-extreme weather events.

5.3 Extreme weather may pose a risk or threat to businesses and properties. For example, variations in air temperatures over land masses or ocean temperatures could directly and indirectly affect ecosystems, humans, and the economy. In some areas, there could be regional increases in the form of more pronounced heat waves and heavy precipitation events, which exceed the levels expected from standard variability.

5.4 Extreme weather might yield economic damages in the form of flood and storm damage, crop losses, wildfire losses, supply chain disruptions and critical infrastructure outages. This guide addresses adaptation strategies and plans, taking a measured approach to promote effective risk management strategies.

5.5 This guide does not address the uncertainty of unpredictable and severe weather events. This guide does not address connections between impacts of rising temperatures and extreme events or the probability of the rate of increase of these events. However, this guide does discuss options for addressing vulnerabilities to the impacts of extreme weather and natural catastrophes.

5.6 *Procedure for Planning A Strategy*—A plan of adaptation to extreme weather should educate groups, businesses and individuals to reduce risks, and build safety restraints into their activities, increasing resiliency. The development of a strategy, and application of this guide, may be approached from a starting point of having determined the priority risks that need to be addressed (for example, through a risk assessment). Alternatively, if a risk assessment has not been undertaken, the approach outlined in Fig. 1 may be applied starting with identifying the relevant region (that is geography). For example there are eight regions shown in Fig. 2.

5.6.1 If the regional approach is followed, the user first decides on the appropriate regions for planning, selecting from one of eight regions of the United States. Certain areas of Canada adjacent to the Northeast, the Midwest, the Great Plains or the Northwest may benefit from this regional organization of the guide. Certain areas of Mexico adjacent to the Southwest or Great Plains may also benefit from guide use.

5.6.2 The priority areas of concern are shown in Table 1, based upon the selected region. There may be other priority areas, based upon local conditions and state by state priorities.

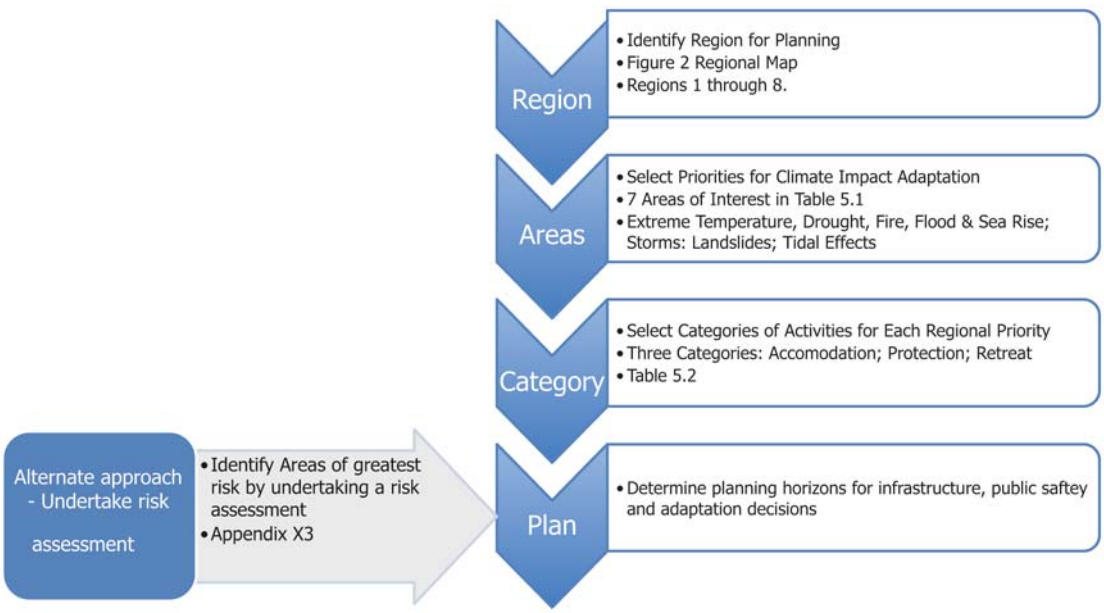

FIG. 1 Procedure for Adaptation Planning Strategy Development

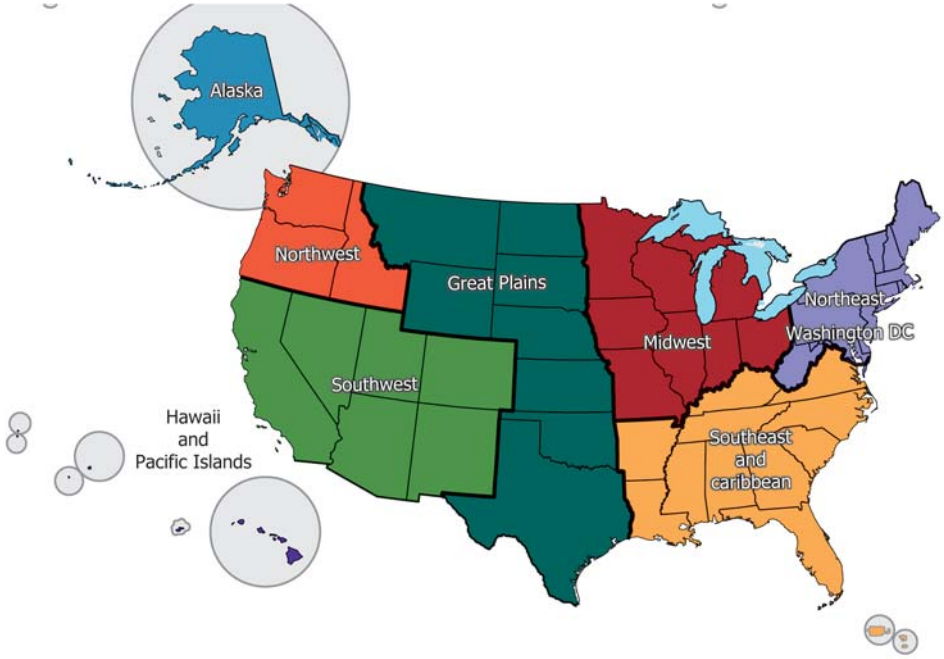

FIG. 2 National Climate Assessment Regions (National Climate Assessment, 2014)

