RECLAMATION

Managing Water in the West

Climate Change Adaptation Strategy

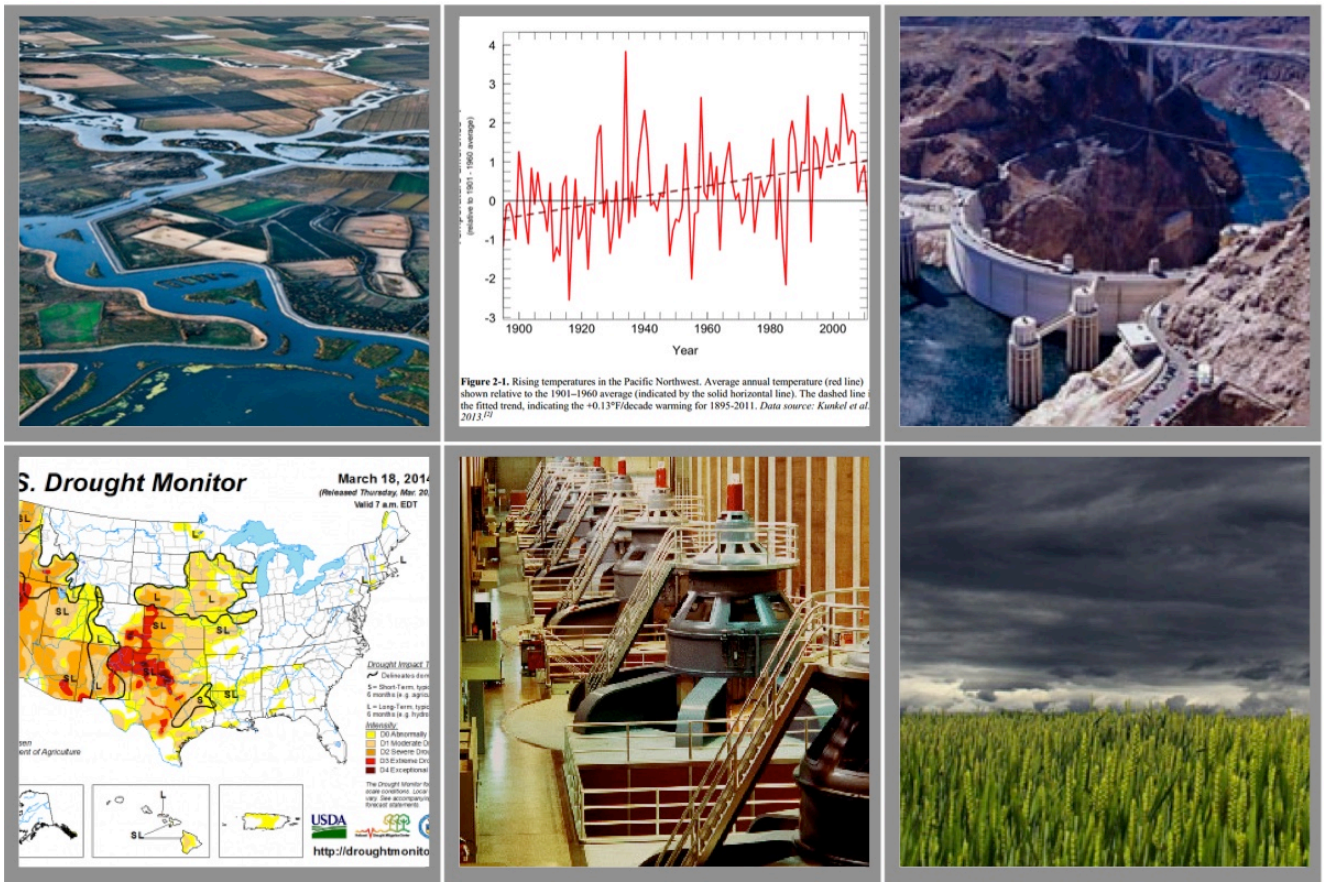

Figure 2-1. Rising temperatures in the Pacific Northwest. Average annual temperature (red line) shown relative to the 1901–1960 average (indicated by the solid horizontal line). The dashed line the fitted trend, indicating the +0.13°F/decade warming for 1895-2011. *Data source: Kunkel et al. 2013.*[5]

U.S. Department of the Interior
Bureau of Reclamation

November 2014

Mission Statements

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

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Executive Summary

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The weather and streamflow patterns that framed the development of water and power systems across the West are changing (Figure 1). As a result, Reclamation's basic mission objectives are at risk, including the ability to deliver needed quantities of water and power to agricultural, tribal, municipal, and industrial water users and water for environmental flows. Climate change also poses a threat to Reclamation's infrastructure, and along with it, the ability to continue to support customers and maintain ecosystems affected by Reclamation projects. Reclamation's response to the changing climate is essential to the sustainability of communities across the Western states and the National economy.

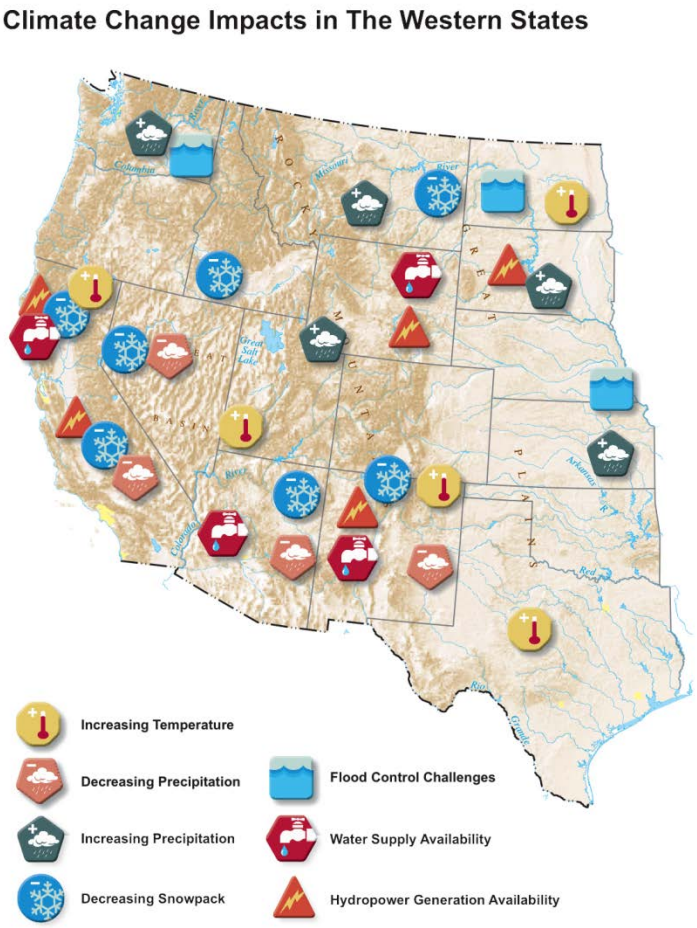

Figure 1: Conceptual illustration of the variety and wide geographic distribution of climate change impacts to water resources in the western United States. With water on the leading edge of climate change impacts, Reclamation must be an early responder and develop new adaptation strategies to support the continued fulfillment of its mission responsibilities.

Reclamation has made significant progress in assessing the impacts of climate change to water resources and implementing on-the-ground actions to mitigate impacts. However, more needs to be done to utilize information about future climate change in order to make decisions now about how best to operate Reclamation reservoirs, prioritize investments in new or improved facilities, and protect species and habitat in a changing climate. Reclamation also has a responsibility to provide leadership and support to customers and stakeholders as they address the challenge of adapting to climate change. This Strategy identifies four primary goals to improve Reclamation's ability to consider climate change information in agency decision making:

- Goal 1 - Increase Water Management Flexibility
- Goal 2 - Enhance Climate Adaptation Planning
- Goal 3 - Improve Infrastructure Resiliency
- Goal 4 - Expand Information Sharing

This Strategy builds on existing actions to identify new activities that extend climate change adaptation efforts across Reclamation's mission responsibilities. These include immediate and longer-term actions addressing each of the four goals (see Table 1). A priority action is also identified for each goal to highlight activities providing critical support for the goal. The actions discussed in this Strategy support consideration of climate change information in mission areas where it is not yet fully considered in order to help Reclamation and its customers and stakeholders build resiliency to climate change impacts.

The goals identified in this Strategy tier from key elements of the President's Climate Action Plan for the Nation (President's Plan), which identifies the continued development of sound science, water management planning and conservation, and increasing the resiliency of infrastructure as critical actions to prepare the United States for the impacts of climate change. The President's Plan highlights the importance of taking action now to maintain agricultural sustainability, manage drought, prepare for future floods, reduce wildfire risks and other objectives that have always been and are critical to Reclamation's mission and customers. This Strategy is also aligned with the Department of the Interior's (Interior) Climate Adaptation Policy (523 DM 1), which calls on the Bureaus to incorporate climate adaptation into agency decision making across mission areas.

Introduction

The impacts of climate change are being felt across the West. Warming is affecting water supplies by changing the overall annual volume of precipitation and altering the balance of rain versus snowfall. Communities are facing increasing problems with water availability and drought, flooding, and increased risks of forest fires. As the Nation's largest wholesale water supplier, Reclamation must provide leadership by taking action, in coordination with other Federal agencies, State agencies, Indian tribes, local governments, customers, and interested stakeholders, to build resiliency to climate change and help ensure water supplies for future generations.

Reclamation has made significant progress in assessing the impacts of climate change to water resources and implementing on-the-ground actions to mitigate impacts. This Strategy identifies new activities, building on existing activities, to extend climate change

The purpose of this Strategy is to provide a framework in which Reclamation managers can develop and adopt innovative solutions that provide more reliable water supplies as the climate changes. The Strategy identifies immediate actions that can be implemented in the short term (2014-2016) and longer-term actions (2016 and beyond) that will be used by Reclamation in formulating future budget priorities. By outlining specific climate adaptation activities, the Strategy provides a foundation to implement the requirements of the Reclamation-wide climate adaptation policy currently in review and planned for release in 2015. The Strategy will also guide communication about the steps Reclamation is taking now and capabilities and actions that the Bureau is building toward in the future. Most importantly, this Strategy represents an agency-wide commitment to face the challenges posed by climate change and to support others in taking action to address climate change impacts.

Reclamation's vast inventory of water and power infrastructure constitutes a very large public investment, giving Reclamation an important stewardship role to manage this infrastructure in the public interest. Reclamation has 476 dams and 348 reservoirs, with capacity to store 245-million acre-feet of water. With this infrastructure, Reclamation provides water to irrigate over 10 million acres of land across the West and to serve 31 million people with water. Reclamation's continued ability to meet contract obligations and to provide reliable and affordable water supplies for irrigation, cities, tribes and the environment is dependent on the resiliency of Reclamation infrastructure and operations to climate change.

Climate change adaptation requires a collaborative, partnership driven response, involving customers, stakeholders and the public. Reclamation shares responsibility with customers for water management, and the infrastructure critical to support water management. Reclamation customers are the water and power users who have contracted with Reclamation to repay the cost of constructing Reclamation projects, assume operations and maintenance responsibilities, and receive energy or capacity from Reclamation-owned hydropower facilities. Reclamation also interacts with a broad array of stakeholders who do not have the same contractual relationship to Reclamation as water and power customers but nonetheless have important interests in maintaining water supply sustainability. Sustainability within a changing climate will require achieving solutions that meet the overall interests of the National economy across these diverse set of interests.

