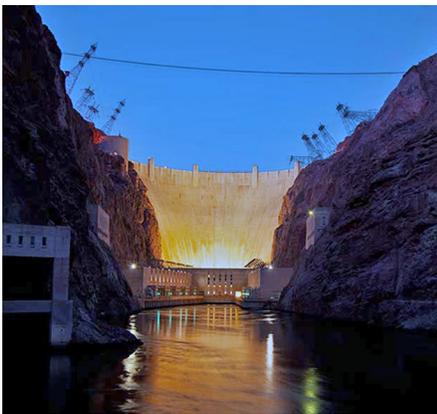


RECLAMATION

Managing Water in the West

Climate Change Adaptation Strategy: 2016 Progress Report



Mission Statements

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.

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.

Climate Change Adaptation Strategy: 2016 Progress Report

Acronyms and Abbreviations

°F	degrees Fahrenheit
BGNDRF	Brackish Groundwater National Desalination Research Facility
CAA	corrective action analysis
cfs	cubic feet per second
CIRES	Cooperative Institute for Research in Environmental Sciences
CR	Comprehensive Review
DSAT	Dam Safety Advisory Team
DWPR	Desalination and Water Purification Research Program
FY	Fiscal Year
GAO	Government Accountability Office
HHA	Hydrologic Hazard Analyses
HydrOS	Hydro Optimization System
IE	Dam Safety Issue Evaluation
Interior	The Department of the Interior
Kw	kilowatts
kWh	kilowatt hours
LCC	Landscape Conservation Cooperatives
MWh	megawatt hours
PRO	Power Resources Office
ODT	Open Data Team
OWDI	Open Water Data Initiative
R&D Office	Research and Development Office
Reclamation	Bureau of Reclamation
RISA	Regional Integrated Sciences and Assessments
SEFM	stochastic event flood model
Strategy	Climate Change Adaptation Strategy
TSC	Technical Service Center
USACE	U.S. Army Corp of Engineers
UCAR	University Corporation for Atmospheric Research
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WWCRA	West Wide Climate Risk Assessments
WWEF	Western Watershed Enhancement Partnership

Contents

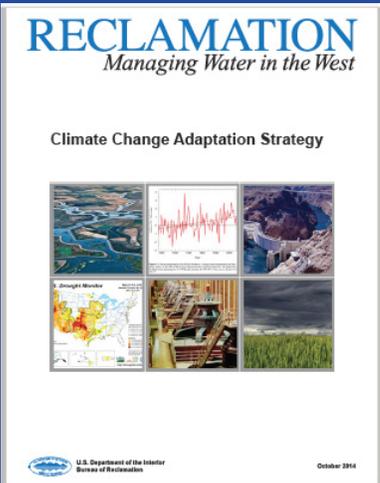
Overview	1
Climate Change Risks and Impacts	2
Phased Process	6
Goal 1: Increase Water Management Flexibility	9
Reservoir Operations Pilot Initiative	10
Hydropower Optimization	12
Hydropower Provides Stability that Supports Using Other Renewable Energy Sources	14
Goal 2: Enhance Climate Adaptation Planning	15
Enhanced Basin Studies and WWCRAAs	16
Climate Change Training	18
Drought Response Program	20
Goal 3: Improve Infrastructure Resiliency	23
Dam Safety Climate Change Assessment Pilots	24
Infrastructure Repair, Replacement, and Renovation Investments	26
Western Watershed Enhancement Program	27
Goal 4: Expand Information Sharing	29
Open Water Data Initiative	30
Coordinate Climate Adaptation Activities with Partners and Stakeholders	32

Reclamation's Climate Change Adaptation Strategy: 2016 Progress Report

The Bureau of Reclamation (Reclamation) released its first Climate Change Adaptation Strategy (Strategy) in November 2014 to address the clear risks that climate change poses to its ability to deliver 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 Strategy identified four overarching goals, with supporting activities, to minimize the risks and impacts from climate change on water and power delivery and ecosystem sustainability through adaptation efforts. The four overarching goals are:

- **Increase Water Management Flexibility** to conserve water, increase water delivery efficiency, generate new sources of supply, identify opportunities to adapt reservoir operations to improve flexibility, and increase hydropower efficiency to optimize power generation and increase renewable energy development.
- **Enhance Climate Adaptation Planning** by incorporating climate change information into planning policy and guidance to improve resiliency across several mission areas, including delivery of water and power and maintaining ecosystems, and to develop climate adaptation strategies.
- **Improve Infrastructure Resiliency** to ensure the longevity of our infrastructure and support climate resilient infrastructure investments.
- **Expand Information Sharing** to support our partners in developing resiliency to climate change.

This 2016 Progress Report provides a status update on many of the activities supporting the four overarching goals. The following sections of this Overview include a description of some of the risks and impacts from climate change that affect water management (Table 1); followed by a summary of Reclamation's progress to date on the implementation of climate adaptation activities (Table 2); concluding with a description of Reclamation's phased approach to climate adaptation. The body of this Progress Report includes chapters on each of the four overarching goals.



In Fiscal Year (FY) 2015, Reclamation issued a Climate Change Adaptation Strategy to address climate change risks to Reclamation's mission, available at: <http://tinyurl.com/climatestrat>.

Reclamation also adopted a Climate Change Adaptation Policy (CMP P16 Reclamation Manual) to communicate the agency's commitment to addressing climate change impacts to Reclamation's mission, facilities, operations, and personnel.

Climate Change Risks and Impacts

Climate change poses a fundamental challenge to Reclamation’s mission and the national economy. The effects of climate change are already being felt across the Western United States. As a result, Reclamation and its water management partners must be prepared to respond to shifts in the baseline of what is considered “normal” for drought, floods, water availability, and water demands over coming decades.

In March, 2016, Reclamation released a comprehensive report, “SECURE Water Act Section 9503(c)—Reclamation Climate Change and Water 2016” (SECURE Water Act Report”) summarizing the effects of climate change on water resources and the identification of adaptation strategies through collaborative efforts with stakeholders, available at www.usbr.gov/climate/secure. Key observations and projections relevant to western water management include the following, as documented in the SECURE Water Act Report:

- 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 U.S. basins. Observed increases in mean annual temperature have been approximately 2 degrees Fahrenheit (°F) (1.1 degrees Celsius [°C]) since 1900. Continued warming of roughly 5 to 7 °F (3 to 4 °C), depending on location, is projected over the course of the 21st century.
- Precipitation changes are also expected to occur, interacting with warming to increase the duration and frequency of droughts and resulting in larger and more numerous floods, varying by basin. The increased intensity of droughts and floods raises concerns about infrastructure safety, the resiliency of species and ecosystems to these changes, and the ability to maintain adequate levels of hydropower production.

Table 1 highlights some of the anticipated climate change impacts identified in the 2016 SECURE Report, including impacts to water deliveries; hydropower; flood management; and fish, wildlife, and ecological resources. (A more comprehensive description of climate impacts to water resources is included in the SECURE Report). In many regions of the West, projected climate-driven changes in water supply (quantities and timing), along with increased demands for water, are expected to strain the ability of existing infrastructure and operations to meet water needs—not only for consumptive uses such as agricultural, municipal, and industrial activities, but also for hydropower, flood control, fisheries, wildlife, recreation, and other largely non-consumptive water-related benefits. Table 1 describes some of these impacts:

Table 1. Potential Climate Change Impacts to Water Management

Types of Impact	Potential Climate Change Impact to Water Management
Water Deliveries	<p>Changes in Water Supply and Demand Climate assessments project that the manageable water supply, in general, will decline in much of the West. A decrease of up to 8 percent in average annual stream flow is projected in several river basins, including the Colorado, the Rio Grande, and the San Joaquin river basins.</p>
	<p>Changes in Timing of Runoff and Water Availability West-wide, runoff is expected to shift to earlier times of the year (less in summer, more in winter and spring), making it more difficult to manage water deliveries as they have been managed in the past. Reservoirs are anticipated to fill earlier in the year, with a corresponding reduction in the water supply available through the summer season.</p>
	<p>Change in Snowpack versus Rainfall Across the West, snowpack generally is projected to decrease as more precipitation falls as rain and warming temperatures cause earlier snowmelt. Water deficits are expected to worsen throughout the Columbia River Basin due to more precipitation falling as rain, shifts in runoff timing, lengthening of the growing season, and greater reliance on stored water.</p>
Hydropower	<p>Changes in Supply and Runoff Timing West-wide, runoff is anticipated to shift to earlier periods of the year (less in summer, more in the winter and spring). Where peak demand for hydropower occurs during the hottest weeks of summer, shift in runoff timing is expected to impact summer hydropower revenues due to a reduction in peak-season hydropower generation.</p>
	<p>Changes in Hydropower Demand The warming projected across the West is generally expected to decrease energy demand during winter (for heating) and increase demand during summer (for cooling). These changes might necessitate adjustments in reservoir operations to better align with demand, although the reduced summer inflow may present its own challenges.</p>
Flood Management	<p>At Reservoirs with Multiple Year Storage Where reservoirs are designed to store several years of runoff, the additional flood risks associated with climate change are generally considered minimal, due to the considerable capacity of those facilities to deal with shorter-duration high flow events.</p>
	<p>At Reservoirs Managed for Annual Refill Where reservoirs require year-round balancing of flood control functions with other purposes, changes in the magnitude, intensity, and severity of extreme runoff events may prompt reconsideration of operating rules to better manage flood risks while maximizing storage opportunities.</p>
Fish, Wildlife and Ecological Resources	<p>Riverine Habitat In Western river basins, it is anticipated that changes to hydrology and climate may make it more difficult to achieve environmental flows to support endangered species. In the Columbia River Basin, projected increases in winter flooding and decreases in summer flows will affect Coho, Chinook, and steelhead salmon.</p>
	<p>Forest Fires In the Missouri River Basin, an increased risk of wildfires is projected due to the expectation that more intense droughts, higher temperatures, and disease will stress forest vegetation.</p>

Progress

This 2016 Progress Report provides a status update on many of the activities identified within the 2014 Strategy. The summary table included in the 2014 Strategy is updated in Table 2, to highlight Reclamation's progress through summer 2016, shown on next page. The table is followed by narratives for many of the activities describing the progress that has been made over the past two years.

Table 2. Goals and Implementation Strategies with 2016 Progress Update

Goals	Implementation Actions	Progress Update
<p>1. Increase Water Management Flexibility</p>	<p>Reservoir Operations Pilot Initiative</p> <p>Research and demonstration to reduce canal water loss and improve water treatment technology</p> <p>Implementing adaptation actions through WaterSMART Grants</p> <p>Continuing support for water reuse and recycling projects through Reclamation’s Title XVI, Water Reclamation and Reuse Program</p> <p>Optimizing hydropower production</p>	<p>Reclamation has five Reservoir Operations pilot studies underway to evaluate how weather, hydrology, and climate change information can better inform reservoir operations.</p> <p>In August 2016, Reclamation launched a new prize competition seeking methods to prevent rodents from burrowing into canals, levees and earthen dam embankments. Through prize competitions, the Federal Government uses incentive prizes to collaborate with members of the public to solve pressing issues. Reclamation continues to invest in laboratory, pilot, and demonstration-scale research to develop clean water technologies through advanced water treatment.</p> <p>Reclamation and the Department of the Interior (Interior) are on track to achieve the goal of 1,040,000 acre-feet of water savings by September 2017, with significant contributions through WaterSMART Water and Energy Efficiency Grant projects.</p> <p>In 2015, Title XVI projects delivered over 369,000 acre-feet of recycled water in the Western States. In 2016, they are projected to deliver over 400,000 acre-feet.</p> <p>Reclamation is implementing hydropower optimizations that could increase generation by 410,000 megawatt hours (MWh)—1,230,000 MWh per year.</p>
<p>2. Enhance Climate Adaptation Planning</p>	<p>Enhance Basin Studies and WWCRA Impact Assessments</p> <p>Research to advance understanding of climate impacts to extreme events and ecosystems</p> <p>Expanded General Planning</p> <p>Drought Response Program</p> <p>Climate Change Training</p>	<p>25 Basin Studies have been funded, with 14 completed.</p> <p>Reclamation funded the use of high resolution weather modeling to evaluate heavy precipitation possibilities in the Taylor Park Dam watershed. These modeling techniques are being piloted to evaluate flood responses and ultimately will help inform decision makers on flooding events.</p> <p>Reclamation is supporting integration of climate change information across planning activities through approaches developed through the Basin Studies and the Drought Response Program.</p> <p>Reclamation’s WaterSMART Drought Response Program, initiated in FY 2015, supports developing drought contingency plans that consider climate change impacts and strategies for mitigating those impacts.</p> <p>Since 2014, Reclamation has worked with partners to offer climate change training courses for technical water resources professionals and for general audiences on integrating climate change considerations into water resources planning.</p>

Goals	Implementation Actions	Progress Update
3. Improve Infrastructure Resiliency	Dam Safety Climate Change Assessment Pilots	<p>In March 2015, Reclamation completed the study, “<i>Climate Change in Hydrologic Hazard Analyses (HHA): Friant Dam Pilot Study.</i>” This study analyzed how climate change information can be incorporated into the Dam Safety Issue Evaluation (IE) level risk analysis process. Future temperature and runoff projections were considered in the Friant Dam IE and the resulting reports will be finalized early in FY17.</p> <p>A second pilot study, also begun in FY15, seeks to incorporate current climate change projections into the fundamental Comprehensive Review (CR) process. This pilot will continued to collect data through the end of FY17.</p>
	<p>Western Watershed Enhancement Program</p> <p>Climate-resilient infrastructure replacement, repair, and renovations</p>	<p>Since its start in 2013, the Western Watershed Enhancement Program has provided nearly \$1,200,000 to cost-share 7 wildfire resiliency projects in Colorado, Idaho, California, Washington, and Arizona.</p> <p>In FY 2015, Reclamation began developing an enhanced decision making framework for prioritizing infrastructure repair, replacement, and renovation investments, to include the consideration of climate change information. The new framework will be tested and refined through a pilot process in 2017.</p> <p>Reclamation is partnering with the National Oceanic and Atmospheric Administration (NOAA) and the Cooperative Institute for Research in Environmental Sciences (CIRES) on research to develop methods for projecting climate change impacts on different types of floods and underlying weather events over different Western States basins. This cooperative agreement concludes at the end of December 2016. Information is available at wcr.colorado.edu, hosted by CIRES.</p>
4. Expand Information Sharing	<p>Improve access to water and hydropower data</p> <p>Coordinate climate adaptation activities with partners and stakeholders</p>	<p>As part of the Open Water Data Initiative, Reclamation is developing new platforms to share data from across Reclamation mission areas using a modernized web-based approach in a transparent and user-friendly format. For example product includes a new interactive web tool, <i>Drought in the Colorado River Basin—Insights Using Open Data</i> a joint project with the U.S. Geological Survey (USGS),” shows the effects of the historic drought in the Colorado River Basin.</p> <p>The Desert and Southern Rockies Landscape Conservation Cooperatives (LCC) have developed a Conservation Planning Atlas that allows people without special software to access and upload spatial data. This means that partners can share data easily and collaborate on analysis and mapping tools without being in the same room.</p>

For example, Reclamation is using a phased approach to incorporating climate adaptation within reservoir operations.

- *2014 Strategy Goal for reservoir operations is to “Increase water management flexibility through climate informed reservoir management.”*
- *In 2014, Reclamation began developing conceptual approaches for considering climate change within reservoir operations, including identifying the tools and models necessary to implement those approaches.*
- *In 2015-16, Reclamation initiated pilot studies to evaluate how weather, hydrology and climate change information can better inform reservoir operations.*
- *Once the pilots are completed, Reclamation will finalize guidance based on lessons learned through these pilots.*

Phased Process

Many of the actions described in Table 1 require extensive consideration of new information, policy considerations, and integration within existing programs. For these types of actions, 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 four steps, illustrated in the figure on next page:

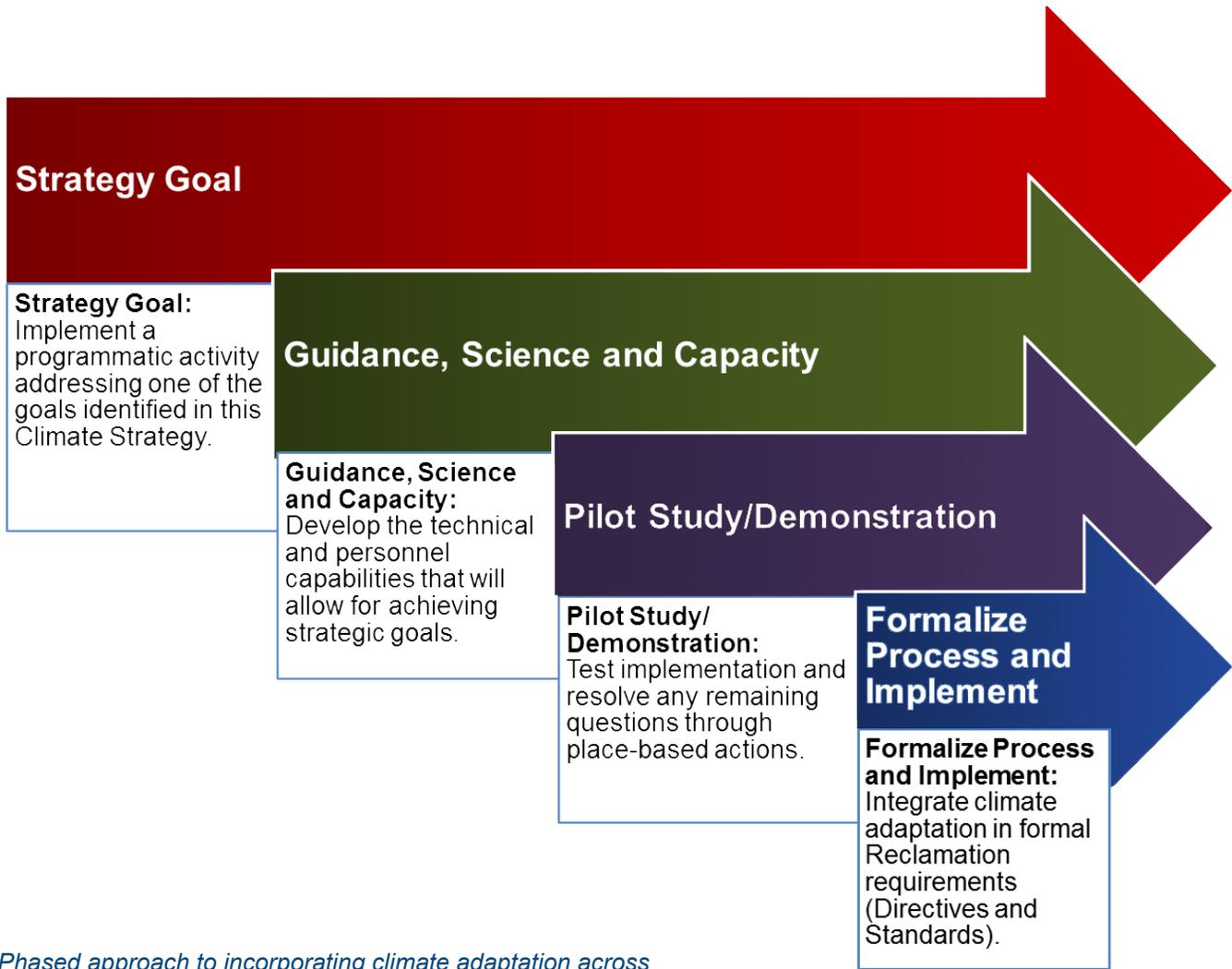
1. Defining the strategic goals (i.e., how Goals 1 - 4 will be addressed by the activity)
2. Developing guidance, science, and capacity to achieve the goal
3. Implementing the guidance through place-based pilots and demonstration activities
4. Formalizing the guidance by developing policy and agency requirements (referred to as “Directives and Standards”)

The concept of risk management in the face of uncertainty is becoming well recognized for climate change adaptation.

A November 2013 Government Accountability Office (GAO) report to Congress recognized 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 (e.g., water conservation) to prepare for extremes and to support healthy and resilient watersheds.



Phased approach to incorporating climate adaptation across Reclamation mission areas.

Goal 1: Increase Water Management Flexibility

The President’s 2013 climate adaptation plan, “Preparing the United States for the Impacts of Climate Change,” identifies the importance of climate adaptation, including directing Federal agencies to identify strategies to prepare for drought, protect fish and wildlife populations, and support agricultural sustainability. Water management in the Western U.S. directly influences each of these identified areas. Reclamation’s Climate Change Adaptation Strategy Goal 1: **Increase Water Management Flexibility** supports identifying and developing appropriate strategies and includes:

- Reservoir Operations Pilot Initiative
- Research and demonstration to reduce canal water loss and improve water treatment technology
- Implementation of adaptation actions through WaterSMART Grants
- Continued support for water reuse and recycling projects through Title XVI
- Optimizing hydropower production

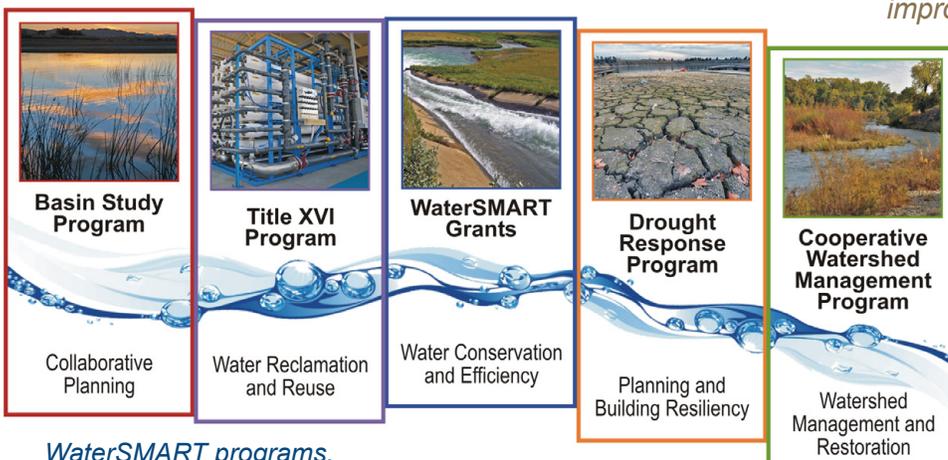
Short-term implementation activities, such as WaterSMART Grants funding projects to improve water and energy efficiency, and support for water reuse and recycling projects continues to be a hallmark of Reclamation’s adaptation efforts as indicated in Table 1 on page 3.

Since Reclamation’s Climate Strategy was released in 2014, Reclamation has also made significant progress on longer-term implementation activities of Reservoir Operations Pilot Initiative and Optimizing Hydropower Production, highlighted in this section.

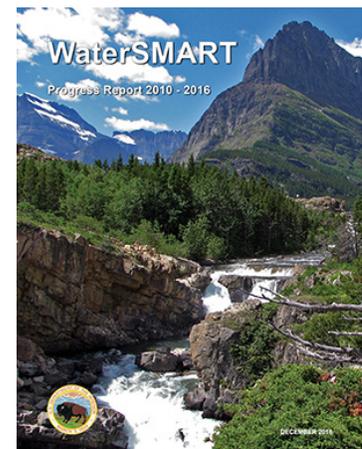
In addition to WaterSMART, in 2016, Reclamation invested in the development of new water treatment technologies to expand water supplies, including:

- *Pitch-to-Pilot funding through the Research and Development Office’s (R&D Office) Science and Technology Program to spur innovation in inland desalination by funding recipients to conduct research at Reclamation’s premiere Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico.*
- *Nine laboratory-scale and three pilot-scale research projects through the Desalination and Water Purification Research Program (DWPR).*
- *Nationwide prize competitions to identify better ways to minimize the concentrate waste from desalination and improve sensors for detecting arsenic in drinking water.*

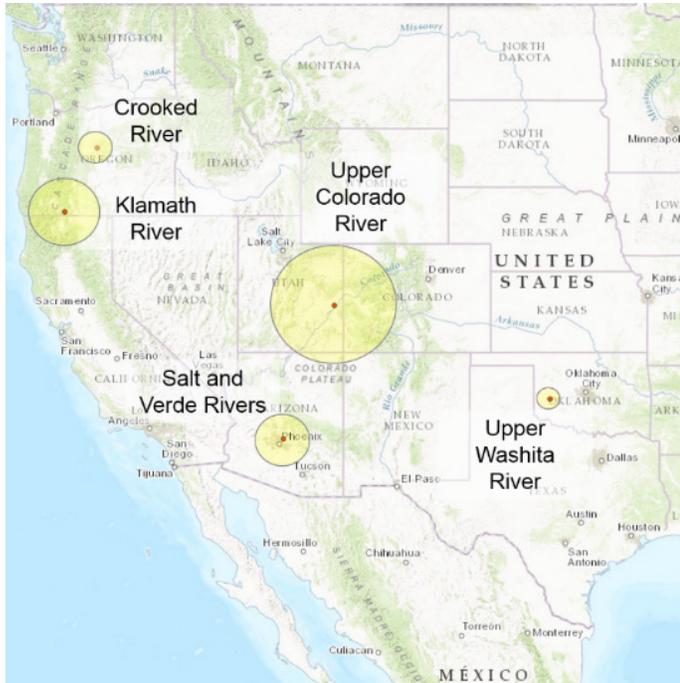
Reclamation’s December 2016 WaterSMART Progress Report describes many of the shorter term implementation actions being taken to improve water management flexibility.