TABLE 1 Example Regional Climate Adaptation Priorities

NOTE 1—Table 1 provides a regional overview of adaptation priorities. The lack of a '*' does not indicate that other climate risks will not occur in a region. In addition, specific risks and adaptation priorities may differ within a region, at the local or site specific scale.

Region	Extreme Temperature (hot or cold)	Drought	Fire	Flood	Storms (wind straight line and tornadic and snow hail, sleet and ice)	Land Movement Subsidence (uplifts and landslides)	Sea Rise and Tidal Effects
1 Northeast	*			*	*		*
2 Southeast and Caribbean	*			*	*		*
3 Midwest	*	*		*	*		
4 Great Plains	*	*	*	*	*		
5 Southwest	*	*	*		*		
6 Northwest			*	*		*	*
7 Alaska	*				*	*	*
8 Hawaii					*	*	*

Flash floods from rivers and streams are examples of local conditions requiring priority planning, in addition to regional priorities.

5.6.3 Priority areas of concern may also be based on previous, climate related, catastrophic events. The areas of New York, Long Island and New Jersey impacted by Hurricane Sandy are examples.

5.6.4 Categories of actions include adaptation, protection and retreat and are shown in Table 2.

5.7 Building a strategy or plan of adaptation to extreme weather educates groups, businesses and individuals to reduce risks, and build safety restraints into their activities, increasing resiliency. Broad examples of strategy or plan elements include, but are not limited to:

5.7.1 Putting in place a group to understand, coordinate and reduce disaster risk based on participation of multiple parties, including local alliances.

5.7.2 For businesses, climate adaptation goals in employee job descriptions, especially in key geographies in an enterprise, or in operations and supply chain.

5.7.3 Establishing a cross-function climate adaptation working group with connections to local or regional organizations.

5.7.4 Setting a budget and providing the necessary resources for proactive adaptation.

5.7.5 Collaborating with neighboring businesses and supply chain partners on climate adaptation planning and execution.

5.7.6 All parties understand their role regarding adaptation that requires disaster risk reduction and preparedness.

5.7.7 Making up-to-date information and plans readily available. Plans and strategies to cope with extreme weather could be integrated into an existing Environmental Management System or Disaster Response Plan. Plan updates should include training for those responsible for response to extreme weather events.

TABLE 2 Category of Responses to Example Climate Events

Adaptation Risk Category	Category 1: Accommodation	Category 2: Protection	Category 3: Retreat/Relocate
Extreme Temperature	Build green roofs, conserve water, and add plantings and landscape to increase shade and oxygen.	Add insulation and energy efficient windows to buildings Provide emergency generators for temperature control centers to address extremes.	Move residences and buildings into more temperate areas; including underground zones for geothermal temperature control.
Drought	Conservation. Plant alternative crops or drought resistant crops. Underground water storage. Recycle of existing water supplies.	Integrated water resource programs for stormwater and "wastewater". Reservoirs. Aquifer recharge and underground water storage. Water retaining soil amendments. Provide emergency water supplies.	Move crops, livestock and residences from risk areas. Provide for technology that uses less water or hydroponic growth with recycled water.
Fire	Construct firebreaks, and fire-fighting stations. Water storage in potential fire areas. Low occupancy development. Controlled burns. Strategic logging to thin out forests near residential areas.	Fire resistant coatings; Stronger regulations and oversight in areas of concern (man-made fires). Water storage in potential fire areas.	Move residences out of high risk areas. Realign development to provide for fire line and reduced spread. Redesign structure to include fire protective natural infrastructure (soil external covering).
Flood	Free-board buildings. Sumps and tunnels to move water away from buildings. Pumping stations and infrastructure control measures, including bridges, culverts, storm water systems; and run-off controls using natural systems.	Build seawalls barrier islands and dunes. Provide run-off structures to manage flooding and provide water storage, retention and detention.	Remove, relocate or raze vulnerable buildings and infrastructure. Replace and restore floodplains, wetlands and natural channels. Redesign development to retreat from flood zones and sea impact areas. Use natural designs to reduce inward flow of waters.
Storms include straight-line and tornadic winds, hail and ice	Emergency Response and shelter plans. Upgrade buildings, including windows, doors, roofs, insulation and other building features. Provide supportive energy systems. Address ice and wind damage issues.	Upgrade building codes for windows, doors, roofs, insulation and other building features. Address energy issues with backup structures.	Include development plans with cooperative energy provisions; Design or redesign occupied areas to address main impacts from storms.
Land Movement includes subsidence	Upgrade building and community designs to address structural and emergency issues (increase strength of buildings and escape routes).	Build retaining structures and run-off structures to reduce erosional areas. Provide for green space to strengthen slope stability.	Move residences out of high risk areas. Provide for free board areas if slope failure occurs.
Sea Rise and Tidal Effects	Free-board buildings away from main impact tidal zones. Sumps and water tunnels to move water away from buildings. Pumping stations and infrastructure control measures, along with riparian zones to address impacts.	Build seawalls, retaining structures, levees and protective sea/flood walls. Provide run-off and storage structures. Address beach erosional issues through restoration of barrier islands and dunes. Repair, upgrade and maintain locks and other structures to control surge for navigation channels and ports.	Remove relocate or raze occupied structures from high risk areas. Provide natural run-off storage and protective structures in designs. Redesign development to retreat from tidal erosional zones and tidal impact areas. Use natural designs to reduce inward flow of waters and sea impacts.