Additionally, with shrinking Federal budgets, leveraging Federal and non-Federal funding through cost-sharing is necessary to fund the actions needed to address climate change. Many of the actions described in this Strategy represent a significant Federal investment at the pilot stage, to develop the science and tools necessary to understand the risks posed by climate change. However, cost-sharing is essential to other actions identified, particularly the implementation of adaptation strategies. To address climate change risks, Reclamation will continue to identify opportunities to leverage Federal and non-Federal funding, similar to the approach taken in the WaterSMART program, to stretch Federal funding as far as possible and provide assistance to stakeholders and customers.

Reclamation will also work with customers to identify opportunities for private investments that support climate resiliency, particularly related to hydropower production and infrastructure investments. Private sector investment in water resources has lagged behind other infrastructure sectors because water is primarily viewed as a public resource in the Western United States. As a result, there are opportunities and a need for increased private participation and innovation to address water supply challenges going forward.

How Climate Change Impacts the Bureau of Reclamation

Reclamation operates 337 reservoirs and is the largest wholesaler of water in the country. Reclamation provides one out of five Western farmers (140,000) with irrigation water for 10 million acres of farmland that produce 60 percent of the nation's vegetables and 25 percent of its fruits and nuts. Reclamation is also the second largest producer of hydropower in the United States, operating 53 hydroelectric powerplants. Other key mission objectives include the protection of endangered species and the environment, recreation, and flood risk reduction. These contributions to the National economy are

estimated to be $24.02 billion with 343,487 domestic jobs as a result of Reclamation supported irrigated agriculture. In addition, $2.341 billion National economic benefit results from water deliveries for municipal and industrial water supplies, which provide for 25,881 jobs.[1]

Climate change poses a fundamental challenge to Reclamation's mission and the National economy. Temperature increases have resulted in decreased snowpack, differences in the timing and volume of spring runoff, and an increase in peak flows for some Western United States basins. (See Figure 2 and Figure 3). The impacts to snowpack and runoff affect the timing and availability of water supplies. Warming is expected to continue, causing further impacts on supplies, increasing agricultural water demands, and affecting the seasonal demand for hydropower electricity. Precipitation changes are also expected to occur, interacting with warming to cause longer term and more frequent droughts and larger and more numerous floods, varying by basin.

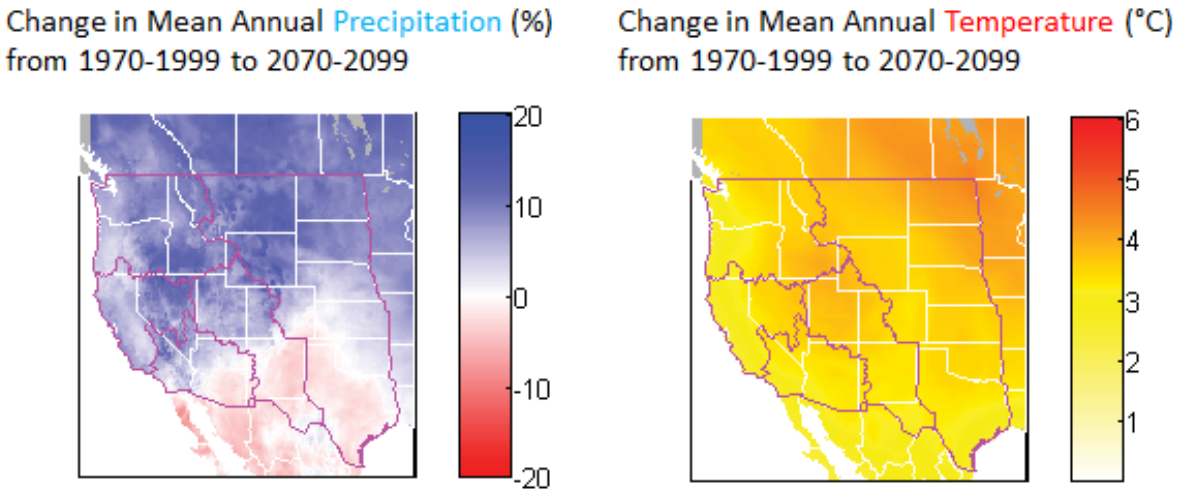

Figure 2: Projected changes to temperature and precipitation in the latter 21st century. Figure represents the median change from a large collection of World Climate Research Programme's Coupled Model Intercomparison Project phase 5 climate projections spatially downscaled over the United States through the Reclamation led partnership http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html.

[1] Information is based upon economic figures for fiscal year 2013 from the US Department of the Interior Economic Report, FY 2013, July 11, 2014.

As a result, Reclamation's basic mission objectives are at risk due to climate change, for example:

- **Water Supply**: Increased frequency and intensity of droughts decreases available water supplies, impacting Reclamation's ability to deliver water and power
- **Infrastructure Resilience**: More frequent or severe flooding can result in damage to project features or operational changes that decrease available water storage
- **Environmental Stewardship**: Maintaining ecosystems and habitat affected by Reclamation projects is more challenging in changing climate and hydrology conditions

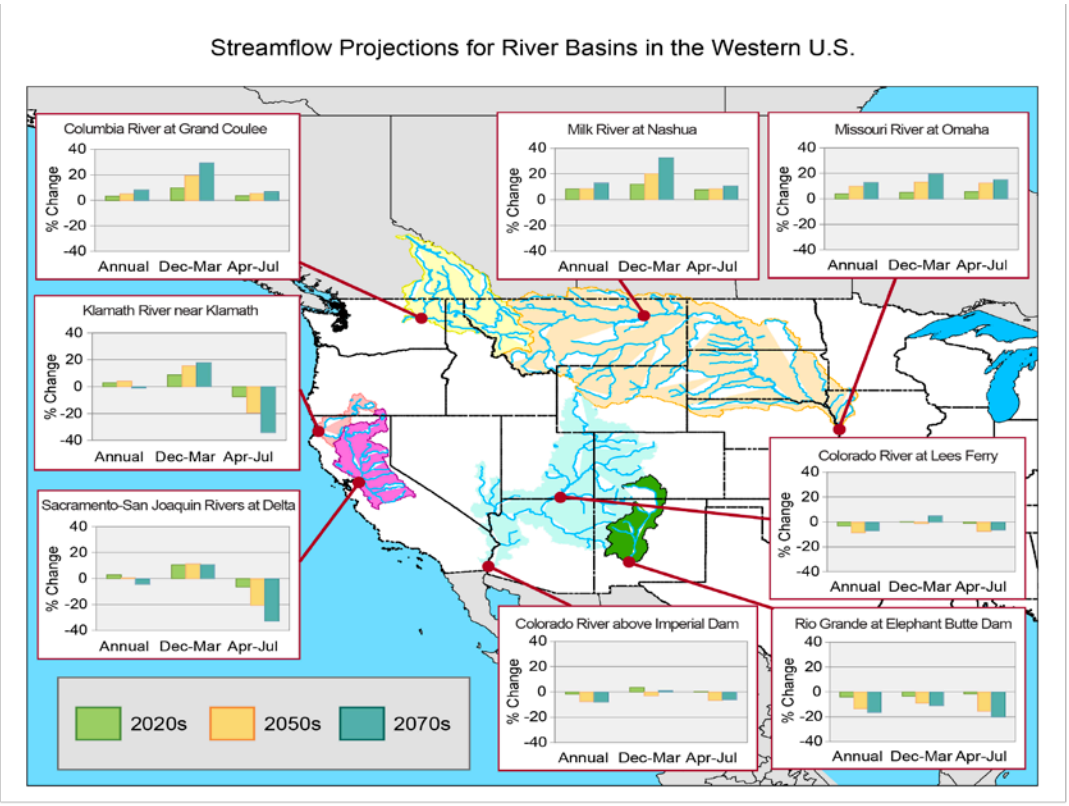

Figure 3: Changes in annual and seasonal runoff indicate significant changes during the 21st century, as identified in the 2011 SECURE Water Act report to Congress (http://www.usbr.gov/climate/SECURE/illustration.html) and published in the 2014 National Climate Assessment. Map colors represent the geographic areas of the river basins that were assessed as part of the 2011 SECURE Water Act.

Many areas of the country are already facing severe water shortages that are projected to worsen with climate change:

- In 2013, the Middle Rio Grande Basin in New Mexico – which was already in an extended drought – experienced the driest consecutive 24 months on record. Resulting water shortages required the formation of an interdisciplinary "Minnow Action Team" in order to maintain compliance with the Endangered Species Act and balance competing demands for water, people and agriculture.
- In the Colorado River Basin, the years 2000 to 2013 represent the worst multi-year drought in approximately 100 years of measured record, which dates back to 1906. Reclamation is collaborating with states and water users to build a drought contingency plan to immediately augment water storage in key reservoirs.
- Following two years of dry conditions in California, California Governor Edmund G. Brown Jr. proclaimed a Drought State of Emergency on January 17, 2014. On April 22, 2014, the U.S. Drought Monitor's weekly report marked the first time in its history that the entire state of California was dealing with moderate to exceptional drought.

Collectively, the impacts of climate change to water resources give rise to difficult questions about how best to operate Reclamation facilities to meet growing demands for water and hydropower now and how to upgrade and maintain infrastructure to optimize operations in the future. More extreme variations in climate will make it difficult for Reclamation to meet competing demands for water, exacerbating tensions, and increasing the potential for conflict. Increased intensity of droughts and floods also raise concerns about infrastructure safety, the resiliency of species and ecosystems to these changes, and the ability to maintain adequate levels of hydropower production.

Uncertainty and Risk

While the impacts of climate change on water resources are evident, it is important to acknowledge the uncertainties that are inherent in climate change science and how they contribute to making climate adaptation a difficult challenge. Projections of future climate change contain uncertainties that vary geographically and depend on the weather variable of interest (e.g., temperature, precipitation, and wind). Trying to identify a specific climate change impact at a particular place and time remains difficult, despite advances in modeling efforts over the past half century. As an example, it is not possible to say with certainty that a flood or drought event is now exactly twice as likely to occur; however, current science may provide enough evidence to judge whether the event is more or less likely to occur overall.

Notwithstanding these uncertainties, the National Climate Assessment[2] of 2014 identifies viable decision support tools currently available to support the incorporation of climate information into resource management decisions, including risk assessments, targeted projections for high-consequence events such as floods and droughts, and vulnerability assessments. The National Climate Assessment further provides that effective decision support processes take into account "key stakeholders, evolving scientific information, and the perceptions of risk." Reclamation's Climate Change Strategy likewise takes into account existing uncertainties regarding climate change information. The Strategy employs a phased approach to work with customers and stakeholders to develop understanding, methodologies, and tools to assess climate change impacts using existing risk management practices, while also recognizing the importance of taking action now to increase resilience and reduce impacts from climate change.

The concept of risk management in the face of uncertainty is one that is becoming well recognized for climate change adaptation. A November 2013 GAO report to Congress[3] recognizes the importance of a proactive approach to addressing climate change risks to infrastructure, stating "while implementing adaptive strategies to protect infrastructure may be costly, there is a growing recognition that the cost of inaction could be greater and – given the government's precarious fiscal position – increasingly difficult to manage given expected budget pressures, which will constrain not just future ad hoc responses, but other Federal programs as well. As stated in a 2010 National Research Council report, increasing the nation's ability to respond to a changing climate can be viewed as an insurance policy against climate change risks." In this spirit, Reclamation will act proactively to maintain and improve existing infrastructure for system reliability, safety, and efficiency (i.e., water conservation) to prepare for extremes and to support healthy and resilient watersheds.

Current Reclamation Activities Addressing Climate Change

Reclamation is already taking actions to address the impacts of climate change by working with partners in river basins across the West to optimize available water supplies for competing water uses. Following are some examples of ongoing climate adaptation efforts:

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[2] National Climate Assessment, 2014 http://nca2014.globalchange.gov/

[3] Government Accountability Office, November 2013, Report to Congressional Requesters, "Climate Change: Federal Efforts Under Way to Assess Water Infrastructure Vulnerabilities and Address Adaptation Challenges." GAO-14-23

- **Climate Adaptation Planning**: Through the Basin Studies, Reclamation partners with non-Federal stakeholders to evaluate the impacts of climate change to multiple water uses within a basin, and to identify adaptation strategies. To date, 19 Basin Studies have been initiated, with five completed, in 15 western states. Two additional studies have been completed and are under review for release.

