

Response to Climate Change

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V. Geographic Climate Regions

A. Introduction

THE USGCRP defines eight geographic regions that have broadly common climatological characteristics (USGCRP, 2009a). In evaluating the EPA water program for this revised *2012 Strategy*, we have included a discussion of particular issues by climate region.

These regions are largely adopted from the USGCRP construct with a few amendments. The “Islands” Region has been broken into two distinctive Island groups (Caribbean and Pa-

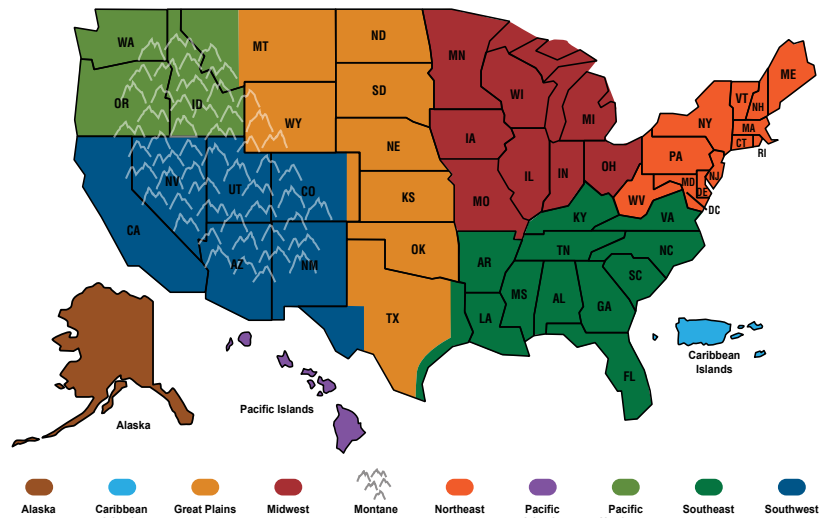
cific Islands); and a Montane Region consisting of the glaciated ranges of the Rocky Mountains, Sierra Nevada, and the Cascades was added to reflect its unique geographic features and expected climate change impacts (Figure 13). Further, while the 2000 Assessment also considered “Native Peoples and Native Homelands” as a Region, we have included tribal issues in Chapter IV, Programmatic Visions, Goals, and Strategic Actions. More detailed information on climate regions can be found on the USGCRP website (USGCRP,

2012) and on EPA’s main climate website (www.epa.gov/climatechange). The NWP will incorporate new information about impacts in the various climate regions as it is developed.

Several EPA Regions span multiple USGCRP regions (see Figure 13 and Table 3). Each EPA Region addresses a variety of climate impacts in their program implementation. This chapter describes strategic issues and key actions that the EPA Regions intend to focus on in the coming years, while the Regions also participate in the implementation of relevant strategic actions discussed in Chapter IV.

The federal government is working to deliver climate services not only at a national scale but also at regional scales. While similar climate characteristics can be grouped broadly within

Figure 13: Climate Regions as Adapted from USGCRP



the climate regions, mitigation, and adaption efforts tend to occur at a very localized scale. EPA intends to work with other federal agencies and stakeholders to consider the spatial variability of climate change when addressing climate impacts. Examples of federal agencies working to develop localized climate-related services, and with whom each of the EPA Regional programs intends to collaborate, include:

- DOI in support of LCCs
- DOI in support of CSC
- NOAA RISAs
- Interagency/NOAA-led National Integrated Drought Information System (NIDIS)
- NOAA National Climatic Data Centers
- National Park Service Climate Friendly Parks Initiative

Further, as described in the ICCATF 2010 Progress Report (CEQ, 2010), regional offices of federal agencies have been asked to coordinate to deliver services related to climate change. As a result, an effort is underway to develop regional hubs that can provide localized assistance, where a regional adaptation coordinator can offer a single point of entry for stakeholders to access federal adaptation science and services. These partnerships will be important for EPA Regions as they work toward achieving their long-term goals, and close collaboration among these federal climate related services will be important to achieve the strategic actions described in this strategy.

Table 3: USGCRP Climate Regions and EPA Regions

Climate Regions	EPA Regions
Northeast	1, 2, 3
Southeast	3, 4, 6
Midwest	2, 5, 7
Great Plains	6, 7, 8
Southwest	6, 8, 9
Pacific Northwest	8, 10
Montane	8, 9, 10
Alaska	10
Caribbean Islands	2
U.S. Pacific Islands and Territories	9

B. Ongoing Programs Relevant to Climate Change Across All Regions

There are a number of ongoing programs and activities, described throughout this report, that are important for protecting water resources irrespective of climate change, and that are also important for both adapting to climate change impacts and reducing GHG emissions. These core programs and principles being implemented by EPA across all climate regions include:

- GI and LID.
- Water efficiency and conservation through the WaterSense program.
- Building sustainability of water and wastewater infrastructure through the CRWU program.
- Improving energy efficiency through the EUM program.
- Promoting proactive, holistic aquatic ecosystem conservation and protection through the HWI.
- Developing tools for coastal resources via the CRE program and the NEP.

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- Protecting underground sources of drinking water by implementing the Geologic Sequestration rule.
- Coordinating federal funding and programs through the Partnership for Sustainable Communities between HUD, DOT, and EPA, to align infrastructure investments, such as for water, housing, or transportation, that will help reduce pollution and build resilience.

As EPA continues to develop approaches to mitigate GHG emissions and adapt to climate change, they will be adopted across the climate regions as guided by Regional priorities.

In addition, working with partners throughout the Regions will be key. One example of partners are the six interstate basin commissions that receive CWA 106 funding (Table 4) along with various other interstate commissions (ICWP, 2012).

