The five sections of this chapter are:

A. **Infrastructure** – including centralized or decentralized technologies and practices for wastewater, drinking water, and stormwater management infrastructure; Climate Ready Water Utilities; energy use and co-generation; and water supply and demand management.

B. **Watersheds and Wetlands** – including landscape strategies to protect and restore watersheds, source water areas (including ground water), and wetlands; natural infrastructure; and low impact development (LID).

C. **Coastal and Ocean Waters** – including programs for coastal wetlands and estuaries; Climate Ready Estuaries (CRE); issues associated with coastal infrastructure and coastal drinking water (e.g., sea level rise, saline intrusion); and ocean water quality, ocean habitats, and marine life.

D. **Water Quality** – including policies and programs to protect human health and ecological integrity (e.g., Water Quality Standards [WQS], Total Maximum Daily Loads [TMDLs], National Pollutant Discharge Elimination System [NPDES] permits, green infrastructure (GI) for stormwater management, and underground injection control [UIC], wellhead protection).

E. **Working With Tribes** – including how the NWP intends to use "traditional knowledge" to help guide this *2012 Strategy* and long-term implementation of adaptation measures.

A. Infrastructure

VISION: In the face of a changing climate, resilient and adaptable drinking water, wastewater and stormwater utilities (i.e., the water utility sector) ensure clean and safe water to protect the nation's public health and environment by making smart investment decisions to improve the sustainability of their infrastructure and operations, and the communities they serve, while reducing greenhouse gas emissions through greater energy efficiency.

The viability of drinking water and wastewater treatment and related infrastructure directly affects the protection of public and ecosystem health. Challenges driven by population growth, land-use change, aging infrastructure, availability of infrastructure funding, regulatory constraints, and various water quality stressors are already driving the water sector to take action. Climate change adds another dimension that will complicate these long-standing challenges for water sector operators and public officials. This chapter highlights how the NWP intends to continue assisting the water sector in achieving public

> "Because the perception that climate fluctuates around a stationary mean is in conflict with recently observed climate dynamics, decision makers need an approach that is responsive to changes in the likelihood of extreme outcomes as well as changes in the "average" climate … Rather than managing the resource to maintain its past condition and state, management may need to take steps to protect the resource … or allow the resource to change as needed to adapt to climate change … In other words the managers of these resources must work to incorporate the impact of climate change in their plans and operations."
>
> National Research Council, 2010d

health and ecosystem objectives in light of climate change and these other challenges. The recently published *Principles for an Energy Water Future* (see Appendix A) underscores many of the concepts in this section.

Goal 1: The NWP works with the water utility sector to build the body of information and tools needed to incorporate climate change into planning and decision making to build the sector's adaptive capacity, reduce greenhouse gases, and deliver drinking water and clean water services.

This Goal highlights the objectives of the Climate Ready Water Utilities (CRWU) initiative to work with drinking water, wastewater, and stormwater utilities to advance their understanding of climate science and adaptation options. Through the CRWU program, the NWP intends to seek to expand the water sector's understanding of climate change risks and respond to the recommendations of the *Climate Ready Water Utilities: Final Report of the National Drinking Water Advisory Council* [NDWAC, 2010]. EPA's *Clean Water and Safe Drinking Water Infrastructure Sustainability Policy* [EPA, 2010c] also encourages water sector utilities to incorporate climate change considerations into their planning and operations, and supports the work of the CRWU initiative.

As recommended by the National Drinking Water Advisory Council (NDWAC) CRWU working group, climate change activities should be closely coordinated with other federal and state agencies, water sector associations, nongovernmental organizations, and tribes. CRWU activities also should be linked to other EPA programs, such as Climate Ready Estuaries (CRE) and Effective Utility Management (EUM). The EUM initiative is a collaborative partnership between EPA and major water sector associations and is based on a series of attributes of effectively managed utilities, including consideration of climate impacts. By coordinating with these and other programs, utilities can ensure that their climate change adaptation and mitigation approaches more readily address utility and community sustainability priorities through utilitywide planning, ongoing asset management and infrastructure repair and replacement, emergency response, and capacity development. Collaboration with the states through the State Revolving Fund (SRF) and other finance programs can also facilitate the consideration of climate change opportunities as states make infrastructure funding decisions.