- **Developing Climate Science and Tools**: Reclamation's Science and Technology Program is taking a leading role to develop the data and tools necessary to support climate change adaptation within Reclamation and by customers and stakeholders. Since 2007, Reclamation has led a partnership of eight Federal, academic, and Non-Governmental Organizations to provide future projections of temperature, precipitation, and streamflow throughout the continental US to support locally relevant decision making. (see http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/).

- **Water Conservation and Reuse**: Since 2009, Reclamation has supported projects contributing over 730,000 acre-feet of conserved water under Interior's Priority Goal for Water Conservation through WaterSMART Grants, the Title XVI Water Reclamation and Reuse Program (Title XVI), and other conservation efforts.

- **Maintaining Resilient Ecosystems**: Reclamation has numerous river restoration and enhancement efforts ongoing across the West that resulted in a broad array of benefits to fish and wildlife resources and their habitats. A number of ongoing restoration programs have begun to incorporate climate change modeling results into their restoration planning (e.g., San Juan River Fish Recovery Program and the San Joaquin River Restoration Program).

- **Collaborative Water Management Solutions**: Reclamation was part of a binational team supporting the adoption of Minute 319, which supplements the 1944 Water Treaty with Mexico. Minute 319 will help increase resilience to climate change by preserving reservoir elevations in the Colorado River, providing environmental flows in the Colorado River Delta in Mexico, and facilitating investments to improve water infrastructure in Mexico.

- **Hydropower Generation**: Reclamation is the second largest producer of hydroelectric power in the Western United States. Reclamation's 53 powerplants annually provide more than 40 billion kilowatt hours, generating nearly a billion dollars in power revenues and producing enough electricity to serve 3.5 million homes. Interior works with the Department of Energy and the Department of the Army to help meet the Nation's needs for reliable, affordable, and

environmentally sustainable hydropower by prioritizing similar goals and aligning ongoing and future renewable energy development through an MOU signed on March 24, 2010. Hydropower production builds resiliency to climate change by providing a minimal emission source of energy that is a reliable and low-cost alternative to fossil fuels. As described below, Reclamation is identifying opportunities to optimize hydropower production to ensure the continued ability of efficient power generation as the variability of water supplies increases with climate change.

Collectively, these ongoing activities provide important tools and information supporting climate adaptation by Reclamation, stakeholders, and partners. Reclamation must utilize the existing information on climate change impacts, identify gaps in knowledge, and take a step forward to use this information in decision processes, using a science based approach. For a more detailed description of Reclamation's ongoing climate adaptation activities, see "Current Climate Change Activities" attached to this Strategy.

A Call to Action

New policy directives, including the President's Plan and the Department's Climate Adaptation Policy, challenge Reclamation to build on existing climate adaptation activities by doing more to manage drought, to prepare for future floods, protect ecosystems, and to build resilient infrastructure. The President's Plan, released in June 2013, provides a blueprint for action to mitigate the effects of climate change to leave a cleaner, more stable environment for future generations. It also identifies a broad range of actions to address the impacts of climate change to water resources, many of which are highlighted in this Strategy, including conserving water resources, managing drought, reducing wildfire risks, and boosting the resilience of buildings and infrastructure. Executive Order 13653, implementing the President's Plan, further directs Bureaus to identify and assess climate change related impacts and risks to agency missions, operations, and programs.

A Comprehensive Approach to Climate Resiliency

To meet the needs for affordable water and power in the West, protect the water-related environment, and meet trust obligations to tribes, Reclamation must address the impacts of climate change and extremes. This requires a continued emphasis on successful, ongoing efforts, such as Reclamation's WaterSMART Basin Studies and WaterSMART Grants, which allow Reclamation to collaborate with non-Federal partners to develop and implement adaptation strategies. Building resiliency also requires Reclamation to consider climate change information in mission areas where it has not been fully

considered in the past. For example, climate change considerations come into play in decisions regarding ecosystem restoration, reservoir operations, and infrastructure investments. Expanding climate considerations into new areas will also require the development of related science and tools, and increasing planning capacity.

Moving forward, Reclamation will improve its ability to adapt to climate change and build resiliency through four goals, supported by immediate and longer-term actions (see Table 1, below). A priority action is also identified for each goal to highlight activities that provide critical support for the goal. While all of the actions identified in Table 1 are important to achieve the four goals, the priority actions exemplify the steps that must be taken.

- **Goal 1 – Increase Water Management Flexibility**: Increase flexibility in reservoir operations, water conservation, efficiency, and reuse to maximize the efficient use of available water supplies and existing water infrastructure.
  Priority Action: Reservoir operation pilots are critical to understand where flexibilities in reservoir operations may be increased through identifying trends in historic and current climate, hydrology, and through improved use of weather forecasting. Ultimately, Reclamation will develop operational plans that use the best available science and information to optimize reservoir operations.

- **Goal 2 – Enhance Climate Adaptation Planning**: Develop capabilities, tools, and guidance to incorporate climate change information across Reclamation's planning processes. These enhanced planning efforts will help Reclamation understand and address climate change impacts to the delivery of water and power, infrastructure, and ecosystems and habitat affected by Reclamation projects.
  Priority Action: Reclamation has existing programs including Basin Studies and West-Wide Climate Risk Assessments (WWCRA) that will be expanded to better address climate change impacts to floods and droughts and impacts to ecosystems.

- **Goal 3 – Improve Infrastructure Resiliency**: Improve infrastructure resilience, reliability and safety to prepare for increased intensity and frequency of floods and droughts. Ultimately, Reclamation will include climate change considerations within evaluations of infrastructure safety as well as in prioritization for operations and maintenance of existing facilities.
  Priority Action: Pilot assessments within the Dam Safety Comprehensive Facility Review process are critical to determine appropriate use of the new state-of-the-science information about changes to floods from climate change. The analysis of climate extremes, including floods and droughts, accomplished

through these pilots will inform many of the activities within the Strategy such as future Basin Studies, planning efforts, and outreach.

- **Goal 4 – Expand Information Sharing**: Collaborate with stakeholders to support mutual climate adaptation efforts through sharing data and tools. **Priority Action**: Improve stakeholder access to water management and hydropower data and support information sharing through outreach activities to support common understanding of climate change information and related adaptation efforts.

Other actions supporting these goals are listed in Table 1. These actions include both new and ongoing activities that, collectively, provide for a comprehensive approach to climate adaptation in a manner that achieves adaptation goals in the near term and prioritizes actions that are needed to inform long term considerations.

For actions that will require extensive consideration of new information, policy considerations, and integration within existing programs, Reclamation is using a phased approach that will allow for the development of the science and guidance needed to successfully integrate climate change into existing processes. The phased approach consists of 4 steps, illustrated in Figure 4:

1. defining the strategic goals (i.e., how Goals 1-4 will be addressed by the activity);
2. developing guidance, science, and capacity to achieve the goal;
3. implementing the guidance through place-based pilots and demonstration activities; and,
4. formalizing the guidance through the development of policy and agency requirements (referred to as "Directives and Standards") to institutionalize the approach.

Figure 4: Phased approach to incorporating climate adaptation across Reclamation mission areas

Strategy Goal: A programmatic activity addressing Goals 1-4 identified in this Strategy
Guidance, Science and Capacity: Develop the technical and personnel capabilities that will allow for achieving strategic goals.
Pilot Study / Demonstration: Test implementation and resolve any remaining questions through place based actions.
Formalize Process and Implement: Integrate climate adaptation in formal Reclamation requirements (Directives and Standards).

Table 1: Goals and Implementation Actions

Goals	Implementation Actions		End Goals
1. Increase Water Management Flexibility	• **High Priority:** Reservoir Operations Pilot Initiative	• **Reservoir Operations Pilot Initiative** • Research and demonstration to improve canal lining and water treatment technology • Implementation of Adaptation Actions through WaterSMART Grants • Continued Support for water reuse and recycling projects through Title XVI • Optimizing hydropower production	• Conserve water, increase water delivery efficiency, and generate new sources of water to increase flexibility of supplies. • Identify opportunities to adapt reservoir operations to improve flexibility • Increase hydropower efficiency to optimize power generation and increase renewable energy development
2. Enhance Climate Adaptation Planning	• **High Priority:** Enhanced Basin Studies and WWCRA Impact Assessments	• **Enhanced Basin Studies and WWCRA Impact Assessments** • Research to advance understanding of climate impacts to extreme events and ecosystems • Drought Response Program • Expanded General Planning • Climate Change Training	• Incorporate climate change information into planning policy and guidance • Increase climate adaptation efforts across several mission areas, including delivery of water and power and maintaining ecosystems • Develop climate adaptation strategies
3. Improve Infrastructure Resiliency	• **High Priority:** Dam Safety Climate Change Assessments Pilots	• **Dam Safety Climate Change Assessment Pilots** • Western Watershed Enhancement Partnership • Climate-resilient infrastructure replacement, repair and renovations	• Ensure the longevity of Reclamation's infrastructure and support climate resilient infrastructure investments
4. Expand Information Sharing	• **High Priority:** Improve access to water and hydropower data	• **Improve access to water and hydropower data** • Coordinate climate adaptation activities with partners and stakeholders.	• Support Reclamation's partners in adapting to climate change

Goal 1 - Increase Water Management Flexibility

The President's Plan recognizes the importance of water management to climate adaptation. The President's Plan directs Federal agencies to identify strategies to prepare for drought, protect fish and wildlife populations, and support agricultural sustainability, specifically identifying the contributions of WaterSMART Grants in providing funding to agricultural water users for more efficient practices to address long-term climate change. Water conservation, water reuse, and efficient water operations can help optimize water supplies in response to drought and mitigate climate change impacts by stretching supplies.

Reclamation's priority action under this goal is to increase the flexibility of reservoir operations as a strategy to adapt to climate change. Reclamation is taking a phased approach to integrating climate change into reservoir operations planning in order to address the need for science and guidance development, as illustrated in Figure 6 at the end of this section of the Strategy. Other actions supporting this goal include continuing support for water conservation and reuse activities and optimization of hydropower generation. Optimizing water delivery and hydropower operations will help ensure continued ability to deliver water and power under changing water conditions.

The following paragraphs describe immediate and longer-term actions to support the goal of increasing water management flexibility to ensure long-term resiliency:

Immediate Actions (2014-2016): In the short-term, Reclamation will continue support for two key programs that are providing water management benefits now, ***WaterSMART Grants*** and the ***Title XVI Program***. By leveraging Federal and non-Federal funding through WaterSMART Grants, Reclamation is able to implement adaptation strategies supported by climate analysis – such as the analysis included in Basin Studies – in a cost-effective way. These grants fund projects that address endangered species needs, incorporate the use of renewable energy, and increase conservation and efficiency, all of which increase resiliency to climate change by optimizing scarce supplies and providing flexibility in times of shortage.

WaterSMART Grants have proven to be effective at increasing water conservation and efficiency. From 2004 through 2013, Reclamation has funded 381 WaterSMART Grant projects, contributing approximately 420,000 acre-feet of water savings towards the Department's Priority Goal for Water Conservation. Maintaining and building upon this

success requires immediate action to increase the appropriations ceiling for WaterSMART Grants under the SECURE Water Act.

