Designation: E3136 – 18

Standard Guide for Climate Resiliency in Water Resources[1]

This standard is issued under the fixed designation E3136; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This standard provides a set of options to plan for water resource resiliency and management in the event of changing environmental conditions. This includes adapting local business and government infrastructure to both chronic and natural conditions and extreme weather events that impact water resources. It also includes planning in order to respond adequately to future 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 or green infrastructure as part of the decision-making process. This standard provides a voluntary framework of the risk management options and steps that may be beneficial to evaluate climate resiliency solutions. It provides strategies for any organization, 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 approaches. This guide references and merges similar, effective programs and tailors them to provide a consistent approach that will facilitate communication and preparation to protect our national water resources from changing environmental conditions.

This standard guide presents a series of options for an individual, group, or entity to use where protecting water resources is the objective. The goal is to help build strategies and plans for changing environmental conditions and their impacts upon water resources.

1. Scope

1.1 *Overview*—Water resources in North America and other areas are subject to various impacts from chronic weather patterns, as well as more frequent extreme weather events. These include drought, flooding, changes in stream patterns, increased or decreased run-off, and changes in water quality. Water resources include both man-made and natural reservoirs, rivers, streams, groundwater, and storage ponds. The infrastructure for water supply, wastewater treatment, fire-fighting and agricultural uses are also subject to chronic weather patterns and more frequent extreme weather related events. This guide will provide an explanation of techniques users may employ to build resiliency and a planning outline for municipalities, states and private industry in order to ensure safe, future, effective availability of water resources.

1.2 *Purpose*—The purpose of this guide is to provide a series of options that organizations may implement to prepare for the environmental impacts and risks from changing environmental conditions, chronic weather patterns, natural or man-made disasters, and extreme weather events. This guide also encourages consistent management of risks from natural disasters to water resources. The guide presents practices and recommendations based on regions and planning horizons that provide institutional and engineering actions to reduce the physical and financial vulnerabilities attributable to changing environmental conditions. It presents available technologies, institutional controls, and engineering controls that can be implemented by individuals and organizations seeking to increase their adaptive and resiliency capacity.

1.2.1 The guide also provides some high-level options for the planning, selection, implementation, and review of strategies in order to ensure that the approach continues to be environmentally responsible, in the best interest of the public, reasonable, and cost effective. This guide can be used to analyze the effectiveness of a community's strategy.

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

1.2.3 The guide does not provide risk assessment, per se, but may help set priorities for a climate resiliency program.

1.3 *Safety*—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 to establish appropriate safety and health practices and determine the applicability of regulatory

[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 E50.07 on Climate and Community.

Current edition approved July 1, 2018. Published August 2018. DOI: 10.1520/E3136–18

limitations prior to use. Adaptation and resiliency measures, however, may be consistent with, and complementary to, safety measures.

1.4 *Objectives*—The objectives of this guide are to determine the conditions of the community, facility, and property with regard to risks of natural disaster events to water resources and actions that can be taken to manage those risks.

1.4.1 The guide presents information on planning and strategies to respond to extreme natural events such as drought, flood, storms and sea level rise upon water resources.

1.4.2 The guide encourages users to set priorities based upon the relevant region in the United States. For each region, the guide identifies key climate vulnerabilities that would require planning and preparation based on that particular scenario. These could be extrapolated to other regions if there are similar conditions.

1.4.3 The guide encourages the user to develop long term solutions for future risks.

1.5 *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 for the user. If it is not clear to the user how to apply standards to their specific circumstances, users should seek assistance from qualified professionals. Risks may vary depending on the entity evaluating the risk. This guide does not take a position on the causes or science of extreme weather, natural disasters, or changing environmental conditions.

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

1.7 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 US Army Corps of Engineers; the US Department of Agriculture; the US Department of Energy; the US Environmental Protection Agency; and the US Department of Defense.

1.8 This guide recommends reference to current regulatory information about risks culled from various state agencies, such as departments of environmental protection and water resources boards.

1.9 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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

E2635 Practice for Water Conservation in Buildings Through In-Situ Water Reclamation

E2717 Practice for Estimating the Environmental Load of Residential Wastewater

E2727 Practice for Assessment of Rainwater Quality

E2728 Guide for Water Stewardship in the Design, Construction, and Operation of Buildings

2.2 *International Standards:*

Australian Standard AS 5334 Climate change adaptation for settlements and infrastructure

ISO 14001:1996 Environmental Management Systems – Specification with guidance for use [products of ISO/TC 207 for which ASTM E 50 was a participant on behalf of ANSI]

ISO 31000:2009 Risk management Principles and guidelines

ISO Guide 73 Risk management—Vocabulary

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

2.3 *National Initiatives:*

American Society of Civil Engineers Standards ASCE/SEI 24-05 Flood Resistant Design and Construction (24-05) 2006 / 74 pp.