5.7.8 Planning to maintain critical evacuation and supply routes, access (for police, fire, medical, and other emergency responders), and infrastructure (water, sewer, stormwater, communications, hospitals, shelters, power with backup generators, airports, rail lines, et al) that reduce risk, adjusted where needed to cope with extreme weather.

5.7.9 Assessment of the safety of nearby facilities that support disaster response efforts (for example, schools and health facilities) and upgrading the plan as necessary.

5.7.10 Definitions for realistic, risk-compliant building guidance and land-use planning.

5.7.11 Education programs and training on disaster risk reduction at facilities that support disaster response efforts (for example, schools and local communities).

5.7.12 Protecting specific ecosystems and natural buffers to mitigate floods, storm surges and other hazards to which participant(s) are vulnerable.

5.7.13 Periodic updates and refinements of the plan and effective risk-reduction practices.

5.7.14 Installing early warning systems and emergency management capacities in your group and hold regular public preparedness drills.

5.7.15 Post disaster needs assessment of survivors to guide reconstruction, with support from community organizations. Design and help implement responses, including rebuilding homes and livelihoods.

5.7.16 Reassessment procedures in plans to determine issues or problems which require evaluation of current processes and revisions to ensure better adaptive strategies in the future. This is an iterative process for continual improvement.

5.8 *Financial and Schedule Considerations*—Users should evaluate and compare life cycle (capital, operation, and maintenance) costs and benefits of the different actions to mitigate

categories of risk management. This includes the time of implementation and planning horizon. Users may pursue one or more categories of management risks simultaneously.

5.8.1 The user should identify the priority planning areas, based upon the overall region. Fig. 2 shows general regions of the country. Table 1 shows some priority planning subjects, based upon region.

5.8.2 An initial risk assessment of the community or specific area will determine the highest vulnerabilities to climate related events. Then the user should also identify conventional, short-term, measures recommended for the region, including emergency response plans for initial response to events.

5.8.3 The National Climate Assessment Report (see U.S. Global Change Reserch Program National Climate Assessment, 2014) addresses seven sectors: human health; water, energy; transportation; agriculture, forests and ecosystems. The user may set priorities for adaptation in the local area according to the most important or urgent sectors.

5.9 *Management Categories:*

5.9.1 Category 1 responses address weather-related risk reduction through the development and use of accommodation or alternative engineering. This means adapting the built environment through structural modifications and agricultural practices such as forestation or construction of green roofs, "free-boarding" of structures and equipment above new flood levels, or water storage. The planning horizon generally includes actions that can be taken within a two-year timeframe.

5.9.2 Category 2 protective responses that prevent damage from extreme weather related events, such as fire-resistant coatings, creation of wetlands and structural barriers to protect structures from damage. These actions may prevent business risk impacts by providing immediate cost savings and lowering a facility's risk profile relative to the potential damage. The planning horizon includes actions that the user can take within a ten-year time-frame.

5.9.3 Category 3 responses address long-term preparation for the most extreme weather related events by development of emerging technologies and retreating or relocating from the areas of highest risk. These options include relocating populations away from coastlines and other flood hazard areas. The planning horizon includes actions that may be available, through research and development programs, rezoning and relocation programs, as well as wetland replication and species replacement in a ten- to thirty-year timeframe.

5.10 *Regional Approach to Climate Resiliency*—The essential principles of this guide are: Environmental assessment by objective; Priority planning; Measuring effectiveness of adaptation measures. This guide groups climate adaptation measures in a matrix for eight regions shown in Fig. 2 and Table 1 and three general categories: accommodation, protection and retreat shown in Table 2.

5.10.1 These figures and tables can be adjusted to reflect the regions in the National Climate Assessment and their highlighted challenges. Refer to U.S. Global Change Research Program National Climate Assessment, 2014.

5.10.2 Regional climate adaptation priorities and classifications may be informed by statistical analysis of historical insurance claims for types of damage to various regions and resources.

5.10.3 Federal and State programs for assistance in climate adaptation implementation may base funding priorities upon previous catastrophic events related to extreme weather. For example, communities in New Jersey may base adaptation priorities after hurricane Sandy on storms, flooding and sea-level rise.

6. Planning and Identification of Actions

6.1 The overall process first involves selecting climate adaptation planning areas, based upon the region of the country. Sample areas are shown in Table 1.

6.2 Based on either the risk identification or regional process, develop a list of potential actions that may improve climate resilience. Examples within the three categories of response include:

6.3 *Category 1 Accommodation*—See Table 2.

6.3.1 *Extreme Temperature*—Adapt all buildings and structures with green roofs and temperature resistant insulation. Research on technologies to cope with extremes through design and natural systems.