Reclamation will also continue support for the ***Title XVI Program***, which provides cost-shared funding to plan, design, and construct water reuse projects. Water reuse and recycling can turn currently unusable water sources into a new source of supply that is less vulnerable to drought and climate change, increasing flexibility and reducing the pressure to transfer water from agricultural to urban uses. The State of California estimates that 900,000 to 1.4 million acre-feet of "new water" could be added to their supply by reusing municipal wastewater that currently flows to the ocean.[4] Beginning in FY 2015, Reclamation will strengthen the connection to climate adaptation by giving additional consideration to allocate funding for Title XVI feasibility studies to proposals that are supported by a climate analysis and will include climate change information in the supply and demand projections used in feasibility studies.

Longer-Term Actions (2016 and beyond): The priority activity under "Goal 1 – Increase Water Management Flexibility" is to incorporate climate adaptation into reservoir operations. This requires a phased approach that will build the science and tools needed to identify site specific modifications to existing reservoir operations. Other long-term actions to address climate change impacts through water management flexibility include ***research on innovative water conservation methods***, conducting ***demonstrations of advanced water treatment technology***, and increasing efforts to ***optimize hydropower production***.

Reclamation's reservoirs are operated using criteria to meet a number of different water management priorities, including reliable water deliveries, power generation, environmental requirements, and needs for flood control management. Historically, uncertainties in weather prediction and assumptions of an unchanging climate have resulted in general rules for reservoir management, often seasonal to annual in definition. Beginning in FY 2014, Reclamation is initiating a ***Reservoir Operations Pilot Initiative*** to determine how reservoir operations are impacted by climate change and how reservoir operations can be made more flexible to adapt to those impacts through a phased approach (Figure 6). The pilots will also investigate how improved weather forecasts may be used to identify additional flexibility in reservoir operations. Contingent on available funding, additional pilots will be initiated in FY 2015 to assess how climate change may impact the operation of reservoirs with different geographic and administrative conditions. These pilot activities will continue through 2017.

[4] WaterSMART – A Three-Year Progress Report, http://www.usbr.gov/WaterSMART/

Beginning in FY 2016, Reclamation will expand on current Science and Technology Program ***water conservation research*** to test and demonstrate new technologies and methods that create water savings. Projects will include demonstrating the benefits of innovative canal lining techniques, such as lime stabilization or in-situ compaction. Reclamation's Desalination and Water Purification Research program currently funds research projects to develop and pilot test new advanced water treatment technologies that can make degraded water supplies available for consumptive use. In future years, Reclamation will seek increased funding to enable full-scale ***advanced water treatment demonstration projects*** to test new technologies at a sufficiently large scale to assure industry and water utilities of its practicality and cost-effectiveness.

Hydropower production helps mitigate climate change impacts by providing an important source of renewable energy. Because hydropower production is also vulnerable to altered water availability resulting from climate change, ***optimizing hydropower production*** is an essential part of Reclamation's overall strategy to respond to the impacts of climate change. 'Reclamation needs to build on successful efforts already taking place to continue generating clean energy and providing Federal leadership in renewable energy development, both of which are priorities in the President's Plan to slow the pace of climate change.

Figure 5: Installation of retrofitted turbine at Hoover Dam to provide more efficient power at a wider range of reservoir elevations.

Reclamation is currently exploring opportunities to optimize power production through development of software systems that respond to power plant conditions and guide operators on how to operate plants more efficiently. It is expected that Reclamation could gain between 19 MW and 57 MW of additional generating capacity at any given time if optimization systems are installed at Reclamation's plants. Implementation of these types of systems has begun in the Pacific Northwest Region, where recommendations are being provided at the Black Canyon Control Center for Anderson Ranch, Black Canyon, Minidoka, and Palisades powerplants. Additional installations are planned through 2016.

In addition, Reclamation has identified several other opportunities to increase hydropower efficiency that could be implemented if additional funding becomes available:

- Equipment upgrades at hydropower and pumping plants: Reclamation has a long successful history of working with customers to upgrade turbines and rewind generators at powerplants to achieve water and energy conservation benefits. Such investments improve hydropower generation resilience as climate change impacts occur and increase the generation of clean renewable energy. Initial assessments indicate there is also an opportunity to improve efficiency and flexibility at some Reclamation owned pumping plants, reducing the amount of Reclamation hydropower energy required for water deliveries.

- Install flow meters: Flow meters are installed at many Reclamation hydropower units, and the data collected from these meters is used by operators to maximize power production and accurately measure water deliveries. However, not all Reclamation plants have flow meters installed. Installing flow meters across Reclamation's remaining non-metered hydropower plants would increase efficiencies in both water and power delivery and improve ongoing operational and planning initiatives designed to increase our resilience to climate change.

- Demonstrate Innovative Technologies: New innovative technologies also have the potential to increase hydropower efficiencies. Preliminary investigations indicate that use of superconducting wire technology may increase generator output by as much as 15 percent. Additionally, improved generator insulation and heat transfer technologies could also increase generator output by up 10 - 15 percent, without redesigning the turbine. These types of improvements could significantly increase the nation's renewable hydropower output and also extend equipment life.

Figure 6: Phased approach to incorporating climate adaptation within reservoir operations

Strategy Goal: Increase water management flexibility through climate informed reservoir management.
Guidance, Science and Capacity: In FY 2014, Reclamation is beginning to develop guidance for considering climate change information in reservoir operations. This includes developing conceptual approaches for considering climate change within reservoir operations and identifying the statistical tools and models necessary to implement those conceptual approaches.
Pilot Study / Demonstration: Reclamation will initiate a pilot study to evaluate how weather, hydrology, and climate change information could better inform reservoir operations at one Reclamation reservoir by the end of FY 2015. Multiple pilot demonstrations at different sites are necessary to ensure an adequate approach that has been fully vetted. These pilot activities will continue through 2017.
Formalize Process and Implement: Update guidance based on pilot activities and incorporate consideration of climate change information in future reservoir operations planning and in new reservoir operations guidelines.

Goal 2 - Enhance Climate Adaptation Planning

The President's Plan, "Preparing the United States for the Impacts of Climate Change," recognizes the importance of planning as a tool for building resiliency to climate change. The Plan highlights progress by Federal agencies in conducting vulnerability assessments to identify risks from climate change to key sectors, including water supply, and directs Federal agencies to evaluate approaches to protect and conserve natural resources in the face of climate change. The Plan further identifies drought preparedness as a priority and calls for the initiation of the cross-agency National Drought Resilience Partnership as a way to link hydrologic information with preparedness planning.

Given budget realities, Reclamation does not anticipate serving as the primary source of funding for a large number of future adaptive actions. Nonetheless, the presence of critical Federal facilities throughout the West and the national interest in addressing climate change necessitates a heightened role for Reclamation to continue to address water resource challenges by providing expert technical assistance and the best available science through collaborative planning efforts. Adaptation planning is of critical importance to ensure that climate change information is incorporated early on when developing longer-term adaptation strategies, such as infrastructure investments or policy and operational changes, implemented over years or even decades. This approach is recognized in the FY 2012 updated Directives and Standards for Water and Related Resources Feasibility Studies (CMP 09-02), which now require that climate change be considered in feasibility studies. In 2015, Reclamation will adopt a climate adaptation policy including the commitment to incorporate climate change in relevant planning studies. Planning efforts also provide an important framework for working with stakeholders to ensure that adaptation strategies have the support necessary to succeed.

Many Reclamation planning efforts can support climate adaptation, including drought contingency planning, appraisal and feasibility studies, and planning for river restoration efforts to protect species and habitats. While climate change information is sometimes considered for these activities through individual studies, there is a need for additional guidance, science, and training and staffing to more fully integrate climate information across mission areas. To address these needs, Reclamation is taking a phased approach that includes both immediate and longer-term actions to integrate climate change into planning processes, as illustrated in Figure 8 at the end of this section of the Strategy. The

following paragraphs describe immediate and longer-term actions to support the goal of enhancing climate adaptation planning activities:

Immediate Actions (2014-2016): Together, the Basin Studies and the WWCRAs form a robust program that utilizes Federal and stakeholder driven activities to identify adaptation strategies that help balance water supplies and demands given impacts from climate change. These activities can be enhanced to further support adaptation efforts conducted with partners and stakeholders and used to inform other Reclamation planning policies, programs, and activities. Reclamation has identified two immediate actions to support climate adaptation planning, including: ***(1) Enhancing the Basin Studies and WWCRAs and (2) initial steps to incorporate climate information across a range of planning activities.***

Reclamation initiated the Basin Studies and WWCRA Impact Assessments in FY 2009 and FY 2010, respectively, to implement the "climate adaptation program" authorized in Section 9503 of the SECURE Water Act. Through the WWCRAs, Reclamation develops baseline information regarding the risks and impacts of climate change to water supplies in the West and to Reclamation's operations. Through the Basin Studies (Figure 7), Reclamation works collaboratively with stakeholders to evaluate the ability to meet future water demands and identify adaptation strategies to address potential climate change impacts.

Enhancing the Basin Studies and WWCRA Impact Assessments is Reclamation's top priority to meet "Goal 2 – Enhance Climate Adaptation Planning" because of the importance of these efforts in developing adaptation strategies. Currently, Reclamation is developing the science and tools necessary to enhance the Basin Studies and WWCRAs by expanding the types of impacts that are considered in these studies. The enhanced program, which will require additional funding above existing budget levels, will place a greater emphasis on incorporating climate extremes – droughts and floods – and understanding impacts to trans-basin diversion projects within the planning processes. Building on ongoing efforts, Reclamation's Science and Technology

Figure 7: Reclamation has partnered with stakeholders on 19 Basin Studies as of 2014 and is continuing to initiate new studies each year. The Basin Studies create partnerships to identify climate adaptation strategies and provide tools that states, Indian Tribes, and water users can use to proactively meet future water demands.

Program will prioritize its research activities to help Reclamation better address less-understood impacts, including impacts to climate events that cause floods and droughts and impacts to aquatic and riparian ecosystems.

With the experience gained through the Basin Studies and WWCRAs, Reclamation is ***taking steps now to incorporate climate adaptation into other Reclamation planning efforts***, including feasibility planning studies and drought contingency planning. Currently, Reclamation is developing guidance, titled, "Technical Guidance for Incorporating Climate Change Information into Water Resources Feasibility Studies." This guidance, which will be finalized in FY 2015, will assist planners in determining an appropriate level of climate change analysis and identify a specific method to use in the evaluation of alternatives being considered in the study.

Reclamation has also led a partnership with Federal and non-Federal entities since 2007 to develop and support the ***Downscaled Climate and Hydrology Projections Website***, hosted at Lawrence Livermore National Laboratories. This web-based tool provides scientists, engineers, and planners quick and easy access to local future climate and hydrology information essential for adaptation planning. In 2014, Reclamation and its partners updated the website to include hydrology projections for the contiguous U.S. consistent with new CMIP5 climate projections. New generations of climate modeling will continue to be made available through this partnership.

In FY 2014, Reclamation is reformulating its drought program to incorporate climate information and build resiliency against future droughts. The President's 2015 budget includes $1.5 million to begin implementation of the new ***Drought Response Program***. Through this program, funding for planning and implementation actions will be allocated through a competitive process that emphasizes involvement from multiple stakeholders and the incorporation of climate change information. This new program will help Reclamation avoid drought-related crises in the short term while laying a foundation for climate resiliency in the long term. The program also directly supports the National Drought Resilience Partnership, identified in the President's Plan – helping communities develop long term resilience strategies by providing key climate change and drought information.

Longer-Term Actions (2016 and beyond): Reclamation's longer-term priorities for enhancing climate adaptation planning include ***expanding support for the General Planning Program and implementing a climate adaptation training program***.