Table 4: Interstate Organizations Receiving CWA 106 Funds

- New England Interstate Water Pollution Control Commission
- Interstate Environmental Commission (NY/NJ)
- Interstate Commission of the Potomac River Basin
- Delaware River Basin Commission
- Susquehanna River Basin Commission
- Ohio River Valley Water Sanitation Commission

C. EPA and Climate Regions – Goals and Strategic Actions

EPA's Regional programs provide a platform for integrating activities across media, including air, water, and land. Many of the Regions, in fact, have developed, or are developing, Regional energy and/or climate change adaptation plans or strategies. In addition, after EPA's Agency-wide adaptation plan is finalized in 2012, each EPA Region will be preparing an implementation plan providing more detail on how it will carry out the work called for in the Agency-wide plan, per the EPA Administrator's June 1, 2011, Policy Statement on Adaptation (EPA, 2011a). This section provides a synopsis of the water-related activities in the Regions and identifies long-term goals and strategic actions that EPA Regions plan to take in the coming years to build resilience at the national, state, tribal, and local levels. Links are provided to Regional websites where more information can be found.

Northeast Region

The Northeast climate region extends from West Virginia and Maryland in the south to the Canadian border in the north, and is bounded by the

northern terminus of the Appalachian Mountain range to the west and the Atlantic Ocean to the east. The region includes 12 states in three EPA Regions (1, 2, and 3) and is home to 63 million people, representing 21 percent of the population of the United States. The population is concentrated along the coast, with a generally more rural interior; therefore, addressing sea level rise and other coastal issues is of particular importance.

Region 1: <http://www.epa.gov/region1/climatechange/index.html>

Region 2: <http://www.epa.gov/region2/climate/>

Region 3: <http://www.epa.gov/reg3artd/globclimate/>

Goal

EPA programs in the Northeast Region intend to work to make coastlines and watersheds more resilient to changes in water temperature, precipitation, and sea level.

Strategic Issues

- Flooding from increasingly frequent and intense rain events, as well as intense tropical storms, will tax aging infrastructure, including combined sewer systems, and adversely impact water quality.
- Dense coastal development and shoreline armoring prevents wetland migration and leads to loss of wetlands as sea level rises.
- Increases in the extent of storm surge and coastal flooding will cause erosion and property damage to the densely populated coasts. The state of New York has more than \$2.3 trillion in insured coastal property (USGCRP, 2009b).
- Sea level rise may increase saltwater intrusion to coastal freshwater aquifers, resulting in water resources unusable without desalination. Increased evaporation or reduced recharge into coastal aquifers exacerbates saltwater intrusion.
- Sea level rise will lead to direct and indirect losses for the region's energy infrastructure (e.g., power plants and oil refineries located along the coast, facilities that receive oil and gas deliveries), including equipment damage from flooding or erosion. Damaged energy facilities also may be a source of pollution.
- Sea level rise, increased water temperatures, salinity distribution and circulation, changes in precipitation and freshwater runoff, and acidification will change aquatic ecosystem species composition and distribution. This will also result in the potential for new or increased prevalence of invasive species.
- Impacts from increasingly diverse types of energy development (e.g., hydraulic fracturing, biomass, land-based and offshore renewable energy development) may negatively impact the region's water resources.
- Despite the increased precipitation that most climate change models predict for the Chesapeake watershed, initial estimates of watershed models are that increases in temperature and consequent increases in evapotranspiration cause a decrease in annual river flows in the mid-Atlantic. Considering that the Baltimore, D.C., Richmond axis is the southern portion of the densely populated Boston–D.C. megalopolis, concern is warranted for securing safe and adequate drinking water supplies under climate change conditions in both the Northeast and Southeast climate regions.

Strategic Actions

In addition to promoting the core climate programs described in the introduction to this chapter, EPA is working with the New England Federal Partners group, the Mid-Atlantic Regional Council on the Ocean, and other regional networks to support the development of consistent scientific methods and robust datasets to inform long-term policy decisions on climate change vulnerability assessments and adaptation planning. This involves:

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- Standardizing regional assumptions regarding future climate change impacts.
- Informing a framework for local, state, and regional decision-making that accommodates existing and emergent data sources for adaptation planning efforts.

Additionally, EPA in the Northeast Region intends to serve as a leader, coordinator, and facilitator on mitigation and adaptation activities within the region. These activities include:

- Promote water and energy efficiency at water and wastewater utilities, and encourage sustainability by promoting WaterSense, CRE, and water sustainability initiatives.
- Support the NEP and CRE programs in the development of tools and the implementation of sea level rise adaptation measures.
- Continue to engage the National Ocean Policy/NOC in addressing sea level rise adaptation and mitigation measures.
- Support emergency preparedness/response capabilities in the water sector, such as the mutual aid and assistance networks in New England.
- Promote structural and nonstructural floodplain and riparian zone management strategies that recognize that intact and well-managed watersheds are more resilient to severe storms, and absorb impacts and help balance flows over time.
- Promote adoption of GI and LID approaches through nonpoint source and stormwater management and funding programs (e.g., Municipal Separate Storm Sewer Systems [MS4] permits that include flexibility for use of LID approaches)
- Support federally recognized tribes and environmental justice populations that are already acutely impacted by water issues that may be aggravated by climate change, and may require targeted technical assistance. For example, Region 2 awarded a grant to the Saint Regis Mohawk Tribe to work together with all Region 2 tribal nations to discuss and design adaptation approaches during 2012.

Southeast Region

The Southeast climate region extends from Virginia to the Texas border with Mexico. It includes the South Atlantic Coast, the Piedmont Coastal Plain, the Southern Appalachian Mountains, the Gulf Coast, and the southern Mississippi River Watershed. All of EPA Region 4 and parts of Regions 3 and 6 are included in the Southeast Region.

The region includes a wealth of ecological and economic resources, such as barrier islands, extensive estuaries, busy shipping ports, and important commercial and recreational fishing resources. Given the continuing population and business growth in the southeastern coastal states and the ensuing pressures on the coastal zones of this region, there are compounded pressures from decreased water supply, as well as

Region 3: <http://www.epa.gov/reg3artd/globclimate/>

Region 4: http://www.epa.gov/region4/clean_energy/index.html

Region 6: <http://www.epa.gov/region6/climatechange/water.htm>

increased flooding, sea level rise, and intense tropical storms compounded by land subsidence and heat-related stress on aquatic ecosystems and human health.