6.3.1.1 Ranchers can reduce the loss of livestock during extreme heat events by improving ventilation in barns and increasing shade. Better designs of barns to include temperature resistant insulation and natural systems to increase air flow.

6.3.1.2 With earlier springs and warmer winters increasing the risk of disease to crops and livestock, for example, by increasing the survival rate of parasites, farmers and ranchers can develop and use disease-resistant crop and livestock species. Also, to minimize the spread of disease among animals, ranchers can modify livestock breeding practices so that animals are living in less densely packed conditions, and move grazing herds to new areas. Evaluate technological research to reduce parasites in species and increase adaptability of species.

6.3.2 *Drought and Conservation*—Plant drought resistant species an adapt planting to preserve moisture; expand water use efficiency, including opportunities to develop water efficient technologies and promote greater efficiency of water use and reuse; support integrated water resources management, including methods to promote resilience of water resources as the climate and environment changes.

6.3.2.1 Diversify crops to adjust to changing temperature and precipitation patterns.

6.3.2.2 Adopt water and soil moisture conservation measures that minimize the impact of potential seasonal water shortages.

6.3.2.3 Change livestock breeding practices and shifting grazing patterns.

6.3.2.4 Develop and using disease-resistant crop and livestock species.

6.3.2.5 Develop tools are being developed to make the food supply more resilient to extreme weather.

6.3.2.6 Monitor broad-scale patterns, such as changes in plant mortality and the spread of invasive plant species. Use the monitoring data to make decisions about adjusting agricultural practices. Consider planting a more diverse sets of crops or the adoption of innovative agricultural practices in areas where yields are threatened. Distribute and encourage the use of technologies to harvest rainwater, conserve soil moisture, and use water more efficiently.

(1) Climate change impacts on agriculture and food production will vary by region. In some places, warmer temperatures may extend the growing season, while in other regions more heavy downpours may increase crop losses. Regardless of whether shifts in climate are ultimately beneficial or harmful, the agricultural industry will have to modify certain practices to adapt to new conditions as a result of anticipated changes in weather pattern.

(2) The user should investigate examples of new technology-based farming techniques such as hydroponics, urban farming, and ladder farming.

6.3.2.7 "Dryland farming" is a technique that uses soil moisture conservation and seed selection to optimize production under dry conditions.

6.3.3 *Fire*—Preserve natural fire breaks and construct new fire resistant barriers.

6.3.4 *Flood*—Many states and communities are taking actions to prepare for and adapt to the impacts of extreme weather. Adaptation measures include a wide variety of activities.

6.3.4.1 Evaluate hydro-climatic statistics and hydrologic-hydraulic (H&H) models related to: 10, 25, 50, 100 or 500 year floods; intense, 50-year 6-hour rainfall; high stream-flows, and water temperature, such as the mean August water temperature. This will facilitate water infrastructure planning, ecosystem protection, and flood hazard mitigation.

6.3.4.2 Raise or flood protect all buildings, evacuation routes and vulnerable utilities, above expected extreme flood levels.

6.3.4.3 To combat potential increases in polluted agricultural runoff from heavier precipitation events, farmers can use buffers and modify or reduce fertilizer and pesticide application.

6.3.4.4 Modify building codes to enable structures to withstand higher water, greater wind, heavier snowpack, and greater range of extreme temperature levels. Adapt for social and economic actions– resource evaluation and recycling; economically sustainable procedures; social evaluation and integration with the natural world. Minimize disruption to business activities or essential services.

6.3.4.5 Estuaries, the transition zones where rivers meet the ocean, are particularly sensitive to extreme weather. Groups and individuals can carry out vulnerability assessments, engage stakeholders, identify extreme weather indicators, and initiate adaptation planning efforts. Specific adaptation options for tidal wetlands, drinking water supplies, and fish in a region help define the adaptation plane. For all of these resources, the protection and/or restoration of buffers and the management of water flows should be considered important for successful adaptation.

6.3.4.6 Dam and culvert capacity may be evaluated under several extreme weather and population growth scenarios to help decision-makers set priorities for design changes in new and rebuilt facilities. In a given region vulnerability assessments may more closely define microsystem sensitivities of ecosystem processes to future climate conditions to identify "top pathways" for management adaptations. "Living shorelines" use vegetation and low rocks to protect the shoreline.

6.3.5 *Storms,* including straight-line and tornadic winds, hail, snow and ice.

6.3.5.1 Restoring natural storm surge buffers and incorporating extreme weather into coastal habitat restoration plans.

6.3.5.2 Upgrading and redesigning infrastructure such as bridges, roads, culverts and stormwater systems.

6.3.5.3 Builders may consider hazards associated with increases in sea level in their project plans. Planners may decide to calculate new required setbacks (the distance between a structure and the shoreline) based on the size of the structure and local erosion rate. Moving structures further from the current shoreline will likely reduce damage from strong storms, as well as potential damage from sea level rise.

6.3.5.4 Provide emergency generators for power outages during storms with high winds.

6.3.6 *Land Movement:*

6.3.6.1 Raise and reinforce structures to accommodate land movement. Use native plantings to reinforce unstable soil areas.

6.3.7 *Sea Level Rise and Tidal Effects:*

6.3.7.1 Raise or re-locate vulnerable structures and place critical utilities above and beyond newly calculated high sea levels. Restore and protect barrier islands, wetlands and dunes.

6.3.7.2 In many cases it is the compound effect of climatic conditions such as sea level rise combined with storm surge that will topple a structure and not necessarily a single variable on its own. Therefore it is important to prepare for multiple effects.