Expanding support for General Planning will increase planning and technical capacity across Reclamation and is critical to supporting the ongoing and new efforts described in this Strategy. Expanding support for General Planning will require additional funding above current budget levels that will be prioritized for staff support in Reclamation

regional offices. General Planning staff in Reclamation's regional and area offices work with stakeholders on a wide range of collaborative planning efforts, including appraisal and feasibility studies, efforts to address endangered species requirements, and planning to address water supply shortages and drought. As new tools and guidance are developed, General Planning staff is facing increased workloads and technical challenges associated with incorporating climate information into existing planning efforts. Many of Reclamation's stakeholders are facing these same challenges as they learn to incorporate new information and modify traditional approaches to planning in order to consider climate change.

Reclamation will incorporate climate adaptation across our planning activities through a phased approach that includes the development of guidance and science, building planning capacity, and pilot implementation of the guidance and science through program activities. Through these steps, Reclamation will develop permanent guidance, formalized

Looking to the future, Reclamation will identify opportunities to expand General Planning by prioritizing funding for additional planning staff and for providing technical and financial assistance to stakeholders to incorporate climate information into planning activities. As programs are updated to incorporate climate change planning activities, and new methodologies are developed, additional staff will be needed to implement the revised programs and activities. Planning staff is also critical to support Reclamation customers and stakeholders as they participate in updated planning efforts, such as the new Drought Response Program.

Reclamation staff must have appropriate Climate Adaptation Training, including training in climate change science, assessment methods, and incorporation of assessment results into planning efforts, in order to implement this Strategy. Since 2012, Reclamation has been collaborating with the Climate Change and Water Working Group (CCAWWG) and University Corporation for Atmospheric Research (UCAR) COMET program to develop and pilot climate change training tools for Federal and non-Federal water agency staff and explore sustained delivery approaches. In order to ensure that Reclamation staff is adequately trained, Reclamation is planning to develop and implement a continuing training program serving Reclamation's diverse staff needs, relying on and incorporating available training tools and working with other agencies to leverage new tools as they become available. Additional funding will be required to support the implementation of a continuing training program beyond the pilot training classes currently available.

Reclamation will also utilize ***Climate Adaptation Training*** to conduct outreach to customers and stakeholders and to share information with states, localities, and tribes. Through this activity, Reclamation and its partners can develop a common understanding

of the impacts of climate change to collectively manage water resources and support stakeholder driven climate adaptation efforts.

Figure 8: Phased approach to incorporating climate adaptation across Reclamation Planning activities.

Strategy Goal: Enhance planning efforts to better understand and address climate change impacts to the delivery of water and power, to infrastructure, and to ecosystems and habitat affected by Reclamation projects.
Guidance, Science and Capacity: In 2014, Reclamation and our partners have updated the **Downscaled Climate and Hydrology Projections Website** to include hydrology projections for the contiguous U.S. consistent with new CMIP5 climate projections. Currently, Reclamation is developing **Technical Guidance for Incorporating Climate Change Information into Water Resources Feasibility Studies.** In the longer-term, Reclamation is committed to identifying opportunities to **expand General Planning** by prioritizing funding for additional planning staff and for providing technical and financial assistance to stakeholders to incorporate climate information into planning activities.
Pilot Study: With the experience gained through the Basin Studies and WWCRAs, Reclamation is taking steps now ***to incorporate climate change information into other Reclamation planning efforts***, including feasibility studies and drought contingency planning. Reclamation will initiate the new Drought Response Program in FY 2015.
Formalize Process and Implement: In FY 2012, Reclamation updated the **Directives and Standards for Water and Related Resources Feasibility Studies (CMP 09-02)** to require that climate change be considered in feasibility studies. In 2015, Reclamation will adopt a **climate adaptation policy** including a commitment to incorporate climate change in relevant planning studies. In the longer-term, with experience gained through the pilot study process, Reclamation will adopt Directives and Standards requiring climate change to be considered within no-action and action alternatives of long-term planning studies and environmental compliance documents.

Goal 3 - Improve Infrastructure Resiliency

The potential for increased frequency and intensity of floods and droughts brings new challenges to infrastructure conditions. Climate change, coupled with the fact that much of the water resources infrastructure in the Western United States is beyond its originally envisioned service life, highlights the need to ensure infrastructure resiliency to meet Reclamation's mission requirements in the future (Figure 9). To prepare for new extremes, Reclamation is identifying opportunities to incorporate climate change information into decisions regarding infrastructure investments and safety upgrades. The President's Plan provides support for this goal, prioritizing the need to build safer communities and infrastructure, manage drought, and prepare for future floods.

The use of climate change information to inform decisions about infrastructure investments is complex and on the cutting edge of climate science development. The latest science suggests that warming is contributing to trends of heavier downpours over much of the U.S., which may lead to increases in local flood potential for some areas (e.g. Figure 10). However, at the local scale where Reclamation makes infrastructure decisions, substantial uncertainty remains about how global climate change will impact wet weather extremes. In spite of this uncertainty, unprecedented droughts, extraordinary fire seasons in some states, and devastating floods in others highlight the fact that changes are occurring now that compel immediate action. In this context, Reclamation is proposing actions to address impacts to infrastructure now and with longer-term actions develop the science and approaches needed to build resiliency over time. This phased approach is illustrated in Figure 11 at the end of this section.

Figure 9: Pathfinder Dam, part of the North Platte Project, is an example of infrastructure that is over 100 years old.

Immediate Actions (2014-2016): In July 2013, Interior and the U.S. Department of Agriculture announced the ***Western Watershed Enhancement Partnership*** (WWEP) to reduce wildfire risk. This Federal, local, and private partnership will reduce the risks of wildfire to America's water supply infrastructure and watersheds in Western States by removing extra brush and other flammable vegetation around critical areas and help protect facilities and water quality through erosion control after wildfires. The WWEP is identified in the President's Plan as a key action to protect vital assets.

Improving watershed functions and reducing the risk of uncharacteristically severe wildfires benefits Reclamation water supply, irrigation, and hydroelectric customers. Flows of sediment, debris, and ash into streams and rivers after wildfires can damage water quality, reduce water storage capacity, and often require millions of dollars to repair damage to habitat, reservoirs, and facilities. To date, six WWEP pilot projects have been initiated. These projects include the preparation of fire management plans, demonstration projects exploring treatments to protect ecosystems and watersheds situated above reservoirs, and identification of joint research needs and opportunities to test new technology, among others.

Figure 10: Extreme rainfall and flooding in September 2013 within the Colorado-Big Thompson Project caused significant infrastructure damage to roads and facilities within the Big Thompson Canyon.

Reclamation is also taking steps now to address the challenges of incorporating climate change information into decisions about infrastructure ***repair, replacement and renovation investments***. Beginning in FY 2015, Reclamation will initiate changes to the criteria used to prioritize these types of infrastructure investments to include the consideration of climate change information. Traditionally, project selections – planned jointly with non-Federal partners – have been based on current management priorities, recent climate conditions, and repayment considerations. The development of revised criteria will support a new decision-making framework, where climate change adaptation information (e.g., historical climate trends, long-term projected climate change, and associated water resources management impacts) is synthesized and factored into prioritization of infrastructure repair, replacement, and renovations.

Longer-Term Actions (2016 and beyond): Reclamation has a pilot initiative underway to incorporate climate change information into the ***Dam Safety risk assessment*** process. The pilot initiative is being implemented through a phased approach that allows for the development of guidance for considering climate change in dam safety evaluations across different locations with distinct climate conditions (Figure 11). The phased approach also allows for additional research regarding climate change impacts to floods and droughts to be conducted and applied as new information and techniques become available.

In FY 2013, the Dam Safety Program initiated a pilot study to develop procedures to apply climate information in an analysis involving Friant Dam in the San Joaquin River Basin in California. Following completion of the Friant Dam pilot study at the end of FY 2014, Reclamation will support additional pilot studies continuing through FY 2017, at different locations experiencing different climate conditions. For example, these could include inland dam sites vulnerable to summer thunderstorm activity, as opposed to locations like Friant, which are influenced by spring snowmelt runoff.

The Dam Safety pilot process is supported by Reclamation research efforts that have begun to contribute significant information on climate change implications to rainfall and extreme flood events. Additional research is needed to develop more reliable methods for determining how climate will impact flood events and how the occurrence of floods may change over different Western United States basins. As this research is conducted, the results will be incorporated in future dam safety pilots and will also be used in the General Planning activities described in Goal 2 and within the Safety and Evaluation of Existing Dams Programs through the Comprehensive Facility Review Process, including Issue Evaluations and Corrective Action Studies.

Figure 11: Phased approach to increase infrastructure resiliency.

Strategy Goal: Increase infrastructure resiliency by considering future climate in evaluating Dam Safety and infrastructure replacement, repair and renovations.

Guidance, Science and Capacity: Additional research is needed to develop more reliable methods for projecting climate change impacts on different types of floods and underlying weather events, estimating their expected occurrence over different western U.S. basins, and providing ways to quantify their future likelihood. Efforts are currently underway to revise criteria for prioritizing infrastructure replacement, repair and renovations to incorporate climate considerations. Guidance will be developed for considering climate change in Dam Safety risk assessments, to be informed by ongoing pilot projects.

Pilot Study / Demonstration: Six pilots have been initiated under the WWEP to reduce the risk of wildfires to water supply facilities. The Dam Safety Program has initiated a pilot study at Friant Dam in California to develop procedures to apply climate information in the dam safety risk assessment process. Following completion of the Friant pilot at the end of FY 2014, Reclamation will support additional pilot studies at sites with different climate change considerations, continuing through FY 2017.

Formalize Process and Implement: Requirements for considering climate change as part of the Dam Safety risk assessment process will be put into place following completion of the pilot and guidance development process. Climate change will be considered in decisions regarding infrastructure replacement, repair and renovations, once the prioritization criteria are revised.

Goal 4 - Expand Information Sharing

Given the important partner equities in water resource management, Reclamation has a responsibility to demonstrate leadership and leverage resources by sharing information and capabilities with partners interested in climate adaptation. Reclamation recognizes for Federal investments in climate resiliency to be successful, strong partnerships with state, tribal, and local governments, as well as water users, stakeholders, the public, and other Federal agencies that have available climate change information are necessary to support decisions. The President's Plan emphasizes the importance of providing open government data that "can fuel entrepreneurship, innovation, scientific discovery, and public benefits."

Reclamation is actively partnering with stakeholders to develop climate adaptation strategies through the Basin Studies, collaborating with multiple agencies on scientific research, and developing applied science tools working with Landscape Conservation Cooperatives (LCCs), Climate Science Centers, CCAWWG, National Center for Atmospheric Research (NCAR), and other University-based organizations. Reclamation also plays an important role in sharing data, information, and tools with Federal and non-Federal partners to support climate adaptation. Reclamation recognizes the importance in collaborating with Federal partners such as the National Oceanic and Atmospheric Administration, Natural Resources Conservation Service, and United States Geologic Survey, in supporting and expanding key weather and climate monitoring networks such as snow, rain, and stream flow. Looking to the future, Reclamation is proposing short and longer-term actions to make important data and tools more accessible and useful, consistent with Executive Order 13653, which calls on Federal agencies to "work together to develop and provide authoritative, easily accessible, usable, and timely data, information, and decision-support tools on climate preparedness and resilience."

Immediate Actions (2014-2016): Operation of Reclamation projects depends on the availability of high quality, comprehensive data on water supply, storage, and delivery. This information is also critical to management activities conducted by many of Reclamation's stakeholders and partners. The Western States Water Council has initiated a Water Date Exchange program seeking to promote standardization and sharing of water availability and use data. Under the SECURE Water Act, the USGS is beginning a new, expanded water census. Reclamation will join in these efforts, pursuing opportunities to improve access to Reclamation water storage and delivery data. Reclamation will also continue internal efforts, including a pilot initiated in 2014 led by the Lower Colorado Region to provide reservoir data available through web based services; and the

development of a Reclamation-wide Geographical Information System, led by the Pacific Northwest Region, to serve localized climate change data sets.