WaterSMART programs.



Reservoir Operations Pilot Initiative



Pilot initiative locations from the Data Visualization Tool Map, www.usbr.gov/watersmart/2010-2016.

Reclamation’s operates its reservoirs using criteria to meet a number of different water management priorities, including reliable water deliveries, power generation, environmental requirements, navigation, and flood control management. Historically, uncertainties in weather prediction and assumptions of an unchanging climate have resulted in seasonal to annual operating criteria for reservoir management. However, we anticipate that these criteria will have to be updated in some locations to consider shifts in climate conditions.

In 2015, Reclamation selected five pilot studies to evaluate how weather, hydrology, and climate change information could better inform reservoir operations. Work began on the pilot studies in January 2016, and these will be completed in December 2017. Reservoir operation pilots may prove critical to understanding where flexibilities in reservoir operations may be increased through

identifying trends in historic and projected climate, hydrology, sedimentation, and conjunctive groundwater management. The five regional pilot studies include:

Great Plains: *Upper Washita, Fort Cobb and Foss Reservoirs*

The Washita Basin Project provides domestic, municipal, and industrial water supply, flood control, recreation, and fish and wildlife benefits. Through initial work on the pilot, Reclamation has identified increased frequency of prolonged drought, less frequent but higher intensity precipitation events, and increased reliance on groundwater during dry periods as the main risks to reservoir operations under future climate scenarios. The main objectives of the pilot study include updating the operations model, considering improved forecasting techniques, and evaluating risks associated with reservoir supply availability using future climate change projections. The pilot will leverage the currently on-going Upper Washita Basin Study and Foss Reservoir Master Conservancy District, Drought Contingency Plan.



The Klamath River Basin pilot will build on the Klamath River Basin Study.

Mid-Pacific: *Klamath River Basin, Klamath Project*

The Klamath Project provides water for irrigation, two national wildlife refuges, fish and wildlife benefits, power production, and tribal water supplies. The pilot, currently underway, identified the volume and timing of available water and power supply, changes to regional snowpack, and changes to groundwater recharge and discharge to project facilities as the main risks to reservoir operations under future climate scenarios. The main objectives of the pilot study include exploring the use of improved forecasting techniques, evaluating the impact of projected increases in ambient temperature on agricultural demands, and improving the operations model to integrate reservoir operations planning with current operations decisions.

Pacific Northwest: *Ochoco Creek and Crooked River*

The Crooked River Project in central Oregon provides water for irrigation, fish and wildlife, and flood control for the area. The pilot identified the transitional climate in the study area (snow to rain transitional elevations), runoff timing and volume, and increasing demands as the main risks to reservoir operations under future climate scenarios. The main objectives of the pilot study include updating the reservoir operations model, improving reservoir refill reliability using secondary forecasting techniques, and evaluating the use of forecast triggers to document the performance of flood management rule curves to increase flexibility of operations under future scenarios. The pilot will leverage the on-going Upper Deschutes Basin Study and includes coordination with the U.S. Army Corp of Engineers (USACE).

Upper Colorado: In 2013, Secretary of Interior tasked the Upper and Lower Colorado River Basin States to develop drought contingency plans. The Upper Colorado Region pilot study will leverage the efforts in the upper Colorado basin targeted at protecting power generation at Glen Canyon Dam. This pilot will document aspects of the drought contingency planning effort to use in developing guidance, including documenting using the Colorado River Simulation System model in determining climate change impacts and identifying risks to meeting power generation requirements under prolonged drought conditions. The pilot will also evaluate scenarios identified in the drought contingency plan as examples for using operations to mitigate long-term drought conditions.

Lower Colorado: *Salt River Project, Salt and Verde Rivers*

The Salt River Project provides storage for municipal and industrial water supply, power production, recreation, and flood control. The pilot has identified the impact of extreme precipitation events, impacts to water quality (e.g., forest fires and rising water temperatures) on infrastructure, and increased reservoir sedimentation that reduces storage capacity as the main risks to reservoir operations under future climate scenarios. The main objectives of the pilot study are to identify and evaluate observed and projected changes to surface water availability within the current operating limits of the system, explore the projected impacts of climate change on extreme rainfall events, and consider rates of reservoir sedimentation in the basin for incorporation in long-term planning.



Horseshoe Dam north of Phoenix, Arizona, stores water for the Salt River Project.

Next Steps: The pilot studies will be used to update and further refine Reclamation guidance to incorporate consideration of climate change information in future reservoir operations planning and in new reservoir operations guidelines. This activity includes coordination with on-going activities in Reclamation's R&D Office, Dam Safety Office, and Technical Service Center (TSC) as well as external coordination with NOAA and USACE.

Hydropower Optimization

Reclamation has historically increased water management flexibility within our hydropower program through capital investments, namely by replacing turbine runners (i.e., turbine blades) and through generator rewinds, which involve replacing specific components of the generator with modern components to decrease losses and improve efficiencies or capacity. Replacing an antiquated runner with a more modern design and improved materials boosts operating efficiencies. Likewise, rewinding a generator with modern windings and insulating materials boosts operating efficiencies and may increase unit capacity.

Since 2009, Reclamation regional power programs have collectively replaced 32 turbine runners. On average, new turbines improve operating efficiencies by 3 percent, which equates to over 343 million kilowatt hours (kWh) of additional generation (given historic performance), the equivalent demand of over 30,000 homes. In that same period, Reclamation has added 11,000 kilowatts (kW) of capacity at our existing power facilities, with an additional 28,000 kW scheduled to come online by 2019.

Because most Reclamation hydropower facilities and power train equipment (e.g., turbines) were properly designed at their onset, opportunities to achieve efficiency and capacity gains are relatively limited. Nevertheless, Reclamation, in collaboration with our customers and stakeholders, will continue to evaluate and pursue capital investment projects, as appropriate, to better manage our water and generation resources and increase operational flexibilities.

In addition to conventional capital investment projects, Reclamation is also leveraging new computer-based technologies to optimize power generation.



Elephant Butte Powerplant, New Mexico.

In 2012 Reclamation began creating and implementing a flexible, stand-alone hydropower optimization system, Hydro Optimization System (HydROS), using modern computing hardware and algorithms.

Hydropower plants operate within a variety of operational and institutional constraints, including rough and cavitation zones, ramping rates, voltage and frequency control requirements, water supplies, environmental targets, etc. The optimization system navigates these constraints to recommend the optimal unit commitment and loading levels to plant operators to meet specific power or flow rates. In effect, the system maximizes the hydropower output for each acre-foot of water that passes through the plant and offers a more cost-effective alternative to increase operating efficiencies relative to more conventional, capital investment methods (e.g., turbine replacements and generator rewinds).

HydrOS consists of five primary components: communications backbone, HydrOS optimization engine, visual interface, data logger, and offline simulation component. At this time, HydrOS has been installed at the Elephant Butte powerplant (comprising 27,945 kW of capacity) and the Black Canyon Control Center (which oversees four powerplants: Anderson Ranch, Black Canyon, Minidoka, and Palisades, comprising 254,464 kW of capacity). Initial results indicate an estimated 2% efficiency increase in hydropower generation—or over 18.8 million kWh of additional generation (given historical performance), the equivalent demand of over 1,700 homes. An analysis is currently ongoing to verify these results.

In addition, an inter-agency agreement has been executed between Reclamation and USACE for HydrOS support. Some of the new features currently under development include considering condensing units for spinning reserve (i.e., reserve capacity synchronized to the grid, ready to meet demand within a short time interval), condensing units for efficiency gains rather than shutdown, and better detection of instances where an optimization could not be calculated due to conflicting operational constraints. These improvements can help increase the value and capabilities that hydropower can provide to the grid.

HydrOS installations are also scheduled for the Casper Control Center (which oversees 20 powerplants, comprising 811,563 kW of capacity)¹ and the Glen Canyon Control Center (which oversees 8 powerplants, comprising 1.7 million kW of capacity)². A 2% efficiency increase across these facilities would result in an additional 151 million kWh of generation (given historical performance), the equivalent demand of over 13,000 homes.

To complement HydrOS, Reclamation is also collaborating with the Department of Energy and Power Marketing Administrations to explore additional potential applications for HydrOS outputs, specifically in long term planning and forecast models.

Bureau of Reclamation Sustainable Energy Strategy

Reclamation's Sustainable Energy Strategic Plan (2013) provides guidance as the agency continues its vital role in developing and supporting renewable energy production for the nation's power grid.