Goals

Region 4 established a cross-program multimedia Energy and Climate Change Steering Committee and Workgroup that developed and is implementing an Energy and Climate Change Strategy. Similarly, Region 6 developed a Clean Energy and Climate Change Strategy through a cross-program, multimedia workgroup. These workgroups intend to work to achieve the following long-term goals:

- **Sea Level Rise:** Work with coastal states, tribes, counties, cities, and federal partners to enhance adoption of adaptive measures to lessen or avoid significant adverse effects and increase resiliency.
- **Current Data:** Update changing precipitation patterns, stream hydrology, and available water resources data and reflect them in core water program implementation, as appropriate and taking uncertainty into consideration.
- **Water Utility Energy and Water Use Efficiency:** Promote energy and water use efficiency by working with partner utilities.
- **Geological Sequestration:** Build state programs' capacities and technical skills for implementing the Geological Sequestration Rule for Class VI wells and related permitting program.
- **Vulnerable Populations:** Work with vulnerable and historically under-represented communities to build climate change adaptation and mitigation capacities.

Strategic Issues

- Decreased water availability due to increased temperature, increased evaporation, and longer periods of time between rainfall events, coupled with an increase in societal demand, is very likely to affect many sectors of the Southeast's economy.
- Increasing evaporation and plant water loss rates alter the balance of runoff and ground water recharge, which (along with sea level rise) is likely to lead to saltwater intrusion into shallow aquifers in certain coastal areas of the Southeast.
- As sea level rises, barrier island configurations will change and coastal shorelines will retreat. Wetlands will be inundated and eroded, and low-lying areas, including some communities, will be inundated more frequently—some permanently—by the advancing sea.
- As sea level rises, temperature increases, and rainfall patterns change the salinity of estuaries, coastal wetlands, and tidal rivers, which are likely to become more variable. There will likely be longer periods of high salinities destroying coastal ecosystems or displacing them farther inland over time.

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- Higher intensity and potentially more frequent storm surge flooding of coastal ecosystems and communities are likely in some low-lying areas. This concern is particularly acute along the central Gulf Coast and in south Florida and coastal North Carolina. Combined with up to 2 feet or more of sea level rise, increased storm surge is likely to result in significant human and natural resource consequences for this region.
- Hurricane intensity may increase with climate change and pose an increasingly severe risk to people, personal property, and public infrastructure in the Southeast. Hurricanes have their greatest impact at the coastal margin where they make land-fall, causing storm surge, severe beach erosion, inland flooding, and wind-related damage to both cultural and natural resources.

The warming projected for the Southeast during the next 50 to 100 years will create heat-related stress for fish and aquatic ecosystems, and may result in a decline in dissolved oxygen in stream, lakes, and shallow aquatic habitats, leading to fish kills and loss of aquatic species diversity. Other effects of the projected increases in temperature may include more frequent outbreaks of shellfish-borne diseases in coastal waters and altered distribution of native aquatic plants and animals.

Strategic Actions

In addition to continuing to implement the ongoing climate programs described in the introduction to this chapter, Regions 3, 4, and 6 intend to support the above long-term goals through the following strategic actions:

■ Sea Level Rise

- Support national NEPs, focusing on the development of tools and implementing sea level adaptation measures.
- Engage with the South Atlantic Alliance and the Gulf of Mexico Alliance, to promote resilience and reduce the impacts of (and adapt to) climate change.
- Continue to engage with the National Ocean Policy/NOC and the Gulf Coast Ecosystem Restoration Task Force to assist in adapting to and reducing the effects of sea level rise.
- Develop pilot regional partnerships with FEMA's Long Term Community Recovery Program to encourage pre-disaster planning and promote incorporation of sustainable, resilient reconstruction and energy management improvements into water/wastewater facilities damaged in declared disaster areas.

■ Current Data

- Work with EPA Headquarters, states, and tribes to incorporate changing temperatures and hydrologic data into EPA and delegated state programs.

■ Energy

- Recruit additional WaterSense partners, providing technical assistance and utilizing applicable grant programs.

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- Host GI training workshops and installation of GI demonstration projects. Region 4 has an ongoing project with the city of Jacksonville, Florida, to promote implementation of GI projects and principles. Region 6 is working with Dallas on a series of GI and urban heat island mitigation and adaptation projects.
- Build internal capacity to assist water/wastewater facilities in the assessment of energy use and ways to reduce energy demands, and in identifying willing partners for which results can be measured to serve as models.
- Develop Regional capacity for and implementation of a Regional Pilot Energy Management Program for Water/Wastewater Facilities.

■ Geologic Sequestration

- Host training and other technical assistance activities for states on implementation of the Geological Sequestration Rule for Class VI wells, and exercise regulatory oversight of UIC permits for CO₂ sequestration.

■ Vulnerable Populations

- Work with vulnerable and historically under-represented communities to ensure information, access, and attention exists for building the needed climate change adaptation and mitigation capacities.
- Through a newly established EPA-Tribal Climate Change Network, EPA Region 6 intends to continue to work with tribal communities to provide timely and effective access to and sharing of climate change information for building mitigation and adaptation capacities in Indian Country.

Midwest Region

The Midwest's climate is shaped by the presence of the Great Lakes and the region's location in the middle of the North American continent. This location, far from the temperature-moderating effects of the oceans, experiences large seasonal swings in air temperature from hot, humid summers to cold winters. Areas from EPA Regions 5 and 7 are included in the Midwest climate region. In addition, Region 2 is connected ecologically to this climate region through the Great Lakes and the St. Lawrence Seaway. The Great Lakes are a natural resource of tremendous significance in the Midwest, containing 20 percent of the planet's fresh surface water. Much of the region, outside of the Great Lakes Basin, drains to the Mississippi River, and as such, contributes to long-range impacts in the Gulf of Mexico. Issues of particular concern in this Region include extreme variability in precipitation and temperature, and preserving the ecological integrity of the Great Lakes.