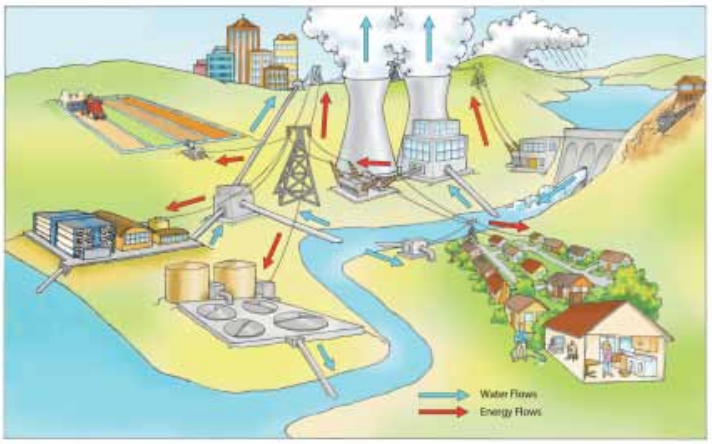
Strategic Action 1: The CRWU program intends to work to improve access to vetted climate data and hydrological science, modeling and assessment tools. *This action reflects the NWP's intent to incorporate climate change science and trend information into a major tool by 2015*.

Water utility officials are struggling with the number and volume of climate change studies produced by federal and state agencies, water associations, universities, and others. Concurrent with utilities moving forward to address climate change challenges, there is a strong need for continued investment in advancing the understanding of climate impacts and strategies (NDWAC, 2010). The NWP intends to continue to work with federal and state partners to improve access to hydrologic science and tools, such as trend and risk assessment tools, downscaled climate modeling, and advanced planning support models and decision support tools.

CRWU intends to refine its Climate Resilience Education and Awareness Tool (CREAT) to assist water utilities with understanding potential climate change impacts and assess their risks. CREAT allows a utility to analyze how various adaptation strategies may help reduce climate risks, enabling them to prioritize the implementation of adaptation measures. CRWU also intends to improve a searchable toolbox of resources that support all stages of the decision process, from basic climate science through integration of mitigation and adaptation into long-term planning (EPA, 2011c).

Strategic Action 2: The NWP intends to assist wastewater and drinking water treatment plants to reduce their greenhouse gas emissions and increase their long-term sustainability. The NWP intends to leverage programs such as effective utility management, sustainable asset management, and energy management, to encourage a combination of energy efficiency, co-generation and renewable energy resources.

Figure 6: Water and Energy Nexus



Water and energy are intimately connected. Water is used by the power generation sector for cooling, and energy is used by the water sector for pumping, treatment, and heating. Without energy there would be limited water distribution, and without water, there would be limited energy production. Image credit: U.S. Global Change Research Program (www.globalchange.gov).

About 80% of municipal water processing and distribution costs are for electricity, which comprises an estimated 3–4 % of national energy consumption; this percentage ranges up to 13% when residential water use is included (EPRI, 2002; EPA, 2011d). In addition, the Water Environment Research Foundation (WERF, 2010) reports that sewage typically contains 10 times the energy required to treat it, presenting an opportunity for using it as an energy source (co-generation). Becoming more energy efficient is a worthy goal for all water sector utilities and is an important step in reducing greenhouse gases and helping insulate utilities from energy costs or supply disruptions (Figure 6).

The NWP intends to continue encouraging water sector utilities to use its Energy Management Guidebook (EPA, 2008a), which uses a management systems approach to reduce energy use, along with other tools to develop sustainable energy management programs. As part of this effort, EPA intends to encourage utilities to document benefits from adopting energy management programs, such as lowering greenhouse gas emissions and operating costs. EPA has also developed a downloadable, Excel-based Energy Use Assessment Tool that can be used by small- to medium-sized systems to conduct a utility bill and equipment analysis to assess individual baseline energy use and costs (EPA, 2012b).