Six long-term strategic objectives to further Reclamation's sustainable energy mission were developed to help guide Reclamation in this important endeavor:

- *Increase renewable generation from Reclamation projects.*
- *Facilitate non-Federal development of renewable energy projects.*
- *Increase energy savings and conservation at Reclamation projects.*
- *Support integration of variable non-dispatchable renewable resources in the United States' electrical grid.*
- *Increase benefits of renewable energy through technological innovation.*
- *Improve management efficiencies related to the implementation of renewable energy and energy savings projects.*

¹ Alcova, Big Thompson, Boysen, Buffalo Bill, Canyon Ferry, Estes, Flatiron, Fremont Canyon, Glendo, Green Mountain, Guernsey, Heart Mountain, Kortess, Marys Lake, Pilot Butte, Pole Hill, Seminoe, Shoshone, Spirit Mountain, and Yellowtail.

² Blue Mesa, Crystal, Flaming Gorge, Fontenelle, Glen Canyon, Lower Molina, Morrow Point, and Upper Molina.

Hydropower Provides Stability that Supports Using Other Renewable Energy Sources

Wind and solar energy are valuable energy resources that support climate change adaptation strategy objectives. However, both resources are variable: clouds may dim the sunshine, winds may subside. Given this variability, wind and solar energy integration requires grid support services (“ancillary services”) to ensure that electricity supply equals demand.

Hydropower is a dynamic, renewable energy resource, uniquely fitted to provide the ancillary services necessary to integrate variable renewables. Examples of ancillary services include:



Contingency reserves, wherein supplemental capacity is synchronized to the grid and available should a contingency occur.

Frequency response, wherein supplemental capacity is available to stabilize frequency if a deviation occurs on the grid.

Hoover Dam, Nevada.

Hydropower contingency reserves and frequency response can be made available to the grid within seconds of a contingency event or deviation—much quicker, cleaner, and efficient than alternative energy resources.

Climate change may threaten Reclamation’s ability to support renewable integration as changes in water supply and increased competition for water use could limit the available capacity and flexibility to provide ancillary services. However, actions to increase water management flexibility, including hydropower optimization, turbine replacements, and generator rewinds, can help mitigate these climate change impacts.

Goal 2: Enhance Climate Adaptation Planning

It is Reclamation's Policy to "determine climate change impacts to its mission, facilities, operations, and personnel, and identify appropriate climate change adaptation strategies" (Climate Adaptation Policy, CMP-P16). As recognized in the Third National Climate Assessment, the "pace and magnitude" of projected climate changes highlight the need to be prepared for a "wide range and intensity of projected climate impacts in the future." To ensure the continuation of Reclamation's mission long into the future, Reclamation's Climate Strategy recognizes the need to incorporate climate change considerations early on when planning longer-term adaptation strategies, such as infrastructure investments or policy and operational changes, implemented over years or even decades.

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. Reclamation's Climate Change Adaptation Strategy Goal 2: **Enhance Climate Adaptation Planning** directly addresses this need and includes:

- Enhanced Basin Studies and West Wide Climate Risk Assessments (WWCRA)
- Research to advance understanding of climate impacts to extreme events and ecosystems
- Expanded General Planning
- Drought Response Program
- Climate Change Training

Significant achievements have been made in the areas of enhanced Basin Studies, Climate Change Training and the Drought Response Program since the release of Strategy in 2014. Those achievements are highlighted in this section.

"Over the past few years, the focus moved from the question "Is climate changing?" to the equally important question: "Can society manage unavoidable changes and avoid unmanageable changes?"

Research demonstrates that both mitigation (efforts to reduce future climate changes) and adaptation (efforts to reduce the vulnerability of society to climate change impacts) are needed in order to minimize the damages from human-caused climate change and to adapt to the pace and ultimate magnitude of changes that will occur."

–Third National Climate Assessment

Reclamation contributes to the Department's Priority Goal for Climate Change Adaptation Management through multiple efforts, including incorporating climate change data into at least five Reclamation-wide or regional planning efforts in the 2016-17 time frame for the goal.

FY 16-17: DEPARTMENT OF THE INTERIOR AGENCY PRIORITY GOAL

Climate Change Adaptation Management

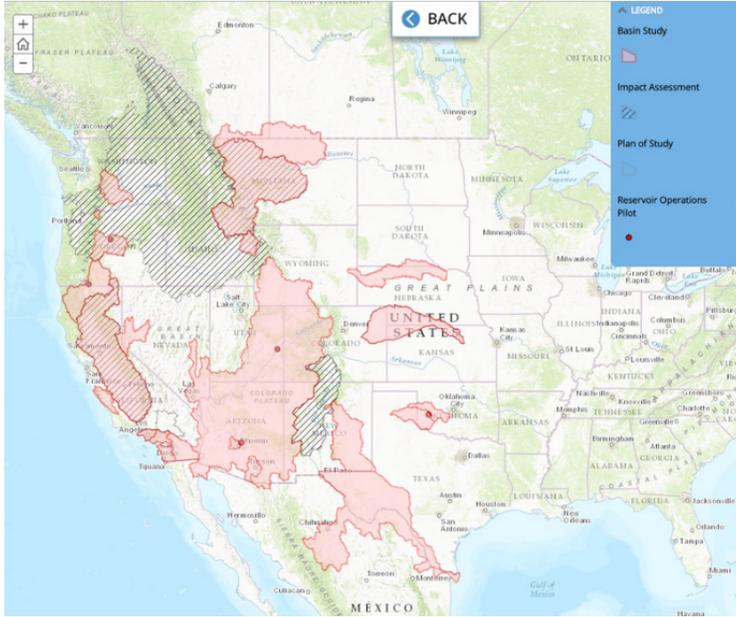
Understand, communicate, and respond to the diversity of impacts associated with climate change to improve the resilience of the nation's communities, natural resources, and safeguard our cultural heritage sites. By September 30, 2017, the Department of the Interior will mainstream climate change adaptation and resilience into program and regional planning, capacity building, training, infrastructure, and external programs, as measured by scoring at least 300 of 400 points using the Strategic Sustainability Performance Plan scorecard.

THEMES: Natural Resources and Environment



Enhanced Basin Studies and WWCRA

Conducting the Basin Studies, WWCRA, and the LCCs continues to be an important component of Reclamation's climate adaptation planning efforts. These activities are complementary and represent a comprehensive approach to assessing climate change impacts on Reclamation's mission and the identification of adaptation strategies.



Basin Study locations from the Data Visualization Tool Map, www.usbr.gov/watersmart/2010-2016.

Through the WWCRA, Reclamation develops baseline information about the risks and impacts of climate change to water supplies and demands, as well as Reclamation's operations. The information developed through the WWCRA is used in Basin Studies to work collaboratively with stakeholders to evaluate the ability to meet future water demands and identify mitigation and adaptation strategies. Reclamation shares the information developed through WWCRA and Basin Studies with resource managers through the LCCs. Collaboration with partners through the LCCs and Basin Studies, in turn, helps to identify science needs and gaps that can be addressed by the WWCRA.

After releasing Reclamation's Climate Strategy in 2014, we have taken steps to enhance the Basin Studies by emphasizing consideration of climate change impacts to extreme events, such as flooding, and by building on completed basin studies. For example, in the Truckee River Basin Study, Reclamation performed a flood risk analysis that used downscaled climate projections to assess the potential changes in flood frequency and magnitude in the future under climate change. The maximum historical recorded flow in the Truckee Basin is 37,600 cubic feet per second (cfs), which occurred during the January 1997 record



Truckee River Flood in Reno, Nevada, in 1997.

flood. However, the Basin Study flood risk analysis projects that the likelihood of a flood event with flows from 20,000 to 40,000 cfs will increase by between 10 and 20 percent through 2050, and by 30 to 50 percent for the years 2050 to 2099. The increased risk of more severe flood events helped inform the range of adaptation strategies considered in the Basin Study.



LCC boundaries and project locations from the Data Visualization Tool Map, www.usbr.gov/watersmart/2010-2016.

As more Basin Studies are completed, Reclamation is supporting stakeholder-driven efforts following from the studies. For example, the Colorado River Next Steps activity builds from the Colorado River Water Supply and Demand Basin Study completed in 2014. The Next Steps, developed cooperatively by Reclamation, States, tribes, and various conservation organizations through the Basin Study, are being led by various stakeholders and include activities such as advancing the use of climate projections in future studies.

Reclamation is also supporting climate adaptation planning through the LCCs. Reclamation and the USFWS co-lead both the Desert and Southern Rockies LCCs, which have funded 44 projects since 2009 to develop tools and science that analyze and address climate change impacts.