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

National Climate Assessment https://nca2014.globalchange.gov/

2.4 *Government References:*

National Research Council (NRC), 2004 Adaptive Management for Water Resources Project Planning, Panel on Adaptive Management for Resource Stewardship, Committee to Assess the U.S. Army Corps of Engineers Methods of Analysis and Peer Review for Water Resources Project Planning

United States 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)

United States Department of Agriculture (USDA) and US Forest Service (USFS) 2014 National Climate Hubs for Adaptation and Mitigation

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)

Climate Adaptation Resources and Guidance https://archive.epa.gov/epa/climatechange/climate-adaptation-resources-and-guidance.html

[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.

Climate Impacts on Water Resources https://archive.epa.gov/epa/climate-impacts/climate-impacts-water-resources.html
Climate Resilience and Preparedness https://archive.epa.gov/epa/production/files/2016-08/documents/ow-climate-change-adaptation-plan

3. Terminology

3.1 *Definitions:*

3.1.1 *adaptive capacity, n*—the ability of a system, either natural or engineered, to adjust to extreme weather, including climate variability and to moderate potential damages; to take advantage of opportunities, or to cope with the consequences.

3.1.2 *benefit cost analysis (BCA), n*—advantages, pay-offs, values, and desired outcomes as compared with economic expenses, accrued liabilities, *asset retirement obligations*, and loss contingencies.

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 *climate extremes, n*—unusual, long-term weather patterns viewed over seasons or longer periods, such as extended drought.

3.1.5 *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'.

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

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

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

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

3.1.10 *extreme weather events, n*—catastrophic storms, high winds, tornadoes, hurricanes, floods, acute water shortages, wildfires, blizzards, heat waves or any other related instances, causing significant injury, loss of life or property damage. These phenomena are at the extremes of the historical distribution, including especially severe or unseasonal conditions.

3.1.11 *extreme weather patterns, 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.

3.1.12 *fire risk, n*—various rating systems to determine the likelihood of a fire, given weather and wind conditions. The National Fire Protection Association has a rating system

3.1.13 *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. This includes chronic flooding.

3.1.14 *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. **E2114, E2432**

3.1.15 *green infrastructure, n*—an adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. Green Infrastructure techniques use soils and vegetation to infiltrate, evaporate, transpire, and/or recycle stormwater runoff. When used as components of a stormwater management system, Green Infrastructure practices such as green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits.

3.1.16 *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. **E2432**

3.1.17 *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, earthquakes, landslides, uplifts, faults and other tectonic effects.

3.1.18 *long term weather patterns, n*—the state of the atmosphere over a considerable period of time including seasonal combinations of conditions such as temperature, wind, cloudiness, moisture and barometric pressure.

3.1.19 *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.

3.1.20 *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.

3.1.21 *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. Includes local subsidence, thermal expansion, and 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.

3.1.22 *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.

3.1.23 *resiliency, 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.

3.1.24 *scenarios, n*—a plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships.

3.1.25 *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).

3.1.26 *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.

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

3.1.28 *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.

3.1.29 *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

3.1.30 *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.

3.1.31 *weather, n*—atmospheric conditions 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 is 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 system. Climate is what to expect such as cold winters and 'weather' is what happens such as a blizzard.

4. Significance and Use

4.1 This Guide addresses issues related solely to resiliency strategies and the development of a plan to address extreme weather and related physical and chemical changes to water resources. This guide does not include specific advice on risk assessment, however, references are provided in Appendix X1. Adaptation and resiliency design strategies and planning may consist of a wide variety of actions by individuals, communities, or organizations to prepare for, or respond to, the impacts of chronic and extreme natural and manmade events.

4.2 *Example Users:*

4.2.1 Small business or enterprise owners;

4.2.2 Service industry employees;

4.2.3 Federal, tribal, state or municipal facility staff and regulators, including departments of health; water, sewer and fire departments;

4.2.4 Financial and insurance institutions;

4.2.5 Public works staff, including water systems, groundwater supplies, surface water supplies, stormwater systems, wastewater systems, publically owned treatment works, and agriculture water management agencies;

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 staff;

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

4.2.10 Wildlife management entities including government, tribal, and NGOs;

4.2.11 Cities, towns and counties, especially in developing climate vulnerability strategies and plans;

4.2.12 Commercial and residential real estate property developers, including redevelopers;

4.2.13 Non-profits, community groups, and property owners.

4.3 This Guide is a first step in crafting a simplified framework 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 resiliency.