The NWP intends to continue to provide information on energy-efficient and co-generation technologies in consultation with other federal agencies—principally the Department of Energy (DOE)—and continue to collaborate with the EPA's Office of Air and Radiation and other

partners to improve existing tools (e.g., ENERGY STAR's Portfolio Manager) and develop new energy benchmarking and auditing tools.

Strategic Action 3: The NWP intends to work with the states and public water systems, particularly small water systems, to identify and plan for climate change challenges to drinking water safety and to assist in meeting health based drinking water standards.

The NWP intends to continue working to enhance partnerships with states, interstates, tribes, and others to improve water sector understanding of climate change adaptation options and identify technical assistance activities to help water systems comply with National Primary Drinking Water Regulations (NPDWRs) under changing climate conditions.

CRWU intends to focus in particular on developing tools for smaller systems. While larger utilities tend to have the resources to engage technical experts for assistance with operations, management, and decision support for climate change, smaller utilities have fewer resources. Building capacity requires providing tools and assistance tailored to smaller utilities, including tools that will prepare them to adapt to the changing climate. CRWU climate change adaptation tools will augment the capacity development efforts of the EPA drinking water program to address small system challenges affecting sustainability, compliance, and day-to-day operations. The NWP also intends to encourage partnerships between water systems to ensure they are able to avoid disruptions and consistently provide safe drinking water to their customers.

Strategic Action 4: The NWP intends to collaborate with partners to promote sustainable design approaches to ensure the long-term sustainability of infrastructure and operations. The NWP has completed *Planning for Sustainability: A Handbook for Water and Wastewater Utilities*, which provides a series of steps to help utilities voluntarily incorporate sustainability considerations into their planning. The Handbook focuses on key elements of planning, such as aligning utility sustainability goals with other community sustainability priorities in areas like housing and transportation; analyzing a range of infrastructure alternatives based on full life cycle costs, including green and natural systems; and ensuring that a financial strategy, including appropriate rate structures, is in place to fund, operate, maintain, and replace the alternatives chosen. Energy efficiency and impacts associated with climate change can be considered throughout the elements described in the handbook.

Recognizing that wastewater utilities are, in reality, resource recovery facilities, the NWP intends to work with the Water Environment Federation (WEF) and other partners to support development of an energy sustainability "roadmap." This roadmap will describe a path forward to help utilities conserve energy and become energy neutral over time. The NWP also intends to work with WEF, National Association of Clean Water Agencies, and other partners to increase public understanding of the value of biosolids as a renewable resource.

The NWP is also working with EPA's Office of Community Sustainability and three states (New York, Maryland, and California) to identify actions that can be taken to integrate the principles of the Housing and Urban Development-Department of Transportation-EPA Sustainable Communities Partnership into their Clean Water SRF programs. Options these states are consider-

ing include changes to intended use plans, project priority systems, and other funding guidance documents. Some of these changes could potentially provide incentives for projects that are energy efficient (that also help reduce greenhouse gas emissions) and/or that potentially reduce vulnerability to climate impacts. We intend to share information on the results of these pilots with other state Clean Water and Drinking Water Programs.

GOAL 2: EPA programs support IWRM in the water utility sector to sustainably manage water resources in the face of climate change.

Federal and state water resource management and protection agencies can encourage water sector utilities to establish partnerships with each other and the private sector (e.g., energy, agriculture) in the context of an IWRM framework (referred to as integrated water management in NDWAC, 2010). IWRM among water utilities and other partners can increase community resilience to climate change and expand opportunities for watershed-wide adaptive actions. The NWP, in consultation with other federal water agencies, states, interstates, and tribes, intends to consider how best to coordinate assistance to support IWRM.

Water supply management and water demand management are IWRM practices to consider, particularly where confidence in the future reliability of water supply quality or quantity is diminishing (e.g., in drought-prone, high growth, or coastal communities). The tools described below offer water sector utilities a range of methods—and there may be others—to extend their water supplies.