Region 2: <http://www.epa.gov/region2/climate/>

Region 5: <http://www.epa.gov/r5water/>
<http://www.epa.gov/r5climatechange/>

Region 7: <http://www.epa.gov/region7/water/si.htm>

Goals

The long-term goals of EPA in the Midwest Region include:

- Use knowledge gained from downscaled climate models and other data to integrate climate considerations regarding precipitation into NPDES permits and long-term control plans (LTCPs), taking into account the uncertainty in model results.
- Understand vulnerability of water-related infrastructure and work with partners to increase resilience of the region's critical infrastructure to extreme storm events.
- Improve the Great Lakes community's understanding of how their ecosystems and populations will be impacted by climate change and their ability to plan and implement adaptation measures for those impacts.
- Protect ground water and surface water quality and quantity.
- Protect vulnerable populations.

Strategic Issues

- Variability in precipitation patterns will be a challenge for both drinking water and wastewater utilities and their systems. More intense rainfall can overload drainage systems and water treatment facilities, increasing the risk of waterborne diseases. This is of particular concern for combined sewer overflow (CSO) communities. Increases in such events are likely to cause greater property damage, higher insurance rates, a heavier burden on emergency management, increased cleanup and rebuilding costs, and a growing financial toll on businesses, homeowners, and insurers.
- In the summer, with increasing evaporation rates and longer periods between rainfalls, the likelihood of drought will increase, and water levels in rivers, streams, and wetlands are likely to decline. Water levels in the Great Lakes are projected to fall between one and two feet by the end of the century (USGCRP, 2009), which may result in significant lengthening of the distance to the lakeshore in many locations, impacting beaches, coastal ecosystems, dredging requirements, infrastructure, and shipping. Declining water levels in the Great Lakes will cause the migration of coastal habitats. Additionally, climate change impacts may also have profound effects on agriculture and significant resulting impacts on water quantity and quality.
- Increased water temperatures will lead to an increased risk of oxygen-poor or oxygen-free "dead zones" that kill fish and other living organisms. Warmer water and lower oxygen conditions can more readily mobilize mercury and other persistent pollutants, which is of concern for lakes with contaminated sediment. In cases where increasing quantities of contaminants are taken up in the aquatic food chain, the potential for health hazards will increase for species that eat fish from the lakes, including humans. Additionally, warming water in the Great Lakes will increase the threat of invasive species, such as zebra and quagga mussels.

- Warmer water may also exacerbate the impacts that nutrient loading has on water bodies. More intense rainfall could increase fertilizer runoff and other forms of pollutant loading to water bodies. Increased use of tile and other drainage management practices as a means to abate flooding of agricultural fields may also carry unintended consequences of increasing pollutant loading to streams and lakes.
- The Great Lakes are a bi-national resource, shared and managed jointly with Canada. Great Lakes climate change work, therefore, has a bi-national management and collaboration component.

Strategic Actions

In addition to continuing efforts in core climate change programs such as GI, WaterSense, and CRWU, specific actions to achieve the long-term goals in the Midwest Region include:

- Work with the agriculture community to consider and promote approaches such as agriculture drainage management to improve resilience and lessen water quality impacts.
- Work with states to adopt and implement EPA's Nutrient Management Framework.
- Review permit applications and issue UIC permits for CO₂ in UIC Direct Implementation states. Review primacy packages (SDWA § 1422 revision applications/GS Class VI applications) and complete the Class VI primacy approval process.
- Work with water utilities to promote energy and water efficiency.
- Engage tribes in federal climate change conversations and continue efforts to work with tribes and tribal organizations to initiate climate change adaptation projects and initiatives.
- Continue working with environmental justice populations, especially in CSO communities, to improve access to climate change information and to consider adaptation strategies.

Great Plains Region

The Great Plains climate region extends from the Dakotas and eastern half of Montana in the north to Texas in the south. On the west, it is bounded by the Rocky Mountains and the Basin and Range geographic provinces, and the central lowlands and coastal plain provinces to the east and to the south. Parts of 10 states in three EPA Regions (6, 7, and 8) are located in this vast grassland prairie, which is home to some 9 million people, with the population expected to grow to about 14 million by 2050. The population gains will largely be in urban areas.

Region 6: <http://www.epa.gov/region6/climatechange/water.htm>

Region 7: <http://www.epa.gov/region7/water/si.htm>

Region 8: <http://www.epa.gov/region8/climatechange/>

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Key issues in this region relate to general population growth; loss of snowpack and declining surface and ground water quality and quantity; competition for water between energy, agriculture, and public supply; and vulnerability of prairie wetlands, prairie potholes, and playa lakes.

Goals

The long-term goal of EPA in the Great Plains Region is to work to provide long-term availability and high quality of water resources and related aquatic habitat and function through:

- Water quality protection and restoration
- Water conservation and efficiency promotion
- Protection of vulnerable populations

Working specifically with partners in the agricultural sector; the renewable energy sector; and the oil, gas, and mining sectors, as well as land developers and land trusts, will be important in achieving this goal.

Strategic Issues

- General population growth, and shifts in population from the region's rural to urban centers, will continue to create demands for water storage to maintain sustainable water supplies and increase competition among water users (e.g., agricultural and municipal uses).
- Loss of snowpack in the western portion of the region will further impact water use, storage, and irrigation practices. This should be taken into consideration as infrastructure is added in the region.
- Declining surface and ground water quantity and quality, coupled with more frequent and severe droughts, will continue to exacerbate water shortages in the region.
- Unique aquatic ecosystems such as prairie wetlands, prairie potholes, and playa lakes will continue to be stressed as changes occur in ground water and surface water sources.
- Increased nonpoint source pollution (e.g., sediments, phosphorus, and nitrogen) is expected as increases in storm intensity are observed. This could result in changes to natural stream morphology and related hydrographs and could negatively impact the biological function of aquatic ecosystems.
- As in the Midwest climate region, warmer water may also exacerbate the impacts that nutrient loading has on water bodies. More intense rainfall could increase fertilizer runoff and other forms of pollutant loading to water bodies. Increased use of tile and other drainage management practices as a means to abate flooding of agricultural fields may also carry unintended consequences of increasing pollutant loading to streams and lakes.
- Water-quality impacts will be amplified by increases in precipitation intensity and longer periods of low flow in streams.