4.3.1 Resiliency 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 resiliency across communities will require action at all levels; individual, business, town, county, state, and federal.

4.3.2 Some municipalities, states, tribes and corporate organizations have already begun taking action toward defining resiliency strategies and planning for extreme weather resiliency. Examples are located in Boston, Miami Beach, and Baltimore. More examples are included in the Appendices.

4.3.3 Real estate development teams may use these techniques to identify future opportunities and liabilities.

4.3.4 The user should consider the most effective scale of resiliency, for example, site, town, catchment, watershed, city, state, tribal area, or regional level. The scale will impact the relative direct and indirect costs and benefits of a solution. This guide may help users understand the most effective scale of resiliency and the appropriate level of action by providing ways to set time and budget priorities.

4.4 This Guide does not address: the uncertainty of unpredictable and severe weather events; the connections between impacts of rising temperatures and extreme events or the probability of the rate of increase of these events. This guide, however, does discuss options to address vulnerabilities from the impacts of changing environmental conditions, extreme weather events, and natural catastrophes.

5. Risk and Vulnerability Assessment

5.1 This Guide establishes a framework of common climate risk and vulnerability assessment approaches for water resources in North America. It may have value when applied to other areas.

5.2 *Introduction to the Concept of a Risk and Vulnerability Assessment:*

5.2.1 Extreme weather may pose a risk or threat to businesses and properties. Extreme weather may yield economic damages in the form of flood and storm damage, crop losses, wildfire losses, supply chain disruptions, critical infrastructure outages, increased insurance rates, decreased property values, and reduction of recreational and tourism resources. This guide addresses resiliency strategies and plans, taking a measured approach to promote effective risk management strategies for the highest priority vulnerabilities identified by the user.

5.2.2 The user should seek the input of the public and conduct outreach activities and community engagement in identifying the most vulnerable water resources in the areas of concern.

5.3 Identify the water resource, its current conditions, beneficial uses and vulnerabilities. This includes the lifespan of any critical equipment and structures used to manage the resource.

5.4 The concept of "adaptive management" is widely used to describe water resources and climate change planning. Many of the concepts in this guide are consistent with adaptive management. This means managing the water resource so as to maximize its adaptive capacity to extreme weather events. See NRC Adaptive Management for Water Resources Project Planning.

5.5 Establish the climate/extreme weather parameters of concern. Decide on a timeframe for the risk and vulnerability assessment.

5.6 *Conduct the Risk and Vulnerability Assessment:*

5.6.1 Assess the climate risk based on the consequence of an impact and the probability and likelihood of occurrence.

5.6.2 Understand the level of risk perception and risk tolerance for the water resource, organization, entity and constituents.

5.6.3 Assess the climate vulnerability of the water resource and components based on 5.2 – 5.6.2.

5.6.4 There are a number of risk evaluation tools. Some public resources are listed in Appendix X2.

6. Adaptation Planning

6.1 This Guide establishes a framework of common approaches in adaptation planning for water resources in North America. It could be modified for use in other areas. This Guide outlines resiliency 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 resiliency and planning options for managing environmental and human risks associated with extreme weather.

6.2 *Preliminary Risk Screening and Detailed Risk Screening*—Set priorities based upon risk and vulnerability of the water resource to extreme weather events and community feedback.

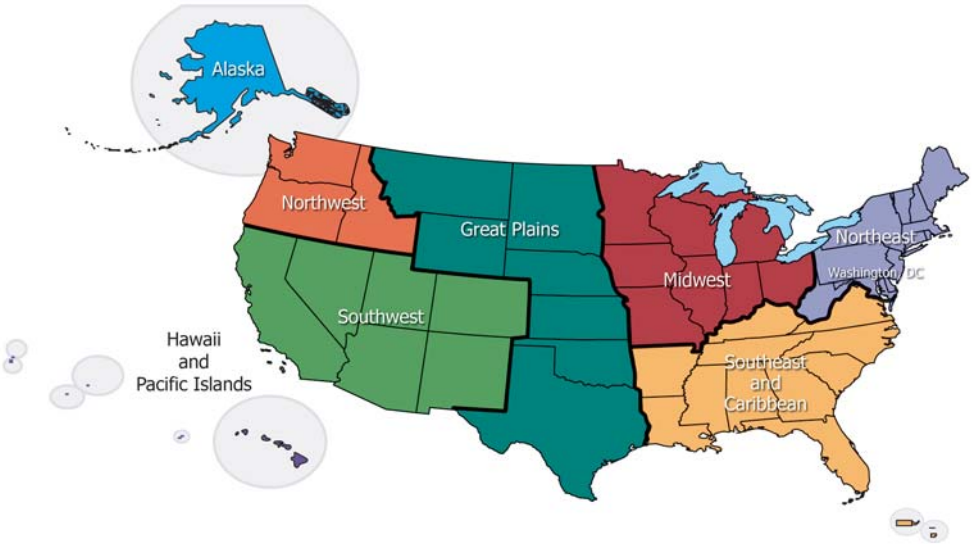
6.2.1 The priority areas of concern are shown in Table 1, based upon the selected region. There may be other priority areas based upon local conditions and state-by-state priorities. Flash floods from rivers and streams are examples of local conditions requiring priority planning in addition to regional priorities. Priority areas of concern may also be based on previous, extreme weather and related, catastrophic events. The areas of New York, Long Island and New Jersey impacted by Hurricane Sandy are examples.