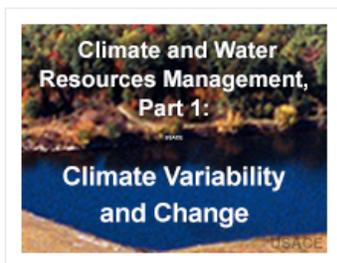
The Desert and Southern Rockies LCCs provide support for implementing Climate Change Adaptation Strategy Goal 2: ***Enhance Climate Adaptation Planning*** by:

- Convening cross-jurisdictional, multi-sector partners
- Assessing current and future landscape conditions
- Modeling and mapping landscape configurations that meet conservation goals
- Identifying strategies to implement actions in specific places to meet conservation goals
- Providing science that supports priorities and landscape assessment
- Communicating priorities, needs, and results across landscapes

Climate Change Training

Having sufficient staff with technical expertise to apply climate change information in the planning context is of critical importance to achieving Reclamation’s Climate Change Adaptation Strategy Goal 2: Enhance Climate Adaptation Planning.

Climate and Water Resources Management, Part 1: Climate Variability and Change



Languages: English
 Publish Date: 2016-02-25
 Skill Level: 1
 Completion Time: 1.00 - 1.25 h
 Includes Audio: yes
 Required Plugins: none
 Topics: Climate, Environment and Society, Hydrology/Flooding

BEGIN LESSON

Add to Queue Your Queue»

Take the quiz?
 Begin Quiz

Reviews:
 ★★★★★ (0 reviews)
[Read or add reviews](#)

Share this resource:
 [Social media icons] 0

COMET online training on climate and water resources management <http://tinyurl.com/cometclimate>.

In spring 2016, two new courses were piloted in Boulder, Colorado: one on the general principles for integrating climate change considerations into water resources management, and another focused more specifically on integrating climate change considerations into long-term planning and environmental compliance.

For more information on climate change training courses offered through Reclamation partnerships, please visit the website for Reclamation’s Research and Development Office at: www.usbr.gov/research.

Since 2012, Reclamation has been partnering with USACE, the University Corporation for Atmospheric Research (UCAR) COMET® Program, NOAA-Regional Integrated Sciences and Assessments (RISA) and other Federal agencies to develop climate change training

resources. Development of these resources was motivated, in part, by the *Departmental Guidance for Enhancing Employee Climate Change Literacy and Capabilities* established by the Deputy Secretary on March 21, 2016, and the *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate* (2011). Two COMET Professional Development Series are being developed and delivered as pilots:

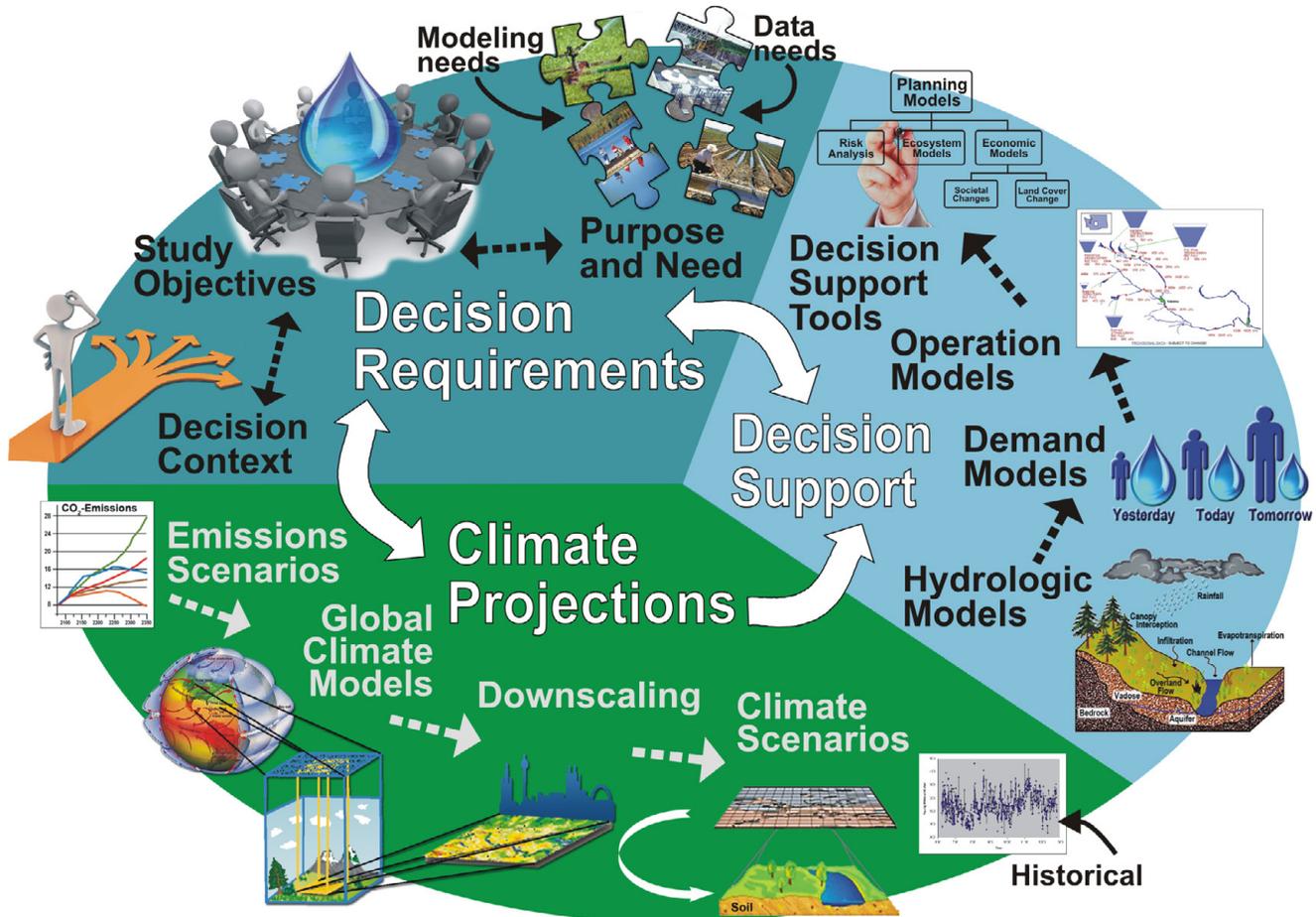
Courses for Technical Water Resources Professionals

To date, Reclamation and its partners have piloted eight courses in this series, some with multiple offerings, reaching both Federal and non-Federal students. Courses have featured a mix of online, self-paced, and instructor-led formats. One course, focused on hydrologic impacts under climate change, has been relatively more popular and has been piloted three times: first as an instructor-led in-person course and then twice again as an instructor-led virtual course to reach a larger, remote student audience at lower cost. Another in-person-to-virtual course conversion in 2016, focus on sedimentation impacts under climate change.

Courses for General Water Resources Audiences

Since 2015, Reclamation and its partners have offered a non-technical training series, *Integrating Climate Change Adaptation into Water, Environmental, and Land Resources Management* for general audiences interested in water resources. This series is aimed at less-technical audiences who play integral roles in helping their water organizations adapt to climate change. These audiences includes senior program and staff managers as well as staff responsible for implementation and developing policy, (e.g., project managers, resource specialists, and public affairs). This series is being developed to meet the needs of several general audience

communities playing a role in water management, including long-term planning and environmental compliance, environmental adaptive management, infrastructure asset management, dam safety, and reservoir operations. The series will feature a mix of course delivery formats including, online, self-paced, instructor-free web-courses and instructor-led residence or remote (virtual) courses. The initial two offerings were delivered in spring 2016, including one course on general principles in integrating climate change considerations into water resources management, and another focused more specifically on integration into long-term planning and environmental compliance.



Climate projections are incorporated into an overall decision process.

Next Steps

Next steps for the technical series include continuing to offer pilot courses while focusing on delivery formats that reach large student audiences at lower cost. For the general audience series, initial offerings are being planned for other sectors of water resources management, including infrastructure asset management, environmental adaptive management, dam safety, and reservoir operations. Ultimately, these courses will inform a sustained climate training, offered as needed, to ensure a climate literate workforce.

Drought Response Program

Drought Planning helps reduce the impacts of drought before a crisis occurs.

The drought contingency planning process addresses:

- How will we recognize the next drought in the early stages? Most drought plans include a monitoring plan to collect water availability data to identify the onset of drought and to assess its severity.*
- How will drought affect us? A “vulnerability assessment” is used to evaluate the risks to resources and sectors within the planning area and the factors driving those risks.*
- How can we protect ourselves from the next drought? Once drought risks have been identified, planners can identify mitigation and response actions to address those impacts.*

In FY 2015, Reclamation initiated the Drought Response Program to support a proactive approach to drought. The Drought Response Program provides assistance on a cost-shared basis to water users to conduct drought contingency planning, including consideration of climate change information, and to take actions that will build long-term resiliency to drought.