Water Reuse and Recycling:

Examples of Inter-utility IWRM in the Metropolitan Water District (MWD) of Southern California

- Orange County, California, recycles 70 million gallons per day (MGD) of sewage thru a $481 million treatment plant (NY Times, 2007) as part of a Ground Water Replenishment System (Orange County Water District, 2008).
- The City of Hemet, California, in the Eastern Municipal Water District provides recycled water to supply public parks and golf courses throughout the southland (Metropolitan Water District of Southern California, 2008).
- The Hill Canyon Water Treatment Plant (WTP) releases recycled water for agricultural irrigation under an exchange agreement between Calleguas MWD and United Water Conservation District (MWDSC, 2008).
- The Thousand Oaks Tapia WTP supplies recycled water to two MWDs for municipal and agricultural irrigation (MWDSC, 2008).

Many of the activities under the strategic actions for this goal can also be considered "no regrets" activities, in that they would provide benefits to utilities under current climate conditions as well as any future changes in climate.

Strategic Action 5: The NWP intends to seek opportunities to better understand and promote through technical assistance the use of water supply management strategies to increase hydrologic, ecologic, public health, and economic benefit.

Water supply management can help communities build resilience when water supplies are at risk. For example, Managed Aquifer Recharge can be used to store water in aquifers for

later use, and complements reuse of reclaimed wastewater to extend use, water loss control to preserve use of already treated water, and desalination to expand access to a useable resource.

Managed Aquifer Recharge: The NWP intends to work to foster research on Managed Aquifer Recharge practices that do not endanger underground sources of drinking water (USDWs). For example, Aquifer Storage and Recovery (ASR) is a process of storing water underground for future use if the injection does not endanger underground sources of drinking water. ASR is increasingly used where freshwater demand is beginning or projected to exceed supply, and use of ASR is likely to increase in drought prone areas, particularly those affected by climate change. When applied to stormwater, this practice can also reduce nonpoint source pollution of our lakes, streams, and rivers. However, the infiltration or injection of stormwater risks contamination of freshwater aquifers.

Reclamation and Reuse: The NWP intends to continue to encourage safe water reclamation and reuse. A wastewater or stormwater utility could, for example, distribute reclaimed water from a centralized treatment system for park irrigation or other uses, recognizing that additional treatment would be required for some applications. Onsite residential reuse of gray water for landscape vegetation reduces the volume of potable water delivered to the site and the volume of wastewater discharged from the centralized wastewater treatment facility. Since outdoor and non-potable water uses typically can account for more than half of all water use, this technique offers significant potential to preserve freshwater resources as well as to reduce treatment costs and energy use (EPA, 2004), and can help address increased frequency, severity, and duration of drought.

Water Loss Control: The NWP intends to provide technical assistance to reduce water loss from drinking water systems, building upon EPA's publication, *Control and Mitigation of Drinking Water Losses in Distribution Systems* (EPA, 2010d). Much of the estimated 880,000 miles of drinking water infrastructure in the United States has been in service for decades and can be a significant source of water loss. The American Water Works Association (AWWA) estimated in *Distribution System Inventory, Integrity and Water Quality* that there are close to 237,600 water line breaks per year in the United States, leading to about $2.8 billion lost in yearly revenue (EPA, 2007).

Treated water that cannot be accounted for equates to lost revenue and requires more water to be treated, which requires more energy and chemical use, which drives up operating costs. A water loss control program improves infrastructure sustainability by reducing costs and maintaining or increasing revenue. A report by the California Public Utilities Commission (CA, 2011b) found after five years of research that repairing leaks in water distribution pipes offers the highest energy savings from nine water-related strategies assessed. Water loss control also protects public health by reducing potential distribution system entry points for pathogens (EPA, 2010c).