Strategic Actions

In addition to promoting the core climate programs described in the introduction to this chapter, EPA intends to undertake the following efforts in the Great Plains Region:

■ Water Quality Protection and Restoration

- Work to reduce nonpoint sources of pollution to rivers and streams by leveraging the EPA's Office of Water's National Nutrients Strategy.
- Work with partners to incorporate changing precipitation patterns, temperature, and hydrology into EPA and delegated state program decision frameworks.
- Build geosequestration evaluation, modeling, and permitting expertise within EPA Regions through technical workshops, seminars, and related training to enhance staff capacity.
- Exercise regulatory oversight of UIC permitting for carbon sequestration.
- Work with states to adopt and implement EPA's Nutrient Management Framework.

■ Water Conservation and Efficiency

- Promote water efficiency and energy efficiency at water and wastewater utilities, and encourage sustainability by promoting WaterSense, CRE, and water sustainability initiatives such as GI initiatives workshops and related outreach efforts in major cities and along the United States–Mexico border.

■ Vulnerable Populations

- Work with vulnerable and historically under-represented communities to ensure the same level of information and access exists for building the needed climate change adaptation and mitigation capacities.
- Continue to work with tribal communities to provide access to climate change information, mitigation and adaptation strategies, and funding options to provide the long-term viability of natural and cultural resources that support Native American populations.

Southwest Region

The Southwest climate region includes California, Nevada, Utah, Arizona, New Mexico, and the westernmost portions of Colorado and Texas. EPA Regions 6, 8, and 9 are located in this area. To the west of the region lies the Pacific Ocean; Mexico borders the southern edge; and the Rocky Mountains border a large part of the region to the east. The population of this region, now approximately 54 million, has the fastest growth rate in the nation. The Southwest Region has multiple climatic zones, each facing somewhat different climate changes impacts. Much of the region is arid with relatively high air temperatures. Several mountain ranges as well as the Pacific Ocean influence climate and water resources in certain parts of the region. Water is stored as snowpack during the winter and released to streams in the spring and early summer, helping to meet increasing water demands. There are three

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major river systems: the Sacramento-San Joaquin, the Colorado, and the Rio Grande. Several huge water storage and conveyance projects also divert water from rivers for

more widespread use by agriculture and growing cities. The lack of rainfall and the prospect of future droughts becoming more severe is a significant concern, especially because the Southwest continues to lead the nation in population growth.

Region 6: <http://www.epa.gov/region6/climatechange/water.htm>

Region 8: <http://www.epa.gov/region8/climatechange/>

Region 9: <http://www.epa.gov/region09/climatechange/>

Goals

The long-term goals of EPA in the Southwest Region are to work with federal, state, interstate, tribal, and local partners to:

- Increase the number of communities and utilities conducting climate change vulnerability assessments and implementing the resulting recommendations.
- Work with partners and stakeholders to evaluate and reduce the impacts of future drought and flooding on surface and ground water resources.
- Protect water quality and quantity to reduce stress on ecosystems.
- Address sea level rise by working with coastal states, tribes, counties, cities, and federal partners to enhance adoption of adaptive measures to lessen or avoid significant adverse effects and to increase resiliency.

Strategic Issues

- Warmer temperatures will reduce mountain snow packs, and peak spring runoff from snow melt will shift to earlier in the season, leading to and increasing the shortage of fresh water during the summer. A longer and hotter warm season will likely result in longer periods of extremely low flow and lower minimum flows in late summer. Water supply systems that have no storage or limited storage (e.g., small municipal reservoirs) may suffer seasonal shortages in summer.
- The magnitude of projected temperature increases for the Southwest, particularly when combined with urban heat island effects for major cities such as Phoenix, Albuquerque, Las Vegas, and many California cities, represents significant stresses to health, energy, and water supply in a region that already experiences very high summer temperatures.
- Reduced ground water supply due to a lack of recharge will be of concern.
- Warmer ocean temperatures may decrease productivity by stopping entrainment of deep supplies of nutrients. The resulting reductions in commercial species will need to be addressed to support continued production of fisheries and aquatic life.

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- Increased frequency and altered timing of flooding will increase risks to people, ecosystems, and infrastructure. Increased flood risk is likely to result from a combination of decreased snow cover on the lower slopes of high mountains and an increased percentage of winter precipitation falling as rain and therefore running off more rapidly.
- Sea levels are rising and contributing to the loss of wetlands and infrastructure located along coastal corridors.
- The magnitude and frequency of wildfires have increased over the last 30 years, which severely impacts water quality in streams, creeks, rivers, lakes, and estuaries.

Strategic Actions

In addition to continuing to implement the ongoing climate programs described in the introduction to this chapter, EPA intends to undertake the following efforts in the Southwest:

- Encourage funding programs to fund GI, energy and water-efficient upgrades to infrastructure, and water conservation.
- Work through the California Water and Energy Project (an interagency partnership) as well as the California Financing Coordinating Committee to leverage funding to support sustainable water infrastructure and water-use efficiency projects.
- Continue to provide funding for tribal sustainable water infrastructure projects in coordination with the Indian Health Services.
- Build partners' and stakeholders' understanding of, and the capacity to respond to, risks of climate change and water.
- Work with states and local governments to expand water sources, storage, and recovery options (e.g., aquifer storage and recharge, water reuse, desalination) for areas experiencing snow pack loss and drought.