6.4 *Category 2: Protective Measures*—See Table 2.

6.4.1 *Extreme Temperature*—Add insulation and energy efficient windows to buildings. Provide emergency generators for internal air-conditioning or heating. Address power usage to reduce impact on electric grid systems.

6.4.2 *Drought*—Integrated water resource programs for stormwater and "wastewater". Reservoirs. Aquifer recharge and underground water storage. Provide emergency water storage. Policies to address water usage reductions when drought conditions realized.

6.4.3 *Fire*—Coat buildings and structures with fire resistant materials. Building code enforcement of required design materials. Neighbor design requirements to help reduce spread of the fire.

6.4.4 *Flood*—Raise, armor, and relocate vulnerable populations, buildings and infrastructure. Restore floodplains floodways, streams, rivers and wetlands. Add storage and conveyance systems to manage flooding.

6.4.4.1 Construct barriers around structures such as seawalls, bulkheads, levees or sandbags to divert water away from structures. Implement zoning to increase freeboard areas.

6.4.4.2 Evaluating drinking water supplies with respect to extreme weather.

6.4.4.3 Mapping coastal hazards and developing emergency response plans with regard to sea level rise.

6.4.4.4 Groups or individuals may want to develop a mapping visualization tool to help educate stakeholders and the public about sea level rise risks. Groups or individuals may want to assess the capacity of existing road culverts (structures commonly placed under roads to allow water to flow) during climate-induced flood events in a watershed.

6.4.5 *Storms,* including straight-line and tornadic winds, hail, snow and ice.

6.4.5.1 Building or repairing dikes, seawalls, and other structures that protect cities from erosion and storms. Zoning to increase freeboard areas. Building design to ensure Structural consideration for increased intensity of an area.

6.4.5.2 Individuals or groups may work together to address a larger coastal zones to protect their coastal resources, minimize erosion, and lower risks of damage from strong storms and sea level rise. Although this may not specifically address future extreme weather or sea level rise explicitly, many of their actions are likely to bolster resilience to expected impacts.

6.4.5.3 Builders may consider roof and structural designs for storm resilience. Warmer atmosphere is capable of holding more water vapor from which heavier snowfalls can result. Changing temperature and pressure differentials can result in higher wind uplift events that should be considered in design.

6.4.5.4 Upgrade building codes.

6.4.6 *Land Movement:*

6.4.6.1 Build barriers above all structures threatened by landslides.

6.4.7 *Sea Rise and Tidal Effects:*

6.4.7.1 Armor shorelines where necessary (soft and hard). Add storage and pump stations. Enhance evacuation procedures and efficiency. Restore coastal island, dune and wetland systems.

6.5 *Category 3: Retreat/Relocate and Innovative Technology*—See Table 2.

6.5.1 *Extreme Temperature*—Remove residential resources to cooler, underground, and/or vegetated areas. Community design to incorporate more natural structures to add elements to reduce temperature and increase oxygen of area.

6.5.2 *Drought*—Remove all crops from drought prone areas and restore with naturally adapted plant species. Develop new crops and species to adapt to drought prone areas but still provide a food source.

6.5.3 *Fire*—Remove development from fire prone areas. Develop designs to allow containment of fires before reaching inhabited areas and allow species migration to safe areas.

6.5.4 *Flood:*

6.5.4.1 Remove structures from expected flood hazard areas and replace with restored wetlands. Relocate structures in non-flood prone areas.

6.5.4.2 Expanding setbacks (the distance between a structure and the shoreline) and instituting other land-use arrangements, including rolling easements , to enable wetlands and beaches to migrate inland. Design development to incorporate these features into inhabited areas.

6.5.5 *Storms,* including straight-line and tornadic winds, hail and ice.

6.5.5.1 Emergency response and shelter plans.

6.5.5.2 Upgrade buildings (windows, doors, roofs, insulation, and other building features).

6.5.5.3 Provide back-up heating and supportive energy systems.

6.5.5.4 Address ice and wind damage issues.

6.5.5.5 Upgrade building codes.

6.5.5.6 Alternative storm protection may include establishing oyster reefs, planting vegetation, such as marsh and dune grass, or using a combination of vegetation and strategically placed low-profile barriers such as rocks or wood.

6.5.6 *Land Movement:*

6.5.6.1 Remove all structure from areas below unstable soil areas.

6.5.7 *Sea Rise and Tidal Effects:*

6.5.7.1 Remove all structures from expected inundation areas.

6.5.7.2 Relocate vulnerable population and infrastructure to above the 100 to 500 year flood levels.

6.5.7.3 Seawalls, bulkheads, barrier islands coastal dunes, living shorelines.

7. Assessing and Selecting Options

7.1 Once adaptation options are identified, consideration of their relative costs and benefits should be made to inform decision making. This may include consideration of:

7.1.1 The implementation and operational costs.

7.1.2 The benefits in terms of reduced or avoided damages.

7.1.3 The timeframe that the benefit will be received.

7.1.4 The current condition or lifespan of the infrastructure being altered. For example, if it is near the end of its lifespan, adaptation can be incorporated into plans for upcoming upgrades or replacements.

7.1.5 Depending upon the complexity of options being assessed, the evaluation may include a high level multi-criteria assessment, cost effectiveness analysis or cost-benefit analysis.