Reclamation will also work to develop a common understanding with stakeholders and customers on the state of climate change science and Reclamation climate change adaptation efforts through the development of outreach activities. The phased approach for improving access to data to support adaptation efforts is depicted within Figure 12.

Reclamation will also look to expand public access to the data tools available at the Downscaled Climate and Hydrology Projections Website discussed under Goal 2. Starting in FY 2015, Reclamation will work with Interior collaborators to begin making these data tools available through the federal Geospatial Platform, which supports the 2014-2018 Interior strategic goal of supporting landscape-level planning in a changing climate.

Longer-Term Actions (2016 and beyond): Reclamation is gathering vast amounts of energy and water data at its power plant and pumping facilities that provides a foundation for a wide range of analyses and decision making. These data collection and management efforts could be improved by expanding access and comprehensiveness and developing data standards to improve the consistency of data across the organization. Investment in this effort would enhance decision-making and investments in the optimization of hydropower generation under Goal 2.

Reclamation and its stakeholders will benefit from increased access to climate change and water resources data. The Assistant to the President for Science and Technology has stated, "Foundational to [meeting the global water challenge] is the need to improve access to and exchange of water data and information, including better modeling of the hydrologic cycle, to include the impact of human-use decisions." In May 2013, the President released an executive order "Making Open and Machine Readable the New Default for Government Information," which was highlighted within the June 2013 Climate Action Plan. In FY 2014, Interior issued an Open Data Plan in order to make data assets more open and available. Reclamation will be working to adhere to the tenets and goals of the Open Water Data Initiative by making information more available to the public in support of water resources management in the Western United States.

Going forward, Reclamation will focus efforts on making the following types of information available through web-based portals in coordination with efforts by other Federal agencies: (1) future climate and hydrology projections; (2) results and reports from the WWCRA Impact Assessments, WaterSMART Basin Studies, and SECURE Studies; (3) real-time and historic operational data of Reclamation's reservoirs and other facilities; and (4) geospatial information that can be used to analyze and visualize historical and temporal climate and hydrological data. This information portal will help

Reclamation enhance internal and external knowledge networks (e.g., LCCs), make information access cheaper and faster, and build awareness among Reclamation staff and partners on cutting-edge information, tools, and adaptation approaches.

Figure 12: Phased approach for enhanced information sharing.

Strategy Goal: Make data and tools that support water operations and climate change adaptation more available to partners and stakeholders.
Guidance, Science and Capacity: Implementation efforts and associated methods and policies need further development and refinement to provide critical operations data and climate change information to Reclamation's partners and stakeholders. This includes Geographical Information Systems, identification and implementation of security protocols, and integration with National and regional efforts of information distribution.
Pilot Study / Demonstration: Beginning in 2014 the Lower Colorado Region is developing a pilot to provide reservoir data available through web based services. The Pacific Northwest Region is developing a Reclamation-wide Geographical Information System to serve localized climate change data sets.
Formalize Process and Implement: A formalized and regularly updated Reclamation-wide system of distribution of information that can support Reclamation and its partners making real time and planning level decisions.

Conclusion

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Reliable water supply is essential to the economy, environment, and communities across the West. Given our experience with existing water supply shortages, extended droughts, and unprecedented floods, all of which are expected to be exacerbated by climate change, action is required now. In basin after basin, demands outstrip supplies, and infrastructure is pressed to serve competing needs under volatile climate conditions. This challenge requires an effective response – Reclamation must demonstrate leadership to maintain the integrity of Reclamation's mission and operations and also to support the sustainability of western water supplies.

This Strategy identifies a comprehensive approach for supporting near term measures that help mitigate the impacts of climate change and support long term resiliency and the activities necessary to incorporate climate change information into agency decision making. The Strategy identifies four critical goals that form the foundation for Reclamation's climate adaptation work: (1) Increase Water Management Flexibility, (2) Enhance Climate Adaptation Planning, (3) Improve Infrastructure Resiliency, and (4) Expand Information Sharing. Underlying this Strategy is a phased approach recognizing that adaptation to climate change can only occur with sufficient time and commitment to develop the science, guidance, and staffing capacity needed to apply climate information in meaningful and appropriate ways.

This Strategy also recognizes the critical importance of making information easily accessible and collaborating with customers and stakeholders to ensure adaptation strategies are developed that have the support to be successful and to leverage Federal and non-Federal dollars to implement those actions. The challenges posed by climate change are simply too complex and impact too many interests to be addressed by any one entity or sector. With this Strategy, Reclamation is committing both to provide leadership and to work together with partners to build resiliency to climate change to support water supply sustainability in the West.

Appendix - Overview of Current Bureau of Reclamation Climate Adaptation Efforts

Introduction

Reclamation's Climate Adaptation Strategy builds on several key climate adaptation activities currently underway. Reclamation is taking steps now to understand and address climate change impacts to water resources and operations through research, science development, and adaptation actions to make us more resilient to climate change. Having this foundation of available science, tools, and programs helps make it possible for Reclamation to integrate climate change information into areas requiring a more complex analysis – such as reservoir operations and dam safety assessments – as described in the Strategy. Following is a summary of ongoing activities and accomplishments supporting each of the four goals identified in the Climate Adaptation Strategy.

Goal 1 – Increase Water Management Flexibility

- **Goal**: Increase water conservation, efficiency, reuse, as well as creation of new water supplies through desalination and treatment of degraded waters, to ensure continued ability to delivery water and power under changing water conditions.

- **Priority Action**: Reservoir operation pilots are critical to understand where flexibilities in reservoir operations may be increased through identifying trends in historic and current climate and hydrology and through improved use of weather forecasting.

Water conservation, water reuse, and efficient water operations can help provide the flexibility that is needed to optimize water supplies in response to drought and to build resiliency to climate change by stretching water supplies further. The President's Climate Action Plan for the Nation specifically highlights the contributions of WaterSMART Grants in providing funding to agricultural water users for more efficient practices to address long-term climate change. As part of this Climate Adaptation Strategy, Reclamation will continue to support water and energy conservation and improvement projects through the WaterSMART Grants and will identify opportunities to implement adaptation strategies developed in completed Basin Studies through this program. Reclamation is also a leader in supporting development and testing of advanced water treatment technologies that can turn saline and degraded waters into useful supplies, through the research and demonstration projects funded under the Desalination and Water Purification Research Program and collaborative work done at Reclamation's Brackish Groundwater National Desalination Research Facility at Alamogordo, New Mexico.

Leveraging Federal Funding. From 2009 through 2013, Reclamation has provided funding through WaterSMART Grants for 191 on-the-ground projects to conserve water

and improve water and energy efficiency. Non-Federal sponsors match Federal funding dollar for dollar on all WaterSMART Grant projects, and many sponsors are able to secure non-Federal funding beyond the required 50 percent level. WaterSMART Grants, therefore, work to leverage Federal funding; from 2009 through 2013, about $116 million in Federal funding, including funding provided under the American Recovery and Reinvestment Act, has been used to implement more than $325 million in water management improvements across the West. In addition, 32 new projects have been selected to receive $19 million in Federal funding in 2014.

Priority Goal for Water Conservation. WaterSMART Grants, along with other programs, contribute to the Department's Priority Goal for Water Conservation: to enable the capability to increase the available water supply to 840,000 acre-feet, cumulatively from 2009 through 2015. Through FY 2013, Reclamation has reported approximately 730,000 acre-feet of water savings toward the Priority Goal – about the amount of water needed for household use in Denver, Colorado, and the surrounding metropolitan area each year.

On-the-Ground Benefits. WaterSMART Grants provide cost-shared financial assistance to carry out water and energy efficiency improvements, including projects that save water, increase energy efficiency and the use of renewable energy in water management, address endangered species and other environmental issues, and facilitate transfers to new uses. On-the-ground projects may also include implementation of climate adaptation strategies identified in a completed Basin Study. Other projects may result in water delivery improvements that also facilitate future on-farm improvements that can be carried out with the assistance of the Natural Resources Conservation Service to accomplish coordinated water conservation improvements.

The following are examples of selected WaterSMART Grant projects:

- In Oregon, the **Three Sisters Irrigation District** was selected for an $859,000 WaterSMART Grant in 2011 (Figure 1). That funding was used to complete work on a $3.3 million phase of the District's ongoing collaborative effort with the Deschutes River Conservancy, including replacing 20,000 feet of open canal with polyethylene pipe. The project is expected to result in 750 acre-

Figure 1: Three Sisters Irrigation District WaterSMART Grant.

feet of water savings annually in the water-short Upper Deschutes Basin in Oregon. Water conserved through this project will be marketed through the Deschutes River Conservancy for a protected instream right to support critical habitat for Bull Trout, Red band Trout, Summer Steelhead, and Chinook salmon. The District also installed a 950-kilowatt capacity turbine generator as part of the project, a renewable source of energy that the District expects to supply 3.1 million kilowatt-hours of electricity.

- Through an FY 2013 WaterSMART Grant, the **Uncompahgre Valley Water Users Association** in Montrose, Colorado, has installed new automatic headgate controls and a Supervisory Control and Data Acquisitions system on the M&D and Ironstone Canals to better manage water supplies throughout the delivery system. By completing these improvements, the Uncompahgre Valley Water Users Association is directly addressing the Conveyance System Efficiency Improvements (Figure 2) adaptation strategy identified in Technical Report F of the 2012 WaterSMART Colorado River Basin Water Supply and Demand Study.

Figure 2: Uncompahgre Valley Water Users Association Conveyance System Efficiency Improvement Project.

- Through an FY 2012 WaterSMART Grant, the **Moroni Irrigation Company** in Sanpete County, Utah, converted approximately 12.5 miles of open channel irrigation canals to pipe to reduce seepage and evaporation losses. The project also included improvements to an existing diversion structure and the installation of new meters. The project is expected to result in water savings of approximately 3,000 acre-feet annually in an area that frequently experiences water shortages. Conserved water will remain in the San Pitch River for other uses. Once the project has been completed, the pressurized system will allow farmers to convert from flood irrigation to more efficient sprinkler systems.

Title XVI Water Reclamation and Reuse. Through Title XVI, Reclamation provides funding for projects that reclaim and reuse municipal, industrial, domestic, or agricultural wastewater and naturally impaired ground or surface waters. Water recycling through the

Title XVI Program provides flexibility, helps to diversify the water supply, and reduces the pressure to transfer water from agricultural to urban uses. Reuse is often a drought-resistant supply, since sources such as treated municipal wastewater continue to be available during periods of water shortage. Since 1992, 53 projects have been specifically authorized by Congress under Title XVI. Title XVI generally limits Federal funding for specific projects to 25 percent of project costs or $20 million. Over $600 million in Federal funding has been provided for Title XVI projects since 1992. Taking into account non-Federal cost share provided by project sponsors, at least $2.4 billion in water reuse improvements have been constructed or will be finished by 2015.

Reclamation allocates program funding through a competitive process. In FY 2013, Title XVI projects together delivered an estimated 385,000 acre-feet of recycled water, making an equivalent amount available for other uses and helping to diversify the water supply. In FY 2014, $21.5 million was allocated for continued construction of authorized Title XVI projects and for development of feasibility studies for potential new water recycling projects.

CALFED Water Conservation Grants. CALFED is a combined State of California and Federal program focused on the restoration of the Sacramento-San Joaquin Delta's fragile ecosystem while improving water supply reliability for urban and agricultural water users. Funding is made available for water conservation under two competitive selection processes:

- Through CALFED Water Use Efficiency Grants, Reclamation accelerates the implementation of cost-effective actions that provide state-wide benefits through water conservation. Water use efficiency from districts linked to the Bay-Delta water supply can result in significant benefits to water quality, water supply reliability, and instream flows.