Pacific Northwest Region

The Pacific Northwest climate region includes Washington, Oregon, Idaho, and the western third of Montana. It is bounded by the Pacific Ocean on the west and the Rocky Mountains on the east and includes

EPA Region 10 and part of Region 8. Canada borders the region to the north.

Of primary concern are current impacts related to

changes in snowpack, stream flows, sea level, forests, and other important aspects of life in the Northwest, with more severe impacts expected over the coming decades in response to continued and more rapid climate change.

Region 8: <http://www.epa.gov/region8/climatechange/>

Region 10: <http://yosemite.epa.gov/R10/ECOCOMM.NSF/climate+change/cc>

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Goals

The long-term goals of EPA in the Northwest Region are to work with federal, state, interstate, tribal, and local partners to increase sustainability and reduce vulnerability of communities and infrastructure, including by conserving water and increasing infiltration, and to partner with other federal agencies and the regional CSC to coordinate and leverage climate research and other activities.

Strategic Issues

- Salmon and other coldwater species will experience additional stresses as a result of rising water temperatures and declining summer streamflows.
- Sea level rise along vulnerable coastlines will result in increased erosion and loss of land.
- Declining springtime snowpack will lead to reduced summer streamflows, straining water availability for all uses.
- Increased insect outbreaks, wildfires, and changing species composition in forests will pose challenges for ecosystems and the forest products industry.
- Water supplies will become increasingly scarce, calling for tradeoffs among competing uses, and potentially leading to conflict.
- Increased frequency of flooding will increase risk to people, ecosystems, and infrastructure.
- Projected heavier winter rainfall may cause an increase in saturated soils and therefore an increased number of landslides, particularly where there have been intensive development or forest practices on unstable slopes.
- Agriculture, ranching, and natural lands—already under pressure due to an increasingly limited water supply—are very likely to be further stressed by rising temperatures.

Strategic Actions

In addition to continuing to implement the ongoing climate programs described in the introduction to this chapter, EPA intends to undertake the following efforts in the Northwest Region:

- **Sustainability**
 - Encourage sustainable infrastructure approaches.
 - Implement water conservation measures.
 - Expand use of GI.
 - Encourage communities and utilities to conduct vulnerability assessments and implement resulting recommendations.

■ Water Quality

- Implement water quality programs factoring in climate change to reduce stress on the ecosystem.

■ Collaboration

- Collaborate with the LCCs.
- Engage in Western Governors Association climate adaptation activities.
- Partner with the CSC and other federal agencies.
- Engage tribes in federal climate conversations and activities.

Montane Region

The Montane region, in EPA Regions 8, 9, and 10, includes three glaciated mountain ranges: the Rocky Mountains, Sierra Nevada, and the Cascades. These areas are unique in that they rely on winter snow accumulation for their water supply. Sensitive ecological communities include bogs and fens. Montane glaciers and snowfields are reservoirs of water for the human populations and ecological communities at lower elevations.

Most ecosystems in the North American Montane Region are predicted to slowly migrate and shift their distribution toward the north in response to

warming temperatures. However, the alpine areas are often distributed as small, isolated regions surrounded by other habitats. These areas can be disconnected from each other by wide stretches of land used for timber production, ranching, or other uses. Instead of shifts in latitude, alpine vegetation and animals will be limited to shifts in altitude, unless connections between suitable habitats can be made. [Jackson, 2006]

Region 8: <http://www.epa.gov/region8/climatechange/>

Region 9: <http://www.epa.gov/region09/climatechange/>

Region 10: <http://yosemite.epa.gov/r10/water.nsf/homepage/water>

Goals

The goal of EPA in the Montane Region is to protect the water quality and biological integrity of the Montane Region and increase the region's resilience to climate change, through water quality and habitat protection and restoration.

Strategic Issues

- A warmer climate will cause lower elevation habitats to move into higher zones, encroaching on alpine and sub-alpine habitats.
- High-elevation plants and animals will lose habitat area as they move higher, with some "disappearing off the tops of mountains."
- Rising temperatures will increase the importance of connections between mountain areas.

Response to Climate Change

- Rising temperatures may cause mountain snow to melt earlier and faster in spring, shifting the timing and distribution of runoff. This in turn affects the availability of fresh water for natural systems and for human uses. Earlier melting leads to drier conditions for the balance of the water year, with increased fire frequency and intensity.
- Water supplies will become increasingly scarce, calling for tradeoffs among competing uses and leading to conflict.
- Increased frequency and altered timing of flooding will increase risks to people, ecosystems, and infrastructure.
- Projected increases in temperature, evaporation, and drought frequency add to concerns about the region's declining water resources.
- Climate change is likely to affect native plant and animal species by altering key habitats such as the wetland ecosystems known as montane fens or playa lakes.

Strategic Actions

In addition to continuing efforts in core climate change programs described in the introduction to this chapter, specific actions relative to the Montane Region include:

- Increase protection and restoration of wetlands to optimize percolation of surface water into ground water.
- Increase protection and restoration of riparian areas to reduce erosion during storm events and snow melt periods and thereby protect water quality.
- Increase protection of headwater streams and wetlands to protect the quality of montane water sources in the midst of precipitation and runoff-timing uncertainties.
- Collaborate with the USFWS, other DOI agencies, states, tribes, and others involved in LCCs in efforts to develop landscape-scale strategies to address climate change issues on a bio-regional basis.
- Coordinate climate change adaptation actions with federal agencies (given the large amount of federal agency holdings in the Montane Region), landholders, and others.
- Partner with other federal agencies to coordinate and leverage climate research and other activities.
- Engage tribes in federal climate conversations and activities.