7.1.6 Other non-financial benefits or values (cultural / heritage).

7.2 The life cycle costs for replacement and protection should be considered over the planning horizons to determine optimal choices and timing for implementation. For example: it may be more beneficial to invest in protection straight away rather than accommodate and then protect, (that is, defer coating a structure based upon building replacement scheduled in 5 years, at which point the structure could be be razed).

8. Implementation, Monitoring, Review and communication

8.1 Individual organizations will need to consider those adaptation options relevant for their organization to implement. Implementation may involve collaboration with other organizations or advocacy.

8.2 Management of the risks from extreme weather to settlements and infrastructure should be embedded in all the

infrastructure organization's practices and processes in a way that it is relevant, effective and efficient. Therefore, the process for managing this type of risk should be part of, and not separate from, those organizational processes. In particular, extreme weather risk should be integrated into the processes for policy development and planning, commissioning, approval, permitting, design, construction, alteration, maintenance, management, operation or decommissioning. Specifically, the infrastructure organization should develop a risk management plan that describes how the management of this type of risk will be integrated in all of the infrastructure organization's practices and processes.

8.3 Adaptation planning is likely to evolve over time as a result of changes to climate risks (or knowledge about risks), changes to what level of risk is considered acceptable and the emergence of new adaptation opportunities (through changes in technology, policy or attitudes). Depending on which factors trigger a review of adaptation planning, organizations will need to consider where it is most appropriate to re-enter their planning process (that is, at the assessment of risk, identification of adaptation options, or evaluation of adaptation options).

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF CLIMATE RISK ACCOMMODATION, PROTECTION AND RETREAT

X1.1 Envision (http://www.sustainableinfrastructure.org/rating/)

X1.2 The Boston Harbor Association, 2014, Designing with Water (http://tbha.org/designing-water-report)

X1.3 FEMA, 2013, Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards (https://www.fema.gov/media-library/assets/documents/30627)

X1.4 EPA Climate Ready Water Utilities (http://water.epa.gov/infrastructure/watersecurity/climate/index.cfm)

X1.5 UKCIP Adaptation Wizard (http://www.ukcip.org.uk/wizard/)

X1.6 California adaptation resources (http://cal-adapt.org)

X1.7 Congressional Budget Office, 2008, Policy Options for Reducing CO_2 emissions.

X1.8 National Climate Assessment, 2014. US Global Change Research Program. Washington, D.C.

X1.9 National Science and Technology Council, Committee on Environment and Natural Resources, 2008, Scientific Assessment of the Effect of Global Change on the United States.

X1.10 National Academy of Sciences, (NAS) 2008, Understanding and Responding to Climate Change

X1.11 United States Climate Change Science Program

X1.12 United States Department of Agriculture (USDA) and US Forest Service (USFS)

X1.13 Executive Order 13653 – Preparing the United States for the Impacts of Climate Change

X1.14 United State Army Corps of Engineers (USACE) - Engineering Regulation ER 1100-2-8162 Incorporating Sea-Level Change In Civil Works Programs (Dec, 2013). (www.corpsclimate.us/ccaceslcurves.cfm)

X1.15 U.S. Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA) FEMA Mitigation Support for Planning and Implementation of Climate Resilient Infrastructure (Draft 2014)

X1.16 American Clean Energy and Security Act of 2009 (by Congressmen Waxman and Markey)

X1.17 Institute of Sustainable Infrastructure, 2012. Envision Version 2.0, A Rating System for Sustainable Infrastructure

X2. PLANNING, REDUNDANCY, AND RESILIENCE FOR CRITICAL INFRASTRUCTURE. SUCH AS POWER, WATER, WASTE TREATMENT, FUEL

X2.1 Back up power and water supplies.

X2.2 Review and implement FEMA and Homeland Security protocols, as appropriate.

X2.3 Review Federal wetlands maps, including updated flood and acceleration zone boundaries.

X2.4 *Underground Storage Tanks*:

X2.4.1 Practices and policies to prepare for extreme events:

X2.4.1.1 Collect GPS data on all active and temporarily closed UST facilities.

X2.4.1.2 Each state and regional field office develops an Emergency Response Plan. After each event, local state and National Guard perform UST site evaluations in areas that were affected. Visually check for flex hose/piping leaks under dispensers due to dispenser wind movement.

X2.4.1.3 Evaluate UST sites in flood locations once it is safe to enter. Some of the assessments can be done via phone calls to UST owners.

X2.4.2 *Post event actions:*

X2.4.2.1 Provide a "checklist" of appropriate activities for states/tank owners after such an event that states could use/distribute in affected areas.

X2.4.2.2 Prepare guidance for other emergencies and provide weather related information on tanks during Operator Training.

X2.4.2.3 Identify caps/fittings recommended rugged enough to remain effective and in place.

NOTE X2.1—This issue was identified by a few different states.

X2.4.2.4 Develop a data collection tool that is agreed upon. The data collected must be useful to the state and the region. This data would be used to determine what sites would be eligible for any grant money made available.

X2.4.2.5 Develop a generic response plan that could be used by any state.

X2.4.2.6 Louisiana Department of Natural Resources (LDNR) developed a plan to ensure that UST facilities that are located along evacuation routes have fuel available for evacuees. They developed this plan in consultation with UST owners, marketers, and trade groups. Here is the link to the Louisiana Fuel Team and Playbook: http://dnr.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=786.

X2.5 *Funding*:

X2.5.1 Removing fuel. Fund to address releases after an impact is very helpful, for example, post Hurricane Katrina response.

X2.5.2 Stabilize equipment and clean up.

X2.5.3 Establish an environmental strike team – like FEMA's.