Reclamation has made consideration of climate change impacts a key element of the new Drought Response Program. Contingency plans funded through the program are required to include a vulnerability assessment to evaluate the risks and impacts of drought. This assessment is based on a range of future conditions, including the effects of climate change. The vulnerability assessment drives the development of potential mitigation and response actions identified in the plans. Mitigation actions identified in the plans will address future drought conditions as exacerbated by climate change. Those mitigation actions are eligible to be funded under the Drought Resiliency Projects component of the program, which prioritizes proposed projects that are supported by a drought contingency plan.



Steps in the planning process used in Reclamation’s Drought Program.

In FY 2015, the first year of program implementation, Reclamation selected 23 projects to receive \$5.2 million in grants for proactive drought plans and projects that will build long-term drought resiliency. Drought contingency plans help communities recognize drought in its early stages, identify the effects of drought and conduct drought prevention. Eleven drought contingency planning projects received \$1.8 million in FY 2015. In FY 2016, approximately \$4.9 million will be allocated to 23 new financial assistance agreements. Approximately \$1.3 million of this funding will be allocated to 9 Contingency Plans and approximately \$3.6 million will be allocated to 14 new Resiliency Projects.

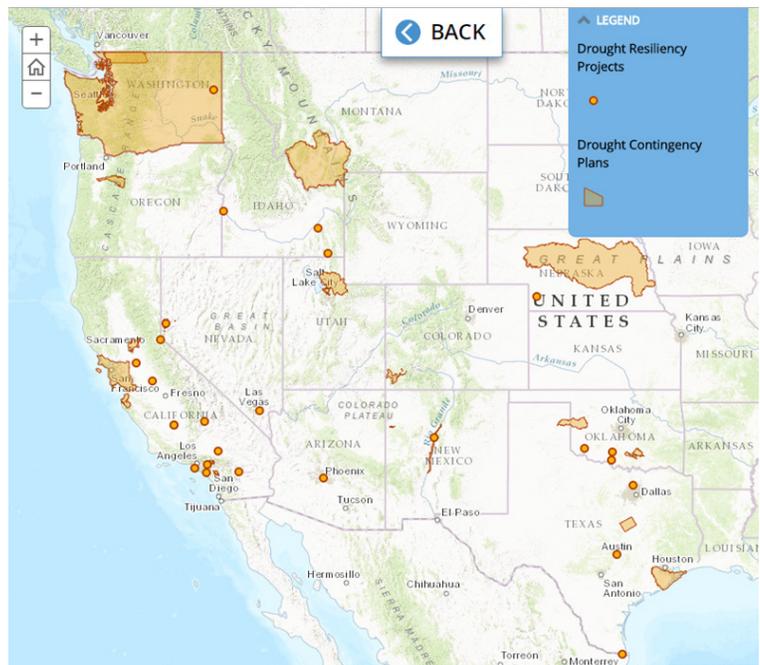
As an example, the Choctaw and Chickasaw Nations received funding in 2015 to prepare a Regional Drought Contingency Plan for their territory in south-central Oklahoma. The Arbuckle Simpson Aquifer covers approximately 500 miles and is the principal source of water for more than 100,000 people. The aquifer supplies water for mining and irrigation and is the source for nearly 100 known springs that are culturally important and that generate approximately \$100 million in tourism revenue per year. The area experienced an exceptional drought from 2010 until spring 2015, causing significant economic hardships and requiring emergency actions, such as hauling water and drilling emergency wells. Through this project, the Nations are working with the South Central Climate Science Center to incorporate climate change information into their drought contingency plan. The plan will build on the vulnerability assessment to identify mitigation and response actions that can be implemented at the local level.

Drought Resiliency Projects are intended to help communities prepare for and respond to drought and to adapt to climate change. In Texas, the Southmost Regional Water Authority was awarded a \$300,000 Drought Resiliency Project Grant in 2015. The Authority is using the funding to develop a monitoring and management program for brackish groundwater wells in the area to ultimately decrease dependence on the Rio Grande River. The region, which recently suffered a record 4-year drought, relies on drought-proof alternative water supplies to augment fluctuating surface water supplies. The project supports implementing an adaptation strategy identified in the Rio Grande Basin Study.

“Droughts are cyclic in nature. Even if we get out of the one we are in now, it will be back, either in California or somewhere else.”

“It behooves us as water managers to create drought contingency plans so that the next time we face a drought, we have a better understanding of the actions we need to take to minimize the adverse impacts.”

–Commissioner López



Drought Response Program Locations from the Data Visualization Tool Map, www.usbr.gov/watersmart/2010-2016.

Goal 3: Improve Infrastructure Resiliency

To ensure that our infrastructure is sufficient to accommodate new extremes and support healthy and resilient watersheds, it is essential that Reclamation act proactively to maintain and improve existing infrastructure for system reliability, safety, and efficiency (e.g., water conservation). Modifying Reclamation's infrastructure for the impacts of climate variability will contribute to addressing the many stressors impacting investments in infrastructure. Reclamation will continue to identify opportunities to integrate operational efficiencies that are more compatible with climate change adaptation goals while investing in our existing infrastructure. These efforts directly support the second pillar of the President's Climate Action Plan, to prepare the United States for the Impacts of Climate Change," by "Building Stronger and Safer Communities and Infrastructure," "Maintaining Agricultural Sustainability," and "Preparing for Future Floods." Improving resiliency of infrastructure investments is achieved by identifying those areas where climate impacts are identified that impact infrastructure investments.

Reclamation's Climate Change Strategy Goal 3: **Improve Infrastructure Resiliency** includes:

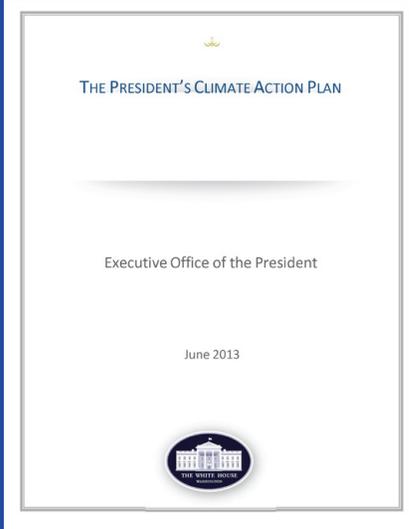
- Dam Safety Climate Change Assessment Pilots
- Western Watershed Enhancement Program
- Infrastructure Replacement, Repair, and Renovations

Progress on each of these activities is discussed in this section.



Nimbus Dam, California, releases during the 1986 flood.

The President's Climate Action Plan



“The President will direct Federal agencies to identify and remove barriers to making climate-resilient investments; identify and remove counterproductive policies that increase vulnerabilities; and encourage and support smarter, more resilient investments . . . in sectors from transportation and water management to conservation and disaster relief.”

“Agencies will also be directed to ensure that climate risk-management considerations are fully integrated into Federal infrastructure and natural resource management planning.”

Dam Safety Climate Change Assessment Pilots

Mission Statement of Reclamation's Dam Safety Office:

"To ensure Reclamation dams do not present unreasonable risk to people, property, and the environment."

In the spring of 1976, Teton Dam was the site of the most significant failure of a Bureau of Reclamation project in the agency's history. The failure of Teton Dam served as a catalyst for Reclamation's Dam Safety Program. For decades, Reclamation's Dam Safety Office has stood out internationally as a leader in its field. While Reclamation has always been concerned with the safety of its facilities, the failure of Teton Dam ushered in a new era of understanding and managing risk.

The Dam Safety Program is pursuing Reclamation's goal of increasing infrastructure resiliency by considering future climate in evaluating the hydrologic risks associated with Reclamation's high and significant hazard dam inventory. The Dam Safety Program analyzes and addresses the hydrologic risks associated with Reclamation's dams through a tiered risk analysis process, referred to as a "hydrologic hazard analysis." The process begins during the Comprehensive Review (CR) with a fundamental risk analysis that uses readily available information. Reclamation completes CRs on an eight-year cycle for every high and significant hazard dam in Reclamation's inventory. If there is evidence to suggest Reclamation's Public Protection Guidelines may not be achieved, then more in-depth analysis is done through issue evaluations (IE). If the issue evaluation results indicate that the Public Protection Guidelines are not being achieved, then a corrective action analysis (CAA) process is initiated.