Alaska Region

Over the past 50 years, Alaska has warmed at more than twice the average rate of the rest of the United States. Its annual average temperature has increased 3.4°F, while winters have warmed by 6.3°F. The higher temperatures are already causing earlier spring snowmelt, reduced sea ice, widespread glacier retreat, and permafrost warming. The observed changes are consistent with climate model projections of greater warming over Alaska, especially in winter,

Region 10: <http://yosemite.epa.gov/r10/water.nsf/homepage/water>

as compared to the rest of the country. Climate models also project increases in precipitation over Alaska. Simultaneous increases in evaporation due to higher air temperatures, however, are expected to lead to drier conditions overall, with reduced soil moisture. Average annual temperatures are projected to rise between 5 and 13°F by late this century. Increasing acidification of Alaskan waters presents a clear threat to Alaska's commercial fisheries and subsistence communities (USGCRP, 2009a).

Goals

- Design and build infrastructure that can withstand warmer conditions and thawing permafrost, flooding, and fire.
- Ensure adequate water supplies for communities dependent on disappearing sources.
- Protect water quality to reduce stress on the ecosystems.

Strategic Issues

- Longer summers and higher temperatures are causing drier conditions, despite trends in increased precipitation. Insect outbreaks and wildfires are increasing with warming.
- A warmer climate will cause freshwater and saltwater species to move further north or into higher zones.
- As permafrost continues to thaw and temperatures rise, some lakes and ponds are beginning to disappear. This impacts drinking water sources and reduces wetland habitat while presenting a challenge for the ecosystem and the people who depend on its natural resources.
- Permafrost thaw has also caused numerous land slumps along riverbanks, which can have an impact on water quality (increasing turbidity) with documented impacts to drinking water in some Alaskan communities.
- Coastal storms increase risks to villages and fishing fleets. The combination of losing their protective sea ice buffer, increasing storm activity, and thawing coastal permafrost is causing some coastal communities to crumble into the sea. Increasing storm activity delays barge operations that supply coastal communities with fuel. The increased storm intensity puts fishing fleets at higher risk.
- Displacement of marine species will affect key fisheries. Thawing sea ice is moving the location and limiting the extent of plankton blooms. As plankton moves to deeper waters, it is less available to species and the food chain that depends on it, including humans dependent on these species for subsistence or economic livelihood.
- Thawing permafrost damages roads, runways, water and sewer systems, and other infrastructure.
- Opening of the Arctic from melting sea ice will create new opportunities for shipping, resource exploration and extraction, and tourism; there may be challenges caused by the increased traffic. Other key issues are the potential for the introduction of invasive species, impacts on subsistence activities, and national security concerns.

Response to Climate Change

Strategic Actions

In addition to continuing to implement the ongoing climate programs described in the introduction to this chapter, EPA intends to undertake the following work in Alaska:

■ Infrastructure

- Encourage sustainable infrastructure approaches.
- Encourage communities and utilities to conduct vulnerability assessments and implement resulting recommendations.
- Encourage energy-efficient motors and pumps in infrastructure to reduce GHG emissions.

■ Water Quality and Water Supply

- Expand use of GI to delay stormwater runoff, mimic timing closer to the natural regime, and increase infiltration.

■ Collaboration

- Collaborate with the Alaska Climate Change Executive Roundtable and the LCCs and Climate Science Center in Alaska.
- Partner with other federal agencies to coordinate and leverage climate research and other activities.
- Engage tribes in federal climate conversations and activities.
- Work with key federal, state, local, and tribal governments to assist communities that are evaluating relocation options as potential adaptation actions.

Caribbean Islands Region

Puerto Rico and the U.S. Virgin Islands, part of EPA Region 2, are located in the northeastern Caribbean Sea and are of volcanic origin. Puerto Rico (PR), including its offshore islands, covers a total area of 3,435 square miles. The main island of PR has three principal physiographic areas: the alluvial coastal plains, karst, and the central mountainous interior. Land surface elevations range from mean sea level to 4,389 feet above mean sea level. PR is home to approximately 3.9 million people, 70% of whom reside in coastal areas. Annual rainfall in PR ranges from about 30 inches in the western end of the south coast to about 160 inches near the top of the El Yunque Rainforest. Surface water provides approximately 75% of the population's freshwater needs. However, aquifers also play an important role in providing fresh water, especially to populations in the south coast and to the industrial sector.

Region 2: <http://www.epa.gov/region2/climate/>

The U.S. Virgin Islands (USVI), including the islands of St. John, St. Thomas, and St. Croix, cover a total area of 133 square miles. St. Thomas and St. John are characterized by steep topography while St. Croix is characterized by lower hills. Precipitation is the only natural

source of fresh water on the islands. The population of the USVI relies on rooftop-rainfall catchments, large-scale desalination of seawater, and ground water.

The sensitive coastal ecosystems and critical infrastructure of the Caribbean Islands face difficulty due to sea level rise, tropical storms, and flooding from heavy rain. Coral reefs are under stress from warmer temperatures and ocean acidification. Water supplies are threatened due to both drought and saline contamination of aquifers.

Goals

The long-term goals of EPA in the Caribbean Region include:

- Work with partners to understand the vulnerability of coastal wetlands and their migration potential, and to protect the most vulnerable areas.
- Work with partners to understand the vulnerability of coastal communities and water-related infrastructure and to increase their resilience to extreme storm events.
- Increase understanding of the role of multiple stressors plus climate change on ecosystems and water-related infrastructure.

Strategic Issues

- Areas with limited ability for wetlands migration will see marked reductions in their ability to provide ecosystem services and will be increasingly vulnerable to intense storm damage in the future.
- Critical infrastructure (e.g., ports, airports, power plants, and sewage treatment facilities) in PR and the USVI located in the coastal zone will be vulnerable to storm surges, sea level rise, and the simultaneous occurrence of both.
- Many hurricanes and coastal inundations are accompanied by heavy rains and river/stream floods, which impact water quality and stream morphology.
- Rising sea levels cause intrusion of salt water into the underground freshwater lens, contaminating the supply of usable ground water and reducing the freshwater supply for the Caribbean Islands.
- Higher ambient water temperatures and degradation of water quality, including adjustments in pH due to acidification, may affect production rates of aquaculture facilities and their susceptibility to diseases such as microbial infections and parasitic infestations. Presently, there are no aquaculture facilities operating in the Caribbean, although a few NPDES permits have been issued.
- Recent events of increased sea surface temperatures have caused stress to coral reefs in the USVI and PR. Increasing sea surface temperatures have the potential to reduce the stability of corals, especially in the presence of stresses from the existing land-based sources of pollution.
- Ocean acidification may potentially diminish the quality of the reefs by impeding the calcification process, increasing carbon in the water, altering ocean chemistry, and

Response to Climate Change

making calcium less available for calcification. Lower pH could also accelerate erosion of existing structures.