X2.5.4 Ensure that there is interstate communication.

X2.5.5 Have an emergency response session at next interstate conference to discuss funding options.

X2.5.6 In a major event, FEMA may reimburse some site evaluation activities.

X2.6 *Legal Considerations*:

X2.6.1 Many programs, such as Federal Flood Insurance, require evaluation of legal status and actions to prepare for and recover from extreme weather events.

X2.6.2 Government and academic resources are available for this aspect of planning, such as The Climate center of Columbia Law School: http://www.ColumbiaCl imateLaw.com

X3. CLIMATE RISK ASSESSMENT EXAMPLES

X3.1 *The Risk Assessment Process*:

X3.1.1 Fig. X3.1 illustrates a climate risk assessment process based on the International Standard ISO 31000:2009 and the Australian Standard 5334 (AS5334) Climate Change for Settlements and Infrastructure which provide a set of internationally endorsed principles and guidance on how organizations can integrate decisions about risks and responses into their existing management and decision-making processes. This approach therefore uses the well-established and universally accepted process for risk management to guide organizations in developing effective resilience strategies. The overall process includes five key steps and a summary of each of these steps is described below. Further information can be found in the AS5334.

X3.2 *Establishing the Context*—There are a number of components required to establish the context for a risk assessment process:

FIG. X3.1 Risk Assessment Process

X3.2.1 A statement of the project objectives, including those concerned with the risks from climate to the asset or activity concerned.

X3.2.2 Defining which extreme weather scenarios will be used to inform the risk assessment (additional information on considering climate projections is provided in section X3.8).

X3.2.3 Identifying the relevant stakeholders, their objectives and how they will be engaged.

X3.2.4 Defining the external and internal factors that may give rise to climate risks or influence vulnerability.

X3.2.5 The risk criteria to be used to assess likelihood and consequence.

X3.2.6 The scope, purpose and structure of the particular risk management activity.

X3.3 *Risk Identification*—This step creates a comprehensive list of risks based on available climate information that might significantly affect the settlement or infrastructure, and helps to understand whether these risks may lead to beneficial or detrimental outcomes. Comprehensive identification is critical, because a risk that is not identified at this stage will not be included in further analysis. To do this an examination of the domino effect of particular consequences, including flow-on, cascading and cumulative effects should also be considered.

X3.4 *Risk Analysis*—Risk analysis involves developing an understanding of the risk. Risk analysis provides an input to risk evaluation and to decisions on whether risks need to be treated and the most appropriate strategies to do so. Risks are analyzed by determining consequences and their likelihood, and other attributes of the risk. Existing adaptive capacity and its effectiveness and efficiency should be taken into account.

X3.5 *Risk Evaluation*—Risk evaluation is used to help decide which risks need to be treated and their priority. This can be done by comparing the risk rating with the risk criteria established when the context was established.

X3.6 *Risk Treatment*—Once the risks to be treated have been identified, a range of possible options for treating each risks is required to allow the most appropriate actions to be selected. The options may include avoiding the risk, accepting the risk, removing the risk source, changing the likelihood or consequences, or sharing the risk with other parties.

X3.7 *Considering Extreme Weather Projections in the Risk Assessment Process*:

X3.7.1 To manage the risks from extreme weather to settlements and infrastructure it is necessary to define how climate is likely to change in the future. This is achieved using extreme weather scenarios that provide a plausible summary of the changes to climate variables that could apply to a particular geographical region and within a particular timescale. Small changes in climate may make a profound difference to a risk assessment or the adaptation actions stemming from it. The uncertainty in applying extreme weather scenarios to a particular settlement or infrastructure item should be clearly understood and stated. The following steps should be applied to determine the extreme weather context that will inform the climate risk assessment and subsequent adaptation responses:

X3.7.1.1 Define the climate risk scenarios and their potential affects.

X3.7.1.2 Define future time slices. The selection of a few sample time slices to inform the change in risk over time is required. For longer-lived assets (for example, bridges) or settlements, a range of time slices such as 2030, 2070 and 2100 or 2040 and 2090 should be considered. Projects or assets with a shorter life expectancy (for example, a 30-year mineral extraction operation) may only need to use a 2030 or 2040 time slice. For detailed analysis of a site or region (for example, a cost-benefit analysis) may require annual, monthly or daily time slices over several decades.

X3.7.1.3 Define the climate variables. The selection of climate variables to be assessed should be determined by the climate sensitivity of a range of asset types, activities and locations. The indirect impacts of extreme weather to critical supply chain assets and services such as access, power and water should usually be considered even if the direct impact occurs outside the boundary of the site being assessed. The types of climate variables used for climate sensitivity should be considerate of regional characteristics.

X3.7.1.4 Selection of climate data. The extreme weather data should be selected for best performance in the region being assessed. Filtered sets of extreme weather data should be publicly available for most locations. The range of extreme weather related variables should be derived from the selected data. Some extreme weather projections have low spatial resolution. Actual climate conditions can vary significantly over distances, particularly in areas with strong vertical relief. Techniques are available for generating more localized projections which can take into account local landscape characteristics. Published extreme weather projections will be updated and become more precise as new extreme weather information becomes available. Relevant and authoritative data should be used (for example, information from NOAA, NCDC, USDA, USGS, USEPA, and USACE). The data used, and the process and reasons for determining its relevance to the risk assessment to be undertaken, should be recorded.