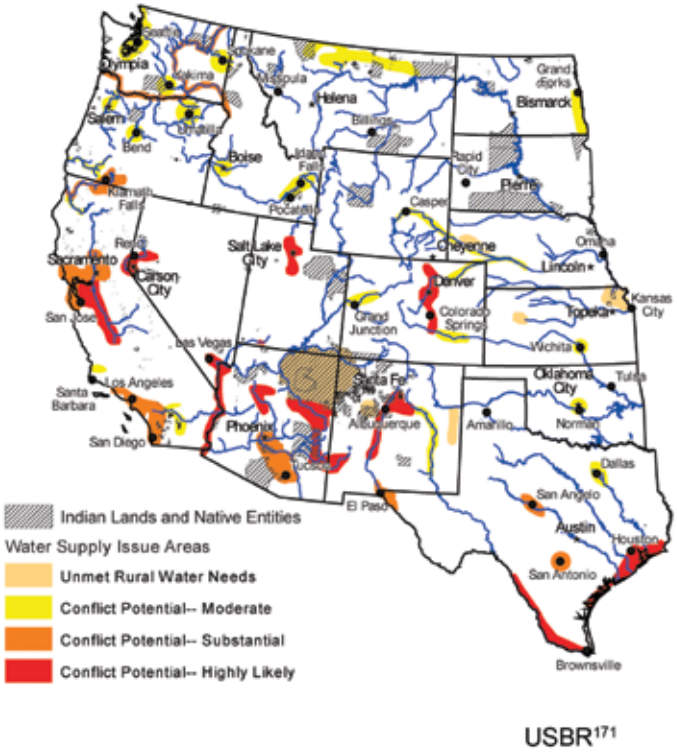
Desalination for Potable or Nonpotable Uses: Desalination to treat marine or brackish water is becoming increasingly important in certain locations and circumstances. Several coastal communities are piloting or using desalination plants to address increasing demand driven

by population growth or drought. These practices are increasing for inland sources for similar reasons or where water sources have been depleted. However, desalination is energy intensive, and there may be risks and costs associated with disposing of waste brines from the treatment. The NWP intends to monitor research developments to understand where efforts may be needed to ensure that the disposal of waste brines do not endanger underground sources of drinking water.

Strategic Action 6: The NWP intends to seek opportunities to evaluate, and provide technical assistance on, the use of water demand management strategies to increase hydrologic, ecologic, public health, and economic benefits.

Water demand management reduces consumption by providing information, technology, and incentives for consumers and industry to use less water. Water demand management calls for consumer education about the full cost of water services. To be sustainable, water utilities should be able to price water to reflect the full cost of treatment and delivery, as well as the cost of protecting water supplies. (Figure 7)

Figure 7: Potential Water Supply Conflicts



USBR[171]

The map shows regions in the West where water supply conflicts are likely to occur by 2025 based on a combination of factors, including population trends and potential endangered species' needs for water. The red zones are where the conflicts are most likely to occur. This analysis does not factor in the effects of climate change, which is expected to exacerbate many of these already-identified issues.

Image credit: U.S. Bureau of Reclamation, 2005.

Metering and Metrics: The NWP intends to support the Water Workgroup of the ICCATF by working with other federal water agencies to develop sector-specific water-use efficiency metrics, and the NWP intends to continue seeking opportunities to assist water utilities in developing and deploying water metering technologies. Measuring water use enables development of conservation pricing as well as metrics for water-use efficiency. Service-connection metering informs customers about how much water they are using, and suppliers use metering to track water use and billing. It will also be of interest to see how the increasing use of real-time customer water use information changes customer behavior as it relates to water use.

Water Use Efficiency and WaterSense: WaterSense is an EPA-sponsored voluntary partnership to protect the future of our nation's water supply by bringing together local water utilities and governments, product manufacturers, retailers, consumers, and other stakeholders to decrease indoor and outdoor nonagricultural water use through more efficient products and practices. WaterSense helps consumers make water-efficient choices and encourages

innovation in manufacturing by standardizing rigorous certification criteria that ensure product efficiency, performance, and quality (EPA, 2011f). These savings at the consumer level translate to significant direct savings in operations and maintenance costs, and indirect savings in infrastructure replacement costs, for drinking water and wastewater utilities. EPA intends to continue to develop specifications for water-efficient products; encourage water efficiency in landscape design, building operations, and codes; and educate the public on the value of water use efficiency through its WaterSense program.

WaterSense has helped consumers save 287 billion gallons of water and $4.7 billion in water and energy bills since 2006. By the end of 2011, WaterSense had partnered with more than 2,400 organizations and professionals, and more than 4,500 plumbing products had earned the WaterSense label (EPA, 2011e).