- Through an innovative partnership with the Natural Resources Conservation Service (NRCS), funding is made available for Agricultural Water Conservation and Efficiency Projects that result in delivery system improvements and on-farm water conservation measures. Reclamation provides financial assistance to entities with water or power delivery authority; NRCS participates in the review of proposals and makes funding available for on-farm water conservation practices that complement the projects selected for Reclamation funding.

From 2010 through 2013, Reclamation has provided funding to 28 water management improvement projects, addressing shortages during a period of severe drought in California. Reclamation has selected six projects across California to receive a total of $1.8 million in CALFED Water Use Efficiency Grants in 2014. Combined with local cost-share contributions, more than $11.7 million in water management improvement

projects will be implemented during the next 24 months. Reclamation has also selected eight projects to receive $6.3 million in Agricultural Water Conservation and Efficiency grants as part of the partnership with NRCS. Combined with local cost-share contributions, more than $36 million in water management improvement projects will be implemented during the next 24 months, helping to address one of the worst droughts in California in decades.

Advanced Water Treatment. Reclamation has been leading efforts to find sustainable and energy efficient ways for developing new water supplies through the **Desalination and Water Purification Research (DWPR) Program** which funds projects to conduct desalination research, development, and demonstrations for the purpose of converting unusable waters into useable new water supplies. The research includes competitive, merit-based cooperative agreements with universities, public, and private sector organizations on a cost-shared basis. As of 2011, DWPR has awarded $11.94 million in Reclamation funding with a cost-share of non-federal funding of over $16.7 million. There are a total of 176 final reports on completed research projects that inform the next generation water treatment technologies from membrane and thermal processes (Figure 3) through identifying solutions to the economic challenges of developing these new water supplies. (http://www.usbr.gov/research/AWT/desalination_technologies.html).

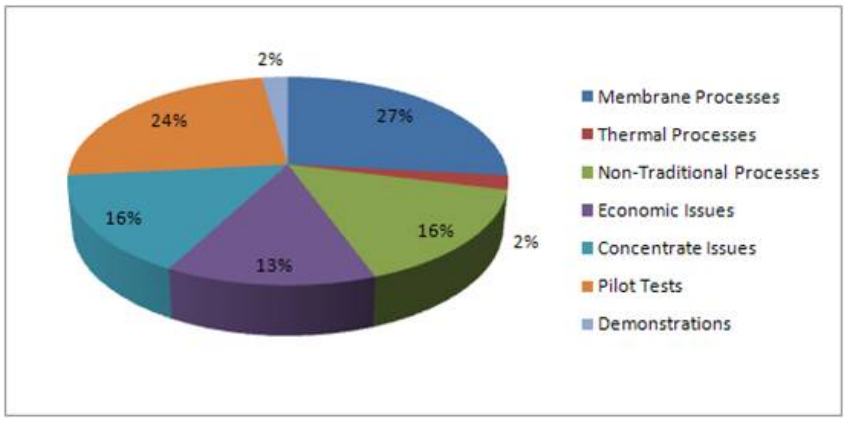

Figure 3: Distribution of DWPR Research Grants as of 2011.

Reclamation is further supporting the development of new water supplies through a desalination research facility focused on the need to lower costs of brackish water treatment, improve the performance, and manage the concentrates removed from the water. In 2001, the Desalination Act authorized Reclamation, in cooperation with Sandia National Laboratories, to plan for a desalination research and development facility in the Tularosa Basin of New Mexico. The **Brackish Groundwater National Desalination Research Facility** (BGNDRF) was commissioned in 2008 and research began in 2009 (Figure 4). BGNDRF provides state-of-the-art research facilities for researchers involved in desalination research studies, pilot-scale projects, and small demonstration projects. The facility uniquely focuses on brackish groundwater desalination, renewable energy integration, development of systems for rural and Native American communities, concentrate management, and treating water produced from oil and gas production. It is the only major research facility in the United States dedicated solely to the desalination of brackish and impaired groundwater and is located within an almost ideal environment for desalination research, the Tularosa Basin, which possesses a vast supply of groundwater resources and a range of water qualities.

Figure 4: Brackish Groundwater National Desalination Research Facility located in Tularosa Basin of New Mexico.

Goal 2 – Enhance Climate Adaptation Planning

- **Goal 2 – Enhance Climate Adaptation Planning**: Develop capabilities, tools and guidance to incorporate climate change information across Reclamation's planning processes. These enhanced planning efforts will help Reclamation understand and address climate change impacts to the delivery of water and power, to infrastructure, and to ecosystems and habitat affected by Reclamation projects. **Priority Action**: Enhance the Basin Studies and WWCRAs to include consideration of climate change impacts to floods and droughts and impacts to ecosystems.

Reclamation has made significant progress in climate adaptation planning through the **WaterSMART Basin Study Program**, initiated in 2009 to implement the SECURE Water Act, Subtitle F of Title IX of P.L. 111-11 (2009). The SECURE Water Act

authorizes Reclamation to evaluate the risks and impacts of climate change in each of the eight major Reclamation river basins identified in the Act and work with stakeholders to identify climate adaptation strategies. The Basin Study Program includes three complementary activities: the Basin Studies, West-Wide Climate Risk Assessments, and the Landscape Conservation Cooperatives (LCCs). Reclamation works with stakeholders to develop adaptation strategies through the Basin Studies. It assesses climate change impacts to operations through the WWCRAs and partner with a range of Federal and non-Federal entities to develop applied science tools to address climate change and other landscape-scale stressors through the LCCs.

Through the **Basin Studies**, Reclamation collaborates with non-Federal cost-share partners to evaluate specific vulnerabilities and impacts to water resources management at a basin-wide scale and identify adaptation strategies ranging from water conservation to increased storage capacity. Since 2009, Reclamation has leveraged $14.3 million in Federal funding with $15.7 million in non-Federal funding to initiate 19 of these collaborative studies, covering many critical watersheds in the Western United States, including the Colorado River Basin, the Sacramento-San Joaquin River Basins, the Yakima Basin, and the Lower Rio Grande Basin (see Figure 5, below). By identifying

Figure 5: WaterSMART Basin Studies.

appropriate adaptation strategies informed by climate analysis, the Basin Studies provide a solid platform to further explore actions that will support a sustainable water supply.

The work that has followed the completion of the Colorado River Basin Study is one example of how Reclamation is building on ongoing efforts to further support adaptation planning. The Basin Study, completed in 2012 by Reclamation and the seven Colorado River Basin States, evaluated the impacts of climate change on basin water supplies and identified adaptation strategies. Currently, groups representing Federal, state, tribal, agricultural, municipal, hydropower, environmental, and recreational interests are all collaborating to examine in more detail the challenges and the potential solutions that will work in the Basin to address water shortages exacerbated by climate change and extended drought. This effort, referred to as "**Basin Study – Next Steps**," will further develop those adaptation strategies identified through the Basin Study.

Three workgroups have been formed in Phase 1 of the Next Steps process. Each group focuses on a topic identified in the Colorado River Basin Water Supply and Demand Study (Figure 6). Specifically, (1) conservation and reuse of municipal and industrial water supplies; (2) agricultural conservation, productivity, and transfers; and (3) environmental and recreational flows. The ultimate goal of the process is to identify steps to address projected supply/demand imbalances that have broad-based support and provide a wide-range of benefits. During Phase 1, the workgroups are documenting municipal and agricultural conservation successes, documenting additional water savings each program may achieve by 2060, exploring potential solutions that protect or improve ecological and recreational resources, and recommending Phase II activities. The Phase I reports for each workgroup will be completed by the end of 2014, followed by the initiation of Phase II activities.

Figure 6: Colorado River Basin

The Next Steps process also includes the Colorado River Basin Tribal Water Study, a comprehensive assessment for the Ten Tribes Partnership that documents current tribal water use and projects future water demand on Partnership reservations, documents use of unused tribal water by others, and identifies tribal opportunities and challenges associated with the development of tribal water. A draft Plan of Study was completed in 2013, and the current use assessment and a portion of the future demands assessment (Phases I and II) will be completed in 2014. The Study completion and report publication is planned for 2015.

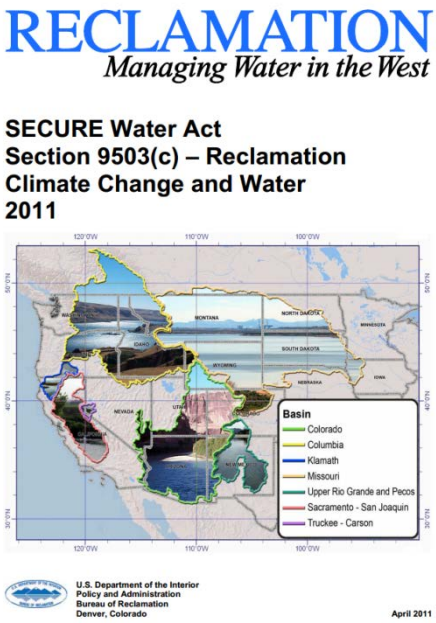

Figure 7: SECURE Water Act 2011 Report to Congress.

West-Wide Climate Risk Assessments were initiated by Reclamation in 2009 to complement the Basin Studies by providing a consistent, baseline assessment of climate change impacts to water supply and demand across the West, with special emphasis on how climate change impacts Reclamation's own operations through WWCRA Impact Assessments. The baseline assessments conducted through WWCRA evaluate risks to water supplies (change in snowpack, changes in timing and quantity of runoff, and changes in groundwater recharge and discharge) and any increase in the demand for water as a result of increasing temperatures and reservoir evaporation rates. These assessments contributed significantly to Reclamation's 2011 SECURE Water Act Report to Congress (Figure 7), detailing the impacts of climate change to water supply and demand in Western river basins. The next SECURE Water Act Report is due to Congress in 2016 and will incorporate information since the 2011 report was published gathered through WWCRA Impact Assessments, Basin Studies, and research activities.

The WWCRAs have generated important information, tools and guidance that can support the integration of climate information into planning activities, as proposed in Reclamation's Climate Change Adaptation Strategy. Some WWCRA accomplishments are as follows:

- Through basin specific WWCRA Impact Assessments, Reclamation evaluates climate change impacts as they relate to Reclamation's mission. This includes analyzing impacts to water delivery, power generation, recreation, flood control,

and ecological resources. The information generated through WWCRA Impact Assessments is used to support Basin Studies by providing a foundation of climate change data, information, and tools that partners can build from to develop adaptation strategies.

- WWCRA Impact Assessments will be completed in each of the eight major Reclamation river basins identified in the SECURE Water Act. To date, four Impact Assessments have been initiated in five of the eight basins, including the Rio Grande, Sacramento and San Joaquin (these two basins are addressed in a single Impact Assessment), Columbia, and Missouri.

- In 2013, Reclamation completed the first WWCRA Impact Assessment in the Rio Grande river basin in partnership with Sandia National Laboratories and the U.S. Army Corps of Engineers (USACE). Three additional WWCRA Impact Assessments are currently underway, including the Sacramento and San Joaquin Basins Impact Assessment, which will contribute information to a basin study ongoing in the same basins, the Columbia River Basin Climate Impact Assessment, and the Upper Missouri River Basin Impact Assessment, which will provide the operations models to be used by Federal and non-Federal partners in the upcoming Upper Missouri River Basin Study.