X3.7.1.5 Determine other associated impact studies required. For detailed analysis of sites and assets, the use of impact studies such as flood modeling are usually required to assess the impact of extreme events or accelerated degradation of assets over time. These impact studies need to use extreme weather data as selected in the steps above to inform their results. The results from inundation and erosion impact studies for storm surge events influenced by sea level rise and combined with impacts of increased extreme rainfall events is necessary for detailed extreme weather risk assessments along the coast.

X3.7.1.6 Obtain past meteorological record. The past meteorological data for a region or site should be sourced to determine the long term average for each climate variable (past 100 years if available), scale of past extreme events, recent trends of change in past 30 years recognizing that in many locations, the changing climate has been observed already. It is acknowledged that for some locations the past meteorological

record is sometimes unavailable or inconsistently recorded, any proxy data used for a location should be identified and justified.

X3.8 Other guidance or approaches to assessing climate risk include:

X3.8.1 NOAA guidance (http://www.climate.gov)

X3.8.2 EPA Guidance (http://www.epa.gov/climatechange/impacts-adaptation/index.html)

X3.8.3 ENVISION tool (http://www.sustainableinfrastructure.org/rating/)

X3.8.4 Sustainable Facilities tool (https://sftool.gov/)

X3.8.5 UKCIP Adaptation Wizard (http://www.ukcip.org.uk/wizard/)

X3.8.6 U.S. Army Corps of Engineers (http://www.usace.army.mil/Missions/EmergencyOperations.aspx); (http://www.usace.army.mil/Media/NewsReleases/NewsReleaseArticleView/tabid/231/Article/562301/us-army-corps-of-engineers-releases-report-on-coastal-storm-and-flood-risk-in-t.aspx)

X3.8.7 Housing and Urban Development (http://portal.hud.gov/hudportal/HUD?src=/program_offices/economic_resilience/sustainable_housing_initiative/president_climate_action_plan)

X3.8.8 Federal Emergency Management Agency (https://www.fema.gov/climate-change)

X3.8.9 U.S. Department of Transportation – Federal Highway Administration (2015). *Virtual Framework for Vulnerability Assessment*. from Federal Highway Administration (http://www.fhwa.dot.gov/environment/climate_change/adaptation/adaptation_framework)

X4. FINANCIAL ASSISTANCE AND SCHEDULE CONSIDERATIONS AND EXAMPLES

X4.1 *Federal Program Examples*:

X4.1.1 Build America Investment Initiative Federal Resource Guide for Infrastructure Planning and Design, May 2015 (http://www.transportation.gov/policy-initiatives/build-america/build-america-investment-initiative)

X4.1.2 FEMA Hazard Mitigation Assistance (https://www.fema.gov/hazard-mitigation-assistance)

X4.2 *State and Local Programs*:

X4.2.1 The State of Massachusetts program is shown as an example. (http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/resiliency-initiative.html). Many other states also have programs and it is suggested to search a state's web site.

X4.3 *Private Sector Program Examples*:

X4.3.1 Nature Conservancy Green Infrastructure (http://www.nature.org/about-us/working-with-companies/companies-we-work-with/building-a-case-for-green-infrastructure.xml)

X4.3.2 Target Stores (https://corporate.target.com/corporate-responsibility/environment/efficient-operations)

X4.3.3 UNISDR R!SE Initiative, Disaster Risk Sensitive Investments (http://www.preventionweb.net/rise/home)

X4.3.4 E2718-10 Standard Guide for Financial Disclosures Attributed to Climate Change.
E2725-10 Standard Guide for Basic Assessment and Management of Greenhouse Gases

X5. BIOLOGICAL AND AGRICULTURAL EXAMPLES

X5.1 The climate adaptation guide describes steps that can be taken to address climate impacts and help conserve ecosystems and make them more resilient. An adaptation guide may include actions, along with check-lists to monitor progress; these are generally organized under major categories, for example, if the plan is focused on an ecosystem it might include actions such as: Manage species and habitats, Conserve and connect habitat.

X5.1.1 In addition to traditional habitat restoration and protection efforts, an entity might envision innovative opportunities for creating additional habitat. For example, government agencies, farmers and ranchers might decide to cost-share conservation practices that benefit at-risk, threatened, or endangered species. These efforts may be useful in responding to extreme weather as well as other existing conservation challenges.

X5.1.2 Similarly, another example strategy for Louisiana farmers growing rice might provide valuable new resources for a variety of waterfowl and shorebirds whose habitat is now disappearing because of wetland loss and sea level rise. It is also possible to use applied management to make habitats and species more resistant to extreme weather so they continue to provide sustainable cultural, subsistence, recreational, and commercial uses. For example, managing stream corridors to preserve functional processes and reconnect channels with well-vegetated floodplains may help to ensure a steady supply of ground-water recharge that maintains cold-water species even when air temperatures rise. Floodplains serve as vital hydrologic capacitors, and may become even more important in many parts of the country as more precipitation falls as rain instead of snow. Protecting and restoring stream habitats to

maintain more narrow and deep stream beds and riparian shade cover can also help keep water temperatures cool in a warming climate.

X5.1.3 Allow corridors for wildlife retreat from fire and flood.

X5.1.4 Address issues of invasive species which could be escalating effects of extreme weather due to better adaptive skills.

X5.2 Climate change may impact agricultural practices in the United States through more frequent water shortages, extreme weather events, flooding, and shifts in growing seasons.

X5.2.1 Farmers and ranchers have always had to cope with variability in the weather. But extreme weather may produce more permanent shifts in temperature and precipitation.