6.3 Consider actions and adaptation solutions to address the climate risks and vulnerabilities. These may include: planning, zoning, design, and construction. Categories of actions include short-term, mid-term and long-term as shown in Table 2.

6.3.1 Identify adaptation best management practices. Include planning for areas that may need resources due to economic factors. Some of the hardest hit areas after extreme weather events are low-income areas where water supplies, including wells are damaged. Reach out to residents of these areas to evaluate needs and include them in the planning processes.

6.3.2 Perform a benefit cost analysis (BCA) of proposed adaptation measures.

6.3.2.1 A BCA is used to evaluate economic effectiveness, based on assets failure threshold, climate impacts, financial



Reference: National Climate Assessment (https://nca2014.globalchange.gov/)

FIG. 1 National Climate Assessment Regions

TABLE 1 Example Climate Resiliency Priorities for Water Resources[A]

Region	Drought & Heat Events	Extreme run-off & Flooding	Storm damage to infrastructure	Sea Level Rise, Tidal Coastal Effects
1 Northeast		*	*	*
2. Southeast	*	*	*	*
3. Midwest	*	*	*	
4. Great Plains	*	*	*	
5. Northwest		*	*	*
6. Southwest	*	*	*	*
7. Alaska		*	*	*
8. Hawaii		*	*	*

[A] This table provides an overview of resiliency priorities. The lack of an '*' does not indicate that other climate risks will not occur. In addition, specific risks and resiliency priorities may differ within a region, at the local or site specific scale.

damages, how long the asset is out of commission, community disruption, and adaption cost.

6.3.2.2 The results are used for public outreach, community engagement and a prioritization and phase-in of adaptation measures such as short-term measures versus long-term measures.

6.4 Establish a plan for how adaptation solutions are incorporated to lessen vulnerability, increase the adaptive capacity of water resource components, and adapt critical infrastructure for resiliency.

6.4.1 Building a strategy or plan of resiliency to extreme weather educates groups, businesses and individuals to reduce risks and build safety restraints into their activities, increasing resiliency. The overall goal is to adapt existing infrastructure for resiliency, and plan for new infrastructure that is resilient to extreme weather events. Broad examples of strategy or planning elements include, but are not limited to:

6.4.2 *Adaptation Management Plan Steps:*

6.4.2.1 Short-term actions to be taken within 1-3 years, with immediate effects upon water resiliency. Planning should also begin for mid and long-term actions.

6.4.2.2 Mid-term actions to be taken within 7 years. Implementation of these actions may take 10 or more years to see results. Begin both planning and design for long term actions.

TABLE 2 Action Planning for Resiliency and Adaptation[A]

Priority (Section)[A]	Short-term (<3yrs)	Mid-term (<7 yrs)	Long-term (>7 yrs)
Drought & Heat Events (7.2)	Water planning Fire Protection Planning Conservation Landscaping	Water conservation Community fire adaptation	Water Storage & reuse Sustainable forest management
Extreme run-off & Flooding (7.3)	Temporary storage and public outreach. Conservation landscaping. Adapt critical infrastructure	Build protection of critical utilities Use green infrastructure	Construct flood storage reservoirs and retention ponds
Storm damage to infrastructure (7.4)	Backup storage/ power Emergency storage and protection. Conservation Landscaping	Establish storm resistant programs Build temporary wind and storm shelters	Reconstruct water utilities for storm and high wind resistance
Sea Level Rise, Tidal Coastal effects (7.5)	Plans for restoration of buffer zones and natural barrier structures Conservation Landscaping	Design barriers and relocation of treatment works Restore or install wetlands and tidal ecosystems	Build diversions and relocate facilities Use green infrastructure

[A] Adapt critical infrastructure for resiliency.