- Longer periods of drought are expected to occur and may produce an increase in the energy and costs associated with the production of drinking water. This will be particularly pertinent in the USVI, where desalination is one of the main sources of drinking water.

Strategic Actions

In addition to continuing to implement the ongoing climate programs described in the introduction to this chapter:

- Support the development of LIDAR images for the Caribbean Region in order to provide more refined data for modeling purposes.
- Support the integration of climate change considerations into FEMA, Commonwealth, and municipal hazard mitigation plans.
- Promote increased use of GI in the Caribbean to enhance resilience by absorbing and infiltrating stormwater and preventing flooding and pollution impacts by providing outreach and education to the public and to design and building professionals. Support PR in the development of tsunami-ready communities.
- Partner with the Caribbean Coastal Ocean Observing System (CariCOOS), the National Weather Service, and other relevant federal and Commonwealth agencies to disseminate information and provide outreach to managers of PR's water infrastructure with regard to current trends.
- Support and encourage increased resilience of water infrastructure through physical upgrades, geomorphic feature protection (e.g., barrier islands, mangrove islets, eolianites, beach rock, and dunes), building code revisions, and working with insurance companies so they implement disaster risk reduction measures in the underwriting criteria of their policies.
- Engage environmental justice (EJ) populations in education on climate change impacts and planning for climate change adaptation.

Pacific Islands Region

The Pacific Islands region in EPA Region 9 encompasses the Hawaiian Islands as well as the U.S.-affiliated Pacific Islands, including the territories of American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), and Guam.

The Pacific Islands are more vulnerable to climate change than nearly any other region in the United States. Key vulnerabilities include availability of fresh water, adverse impacts to coastal and marine ecosystems, and exposure to hazards, including sea level rise and inundation.

Region 9: <http://www.epa.gov/region09/climatechange/>

Goals

- Design and build infrastructure that can withstand storms, flooding, salt spray, and fire.
- Protect existing drinking water supplies and ensure adequate supplies for communities dependent on disappearing sources.
- Encourage communities and utilities to conduct vulnerability assessments and implement resulting recommendations.
- Work with local governments on disaster planning and response, and long-term plans to protect infrastructure and human safety.
- Protect coral reefs, mangroves, and other sensitive ecosystems.
- Educate local and cultural leaders on the impacts of climate change and engage them in planning for climate change adaptation.

Strategic Issues

- Rising sea levels, higher sea temperatures, and ocean acidification associated with climate change are further degrading coral reefs already stressed by overfishing and pollution. Their loss diminishes ecological heritage, shoreline protection, and food supply from the sea, and results in a decline in income from ecotourism in the Pacific Island communities, where tourism is one of the largest industries.
- The western Pacific already experiences the highest rate of Category 4 and 5 storms. Climate change may bring more frequent and higher energy storms resulting in potentially catastrophic damage to island infrastructure. This degree of damage could cripple the economies of Pacific Island communities for significant periods of time, not only impairing economic development, but also the ability of local governments to ensure delivery of basic water and sewer and other public health services.
- **Sea level rise has multiple implications for Pacific Island communities:**
 - For the low-lying atolls, entire islands may be submerged within a generation and may result in environmental refugees seeking new homes.
 - For some low-lying islands, sea level rise can result in “wash over,” in which islands, or portions of islands, are submerged by waves during large storm events. This results in saltwater contamination of agricultural lands, significantly decreasing the productivity of those lands. This loss of agricultural productivity has an acute impact on the largely subsistence-based economies of these communities.
 - For many of the islands, sea level rise has an immediate and accelerated impact on coastal erosion, which affects water quality, coral reef health, coastal infrastructure, available land, and culturally significant sites.

Response to Climate Change

- Sea level rise increases the potential for saltwater intrusion into the sole source aquifers upon which many Pacific Islands rely for drinking water. There are few or no readily accessible alternative drinking water options when a community is confronted with the loss of productivity of a sole source aquifer.

Strategic Actions

In addition to continuing to implement the ongoing climate programs described in the introduction to this chapter:

- Work with local, state, and federal agencies, as well as local educational institutions, to ensure protocols are in place to identify key drinking water resources, monitor water quality, and develop long-term drinking water protection and management plans.
- Work with local, state, and federal agencies to leverage capital improvement funds to develop water and wastewater infrastructure designed to be resilient to the effects of climate change.
- Develop biological criteria as a component of water quality standards as a tool for coral reef protection.
- Use permitting authorities and enforcement to protect drinking water and near-shore water quality consistent with the requirements of the CWA.
- Work with local, state, and federal agencies to invest in local utility managers and employees for the long term so they have the skills and resources to consistently protect public health and safety, even in the event of catastrophic storm events. Collaboratively identify best management practices that are institutionalized through standard operating procedures.
- Work with local, state, and federal agencies to reduce reliance on fossil fuels through energy audits, conservation incentives, and investment in renewable energy sources. This approach will reduce water quality impacts associated with oil spills and develop an energy infrastructure that may be more resilient to severe storm events.
- Work with local, state, and federal agencies, as well as local educational institutions, to reduce stressors to coral reef health (e.g., sedimentation and impacts from fishing and recreation) and to protect coral reef ecosystems in perpetuity.
- Work with local, state, and federal agencies to build awareness of the potential effects of climate change and opportunities to reduce GHG emissions and adapt to impacts.
- Engage cultural leaders and EJ populations in education on climate change impacts and planning for climate change adaptation.