- Since 2010, Reclamation has partnered with the U.S. Fish and Wildlife Service to co-lead the **Desert and Southern Rockies Landscape Conservation**

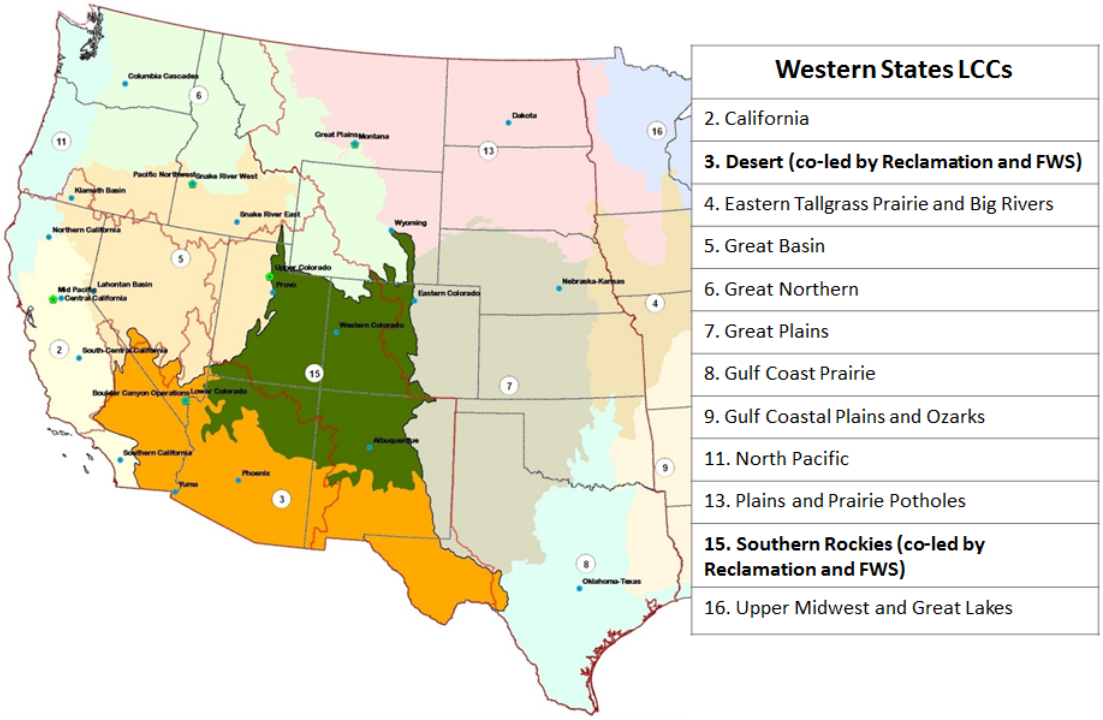

Figure 8: Western States Landscape Conservation Cooperatives.

Cooperatives, which together encompass portions of 9 states and roughly overlie the Colorado River Basin. Reclamation also participates in each of the LCCs overlapping the 17 Western States through membership on Steering Committees and Science Working Groups (Figure 8). The LCCs are partnerships to develop a coordinated, science-based response to climate change and other landscape-scale stressors to land, water, human, cultural, and wildlife resources in a specific geographic area. Partners involved in the Desert and Southern Rockies LCCs include representatives of Federal, state, tribal, and local governments and non-government organizations; resource managers; and others engaged in natural and cultural resource conservation.

- The Desert and Southern Rockies LCCs have been able to identify and fund multiple projects that provide benefits across both LCCs and address critical resources important to the missions of Reclamation, the Fish and Wildlife Service, and partners involved in the LCCs. The projects leverage Federal and non-Federal funds from multiple partners. One Desert LCC project led by The Nature Conservancy builds on the Colorado River Basin Study to develop a decision support tool for incorporating ecological flows into water management models used for basin-wide water supply planning. The Desert LCC will build on this project in 2015 by developing an environmental flows database, including calculations of flow needs developed across geography in 2014-2015.

- Through another project, the Southern Rockies LCC provided funding to the Valles Caldera National Preserve, The Nature Conservancy, and University of New Mexico to quantify how forest restoration efforts impact water yields and reduce risks of catastrophic wildfires exacerbated by climate change. This project was initiated in 2014 and will be completed in 2016. Results can be incorporated into conservation management plans for fisheries, riparian restoration, and terrestrial wildlife species threatened by long-term changes in habitat and climate.

Goal 3 – Improve Infrastructure Resiliency

- **Goal**: Improve infrastructure resilience, reliability and safety to prepare for increased intensity and frequency of floods and droughts.

- **Priority Action**: Pilot assessments within the Dam Safety Comprehensive Facility Review process are critical to determine appropriate use of the new state-of-the-science information about changes to floods from climate change.

The potential for increased frequency and intensity of floods and droughts brings new challenges to infrastructure conditions. The Climate Strategy includes several new efforts

that will improve Reclamation's ability to consider climate change impacts in decisions regarding infrastructure investments. These include research on climate change impacts due to floods and droughts, a series of pilots to integrate climate information into the dam safety risk assessment process, and revising criteria for prioritizing infrastructure improvements to include consideration of climate change. However, even now, Reclamation is identifying opportunities to consider climate change information in decisions regarding infrastructure where possible.

For example, Reclamation is in the process of installing four "wide-head" turbines at Hoover Dam to increase the operational range and flexibility of the hydropower operations. The new turbines will be able to generate power at lower reservoir pool elevations in Lake Mead, which have a higher likelihood of occurring under some climate change scenarios. The existing turbines at Hoover Dam are designed, in general, to operate over a higher range of lake levels. At very low lake levels, operation of existing turbines becomes rough and inefficient.

Installation of two of the new turbines has been completed, and the remaining two will be installed in 2015. "The new turbines will allow the generating units to operate more efficiently over a wider range of lake levels, or 'head', than the existing turbines do," stated Reclamation's former Commissioner, Mike Connor, currently Deputy Secretary of the Interior. ""There are 17 commercial generators in the Hoover Dam powerplant - nine in the Arizona wing and eight in the Nevada wing. Since 1947, an average of about 4.4 billion kilowatt-hours of energy has been generated at the dam annually, or enough to supply about 400,000 U.S. households with all of their electricity needs for one full year. The energy is marketed to customers in southern California, southern Nevada, and Arizona under 30-year contracts signed in 1987.

Goal 4 – Expand Information Sharing

- **Goal**: Collaborate with stakeholders to support mutual climate adaptation efforts through sharing data and tools.

- **Priority Action**: Improve stakeholder access to water management and hydropower data. Support information through outreach activities for a common understanding of climate change information and related adaptation efforts.

Partnerships with state, tribal, and local governments, as well as water users, stakeholders, the public, and other Federal agencies are critically important to Reclamation's ability to build resiliency to climate change. Fundamental to developing new information for adapting to climate change is assessing the current state of knowledge, identifying where gaps exist, and finding opportunities to address those gaps.

Reclamation is actively engaged in multiple collaborative efforts with Federal and non-Federal partners to develop and share information for a common understanding of climate change impacts to water resources in the West. One example is Reclamation's partnership with the U.S. Army Corps of Engineers, the U.S. Geological Survey, the National Oceanic and Atmospheric Survey (NOAA), and others through CCAWWG to identify mutual science needs for long-term planning[5] and short-term operations[6]. The development of these gaps has included strong stakeholder interaction and involvement through the Western States Water Council, the American Water Works Association, Family Farm Alliance, Western Area Power Administration, Seattle City and Light Department. Reclamation's Science and Technology Program has invested in a range of solutions to meet needs identified collaboratively by CCAWWG, including climate change training programs for Reclamation staff.

Since 2011, Reclamation's Science and Technology Program partnered with the USACE and NCAR to improve tools and methods for assessing climate change impacts on water resources. An initial project has involved identifying strengths and weaknesses of current methods that inform Reclamation's vulnerability assessments and adaptation planning[7]. The project focused on methods to downscale climate projections and simulate hydrologic impacts, including those that the WWCRA team has relied upon to assess vulnerabilities and support adaptation planning. This initial effort has revealed opportunities for research to develop improved techniques, and has led to a subsequent 2013-2015 effort to develop and apply such techniques. During the course of these efforts, the research team has remained engaged with the WWCRA team to enhance the relevance and utility of these efforts.

The planning process relies upon access to information to make statements about future climate possibilities. The Science and Technology Program and WWCRA activities have been developing data and tools for Reclamation and others that will analyze climate change impacts to water management and operations and support several of the activities described in the Strategy, including the reservoir operations and dam safety pilot activities. For example:

- **Website for Downscaled Climate and Hydrology Projections:** The science and Technology Program has worked with Federal and non-Federal partners since

[5] http://www.ccawwg.us/docs/Long-Term_Summary-standalone-final.pdf

[6] http://www.ccawwg.us/index.php/activities/short-term-water-management-decisions-user-needs-for-improved-climate-weather-and-hydrologic-information

[7] http://www.usbr.gov/research/docs/updates/2013-21-sensitivity.pdf

2007 to develop future climate and hydrology projections. These information resources are served though a website that provides users access to the monthly gridded precipitation, temperature and hydrologic projection data, as well as additional climate projection information that covers the contiguous United States (Figure 9). Since 2007, the website has served more than 1,400 users from science, planning, and education communities.

In 2010-2011, WWCRA and the Science and Technology Program partnered with the University of Washington's Climate Impacts Group, NOAA, National Weather Service, and the Colorado Basin River Forecast Center to translate a large set of downscaled climate projections over the Western United States into corresponding gridded hydrology projections at a 12 kilometer resolution. The impacts to Western water resources in the United States derived from this data were highlighted in Reclamation's SECURE Water Act Report released in April 2011.

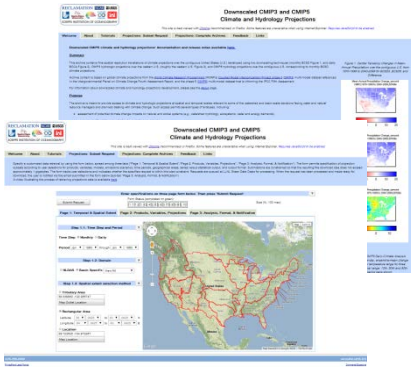

Figure 9: Lawrence Livermore National Laboratory hosted archive of climate change projections.

In 2011-2014, WWCRA and Science and Technology Program partnered with Climate Analytics Group, Santa Clara University, USACE, and NCAR to develop next-generation downscaled climate and hydrology projections with hydrology projections covering the contiguous United States. WWCRA is currently working on translating these new projections into information products that will inform SECURE Water Act reporting in 2016.[8]

Figure 10: Climate change future streamflow projection website.

- **Streamflow Projections Website**: In 2011, a WWCRA activity involved developing a user-friendly website where users could easily access streamflow projections for 195 sites on streams and rivers throughout the Western United States. Streamflow projections are provided for the locations utilized within the SECURE Water Act Report to Congress in 2011 (Figure 10). http://gis.usbr.gov/Streamflow_Projections/

[8] http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html

Since 2012, Reclamation and USACE have been collaborating with CCAWWG and the University Center for Atmospheric Research COMET program to develop and pilot climate change training tools for Federal and non-Federal water agency staff and to explore sustained delivery approaches[9] (Figure 11).

Figure 11: Climate Change and Water Working Group developed training class within the "Assessing Natural Systems Impacts under Climate Change" series.

Initial efforts have focused on developing a new COMET Professional Development Series, "Assessing Natural Systems Impacts under Climate Change." The series is designed to provide technical training to water resources professionals on how to incorporate climate change science and uncertainties into a variety of natural resource impacts assessments, including those related to surface water hydrology, crop irrigation requirements, water temperature, river and reservoir sedimentation, water quality, and land cover. While the initial effort has successfully engaged technical practitioners, there is also a need to provide training for less-technical practitioners who will play critical roles in mainstreaming climate change into mission activities (e.g., senior leaders, program managers, project managers, resource specialists, public affairs). In response, training partners have recently begun to scope and develop a parallel professional development series aimed at these communities.

[9] http://www.ccawwg.us/index.php/education/recent-training