Water Pricing: The funding for daily operation and maintenance and long-term capital investments for drinking water and wastewater systems is typically generated through user fees. When measured as a percentage of household income, the United States pays less for water and wastewater bills than other developed countries. Because of this, there is a perception that water is readily available and water services are generally inexpensive. To meet our current and future infrastructure needs, public education on water sector system operations and costs, as well as private water conservation, is vital.

Pricing of water services should accurately reflect the true costs of providing high-quality water and wastewater services to consumers in order to both operate and maintain infrastructure and plan for upcoming repairs, rehabilitation, and replacement of that infrastructure. Drinking water and wastewater utilities should be able to price water services to reflect these costs, while also adjusting rates as needed to ensure that lower income communities can afford water and wastewater services.

There is an extensive body of knowledge on pricing water services and helping consumers learn about how pricing affects their community. EPA intends to continue to seek opportunities to work with our utility and state partners in identifying revenue templates that provide sufficient resources for infrastructure operations, maintenance, rehabilitation, and replacement, and send the right market signals about water use.

Strategic Action 7: The NWP intends to work to increase cross-sector knowledge of water supply climate challenges and develop watershed specific information to inform state, interstate, tribal, and local decision making.

It is important that state and local governments and their constituents understand the nature and extent of the water challenges they face to make decisions to address them. The NWP intends to work with federal and state science agencies and academia to develop location-specific information about climate change impacts for different sectors in each watershed and aquifer. For example, EPA is participating with other federal and state water agencies and stakeholders in planning the Department of the Interior's (DOI's) National Water Census as well as its *WaterSMART* program to promote the efficient use of water (USBR, 2011). The NWP intends to also expand its effort to collaborate with the U.S. Army Corps of Engineers

as it fosters "collaborative relationships for a sustainable water resources future" (USACE, 2010a), including development of a Federal Support Toolbox to provide a common data portal to support IWRM (USACE, 2010b).

B. Watersheds and Wetlands

VISION: Watersheds are protected, maintained and restored to provide climate resilience and to preserve the ecological, social and economic benefits they provide; and the nation's wetlands are maintained and improved using integrated approaches that recognize their inherent value as well as their role in reducing the impacts of climate change.

Healthy watersheds and wetlands will be critical to climate adaptation and mitigation. This section addresses how EPA intends to protect healthy watersheds, restore impaired watersheds to enhance climate resiliency, and preserve the important functions and ecosystem services provided by the nation's wetlands, especially in the face of climate change.

Healthy watersheds and wetlands provide a host of ecological services, including water purification, ground water and surface flow regulation, wildlife habitat, flood and surge impact reduction, water temperature moderation, erosion control, and stream bank stabilization. In many cases, they also store carbon and sequester other greenhouse gases. These ecosystems already are threatened with a number of stressors, and climate change will exacerbate existing water quality and ecosystem management issues.

Protecting waters and watersheds inherently involves landscape-scale collaboration involving state, tribal, federal, and local partners. Such collaborations promote a holistic, systems approach, enabling partners to more cost-effectively reach shared goals that increase ecosystem resilience to climate change. In particular, the NWP intends to work to implement the National Fish, Wildlife and Plants Climate Adaptation Strategy (FWP, 2011), which lists seven goals (see Table 1).

Table 1: Draft National Fish, Wildlife and Plants Climate Adaptation Strategy

Goals:

- **Goal 1.** Conserve and Connect Habitat
- **Goal 2.** Manage Species & Habitats
- **Goal 3.** Enhance Management Capacity
- **Goal 4.** Support Adaptive Management
- **Goal 5.** Increase Knowledge & Information
- **Goal 6.** Increase Awareness & Motivate Action
- **Goal 7.** Reduce Non-Climate Stressors

FWP, 2011. Fish, Wildlife and Plants Climate Adaptation Workgroup www.wildlifeadaptationstrategy.gov

"The once seemingly separable types of aquatic ecosystems are, we now know, interrelated and interdependent. We cannot expect to preserve the remaining qualities of our water resources without providing appropriate protection for the entire resource." *Tennessee Senator Howard Baker on the importance of the Clean Water Act on the Senate floor, 1977*

"I ask that your marvelous natural resources be handed on unimpaired to your posterity." *Theodore Roosevelt, Sacramento, CA 1903*