To achieve the goal of increasing infrastructure resiliency by considering climate change, the Dam Safety Program is funding two pilot efforts that will develop methodologies to integrate existing climate change data into hydrologic hazard analyses. The first pilot, begun in FY 2013, seeks to evaluate the utility and effect of incorporating climate change information into the issue evaluations phase, with the end goal of quantifying the potential effects of climate change on the hydrologic hazards for dams. The second pilot, begun in FY 2015, seeks to incorporate current climate change projections into the CR process.

Pilot 1: Issue Evaluation Level Pilot Study. The first pilot, initiated in April 2013, is exploring using climate change information within a high level, complex, hydrologic hazard evaluation. Friant Dam, near Fresno, California. Friant Dam was chosen for the first pilot because it was identified during the CR process as having hydrologic risks that are potentially above Reclamation's Public Protection Guidelines. In addition, numerous studies are available on climate change cause and effect relationships in this area of the country. The pilot uses a stochastic event flood model (SEFM) to simulate potential floods from statistical representations of rainfall, snow-pack, storm patterns, temperature, soil moisture and other related variables. SEFM is one of the more technologically complex and advanced tools available for hydrologic hazard analysis at Reclamation dams. Results to date indicate that simulated extreme flood events influenced by climate change have differences in flood peak occurrences and magnitudes, and runoff durations than simulations that do not consider climate change. However, the large uncertainties associated with extreme flood event estimates generated from historic data generally surround the results from climate change informed estimates.

The final phase of this first IE pilot will conclude with the completion of the Friant Dam IE risk analysis. The results were presented to the Dam Safety Advisory Team (DSAT) September 16, 2016. All documents associated with the IE will be published in early FY 2017. The findings and lessons learned from the pilot will be used in future IE pilots for basins that have different climate regimes from the Friant Dam basin. Taylor Park Dam, near Gunnison, Colorado, is currently undergoing a hydrologic IE and will be the subject of the next pilot. This IE is currently scheduled to be complete in December 2018.

Pilot 2: Screening Level Pilot

Study. Dam Safety CRs currently use fundamental statistical analysis of existing (historic) readily available hydrologic and paleo-geologic data to assess the potential hydrologic hazards at Reclamation dams. The Dam Safety Office is conducting a pilot study to evaluate if and how climate change information can be incorporated into these screening level hydrologic analyses. The pilot began in FY 2015 with 23 CRs, and this study includes a discussion component related to climate change and hydrologic hazard. This pilot will continue through FY 2017, when 89 high hazard dams will have been qualitatively assessed for potential climate change effects.

Concurrently in FY 2017, the results from the 55 climate change analyses will be evaluated to look for patterns, trends, usefulness, and also to assess how the analysis can be improved. In FY 2018, results may be considered along with the FY 2015 and FY 2016 data. Then the Dam Safety office will request that the TSC's Hydrologic Hazard Guidelines be updated to include how climate change adaptation information should be incorporated into the CR and IE processes.



Reclamation's Clear Creek Dam (near Yakima, Washington), overtopping flood event, December 9, 2015.

Policy and Guidelines. Reclamation is taking the lead on a revision to Part 753 of the Departmental Manual, Dam Safety and Dam Security Programs. The revision will add a new section committing bureaus to develop and periodically their policy and guidance to address climate change adaptation as the science advances and the impacts become more quantifiable. A draft is currently under solicitor review, and DOI approval is anticipated to be complete by the end of FY 2017. As part of this effort, 52 policy and guideline documents were identified that impacted the six Interior agencies that own or regulate dams. It was determined that nine additional documents will need to be revised to reflect potential climate change impacts on dam safety. Three more documents may warrant revision after Reclamation's pilot projects have been completed.

Infrastructure Repair, Replacement and Renovation Investments

Reclamation is taking steps now to address the challenges of incorporating climate change information into decisions about *infrastructure repair, replacement, and renovation investments*



Cofferdam failure during 1986 flooding.

Reclamation is the nation’s largest wholesale water supplier, operating 337 reservoirs with a total storage capacity of 245 million acre-feet an acre-foot, 325,851 gallons of water, supplies enough water for a family of four for one year).

It is a Reclamation priority to:

- Operate and maintain projects in a safe and reliable manner, protecting the health and safety of the public and Reclamation employees and improving financial accountability and transparency to our contractors.*
- Plan for the future using programs that focus Reclamation’s financial and technical resources on areas in the West where conflict over water either currently exists or is likely to occur in the coming years.*

and protect infrastructure by supporting healthy and resilient watersheds. Reclamation is developing an enhanced decision making framework for prioritizing these types of infrastructure investments, including an approach to determine when climate change information should be incorporated into the design process.

The decision framework is also coupled with new design criteria to assist in the process identifying climate resilient alternatives. The decision framework and design criteria will be tested in

FY 2017 through a pilot process, using infrastructure investments that have the greatest potential to be influenced by climate impacts. Once the investments are selected, the decision making framework and design criteria will be evaluated for effectiveness and adjusted for optimization. The results will be reapplied to infrastructure investment opportunities in out-years.

These efforts will contribute to Reclamation’s climate change adaptation goals. The process will leverage existing baseline assessments and new scientific methods of determining climate variability impacts and other information. Additionally, this information can be incorporated into the final plans of the proposed infrastructure investment to refine and improve the actual project design.

Table 3. Reclamation Reservoirs and Control Structures

245	Million acre-feet of total water storage capacity in Reclamation dams/reservoirs
337	Reservoirs impounded by Reclamation dams
475	Dams maintained by Reclamation
8,116	Miles of irrigation canals for which Reclamation is responsible

Western Watershed Enhancement Program

The Western Watershed Enhancement Partnership (WWEP) was formally established in July 2013, by Secretary of the Interior, Sally Jewell, and Secretary of the U.S. Department of Agriculture, Tom Vilsack. Through the WWEP, Reclamation partners with the U.S. Forest Service (USFS) and others on a multijurisdictional, watershed-scale basis to proactively protect, enhance, and restore watershed function to mitigate against wildfire threats to critical infrastructure. The partnership is a part of President Obama's Climate Action Plan, and is part of a comprehensive approach to preparing the United States for the impacts of climate change, including increased risk of wildfires and drought. These threats are increasing due to hotter, drier conditions and associated stresses associated with climate change.



The Glacier Creek to Mill Creek Fuel Reduction Project focuses on reducing fuel loads to help prevent wildfires from spreading and improve watershed health by enhancing existing fire barriers, such as roads, trails and rivers on 210 acres in Rocky Mountain National Park in the headwaters of the Colorado-Big Thompson Project, Colorado.

In May 2016, Interior announced \$500,000 in WWEP grants to five projects to improve watershed health, reduce wildfire risk, restore wildlife habitat and mitigate the impacts of post-wildfire erosion and sedimentation loss. Projects included: Boise River Pilot Project (Idaho), Cragin Watershed Protection Project (Arizona), Hemlock Project (California), Glacier Creek to Mill Creek Fuel Reduction Project (Colorado), and the Yakima Watershed Enhancement Project (Washington).

As an example, to reduce severe wildfire risk on 730 acres within the catchment basin that flows into Reclamation's Rimrock Lake behind Tieton Dam, about 40 miles west of Yakima, Washington, Reclamation and USFS are partnering with the Washington Department of Ecology, the Yakama Nation, and others on the Yakima Project and Okanogan-Wenatchee National Forest, Washington. This project targets fuel reductions in an area with a recent history of unusually destructive wildfires and contributes to efforts under the Yakima Basin Integrated Plan.

Goal 4: Expand Information Sharing

Reclamation continues to recognize the need to demonstrate leadership and leverage resources by sharing information and capabilities with partners interested in climate adaptation. Reclamation is working on near-term and long-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.”

Reclamation’s Climate Change Adaptation Strategy Goal 4: *Expand Information Sharing includes:*

- Improve access to water and hydropower data through the Open Water Data Initiative
- Coordinate climate adaptation activities with partners and stakeholders



Executive Order 13642 (2013)– Making Open and Machine Readable the New Default for Government Information.

Section 1. General Principles. “Openness in government strengthens our democracy, promotes the delivery of efficient and effective services to the public, and contributes to economic growth. As one vital benefit of open government, making information resources easy to find, accessible, and usable can fuel entrepreneurship, innovation, and scientific discovery that improves Americans’ lives and contributes significantly to job creation.”

What is Open Data?

invalid bareword "detected" in expression "detected-0"; should be "\$detected" or "{detected}" or "detected(...)" or ... (parsing expression "detected-0")

Machine-readable output

Commonly-used formats

Accessible via the Internet (i.e., free)

Manual and automated data retrieval options

RECLAMATION

Open data have machine-readable output in commonly used formats. Data are freely accessible via the internet, and programs provide manual and automated ways to retrieve the data.

Open Water Data Initiative

The Open Water Data Initiative will:

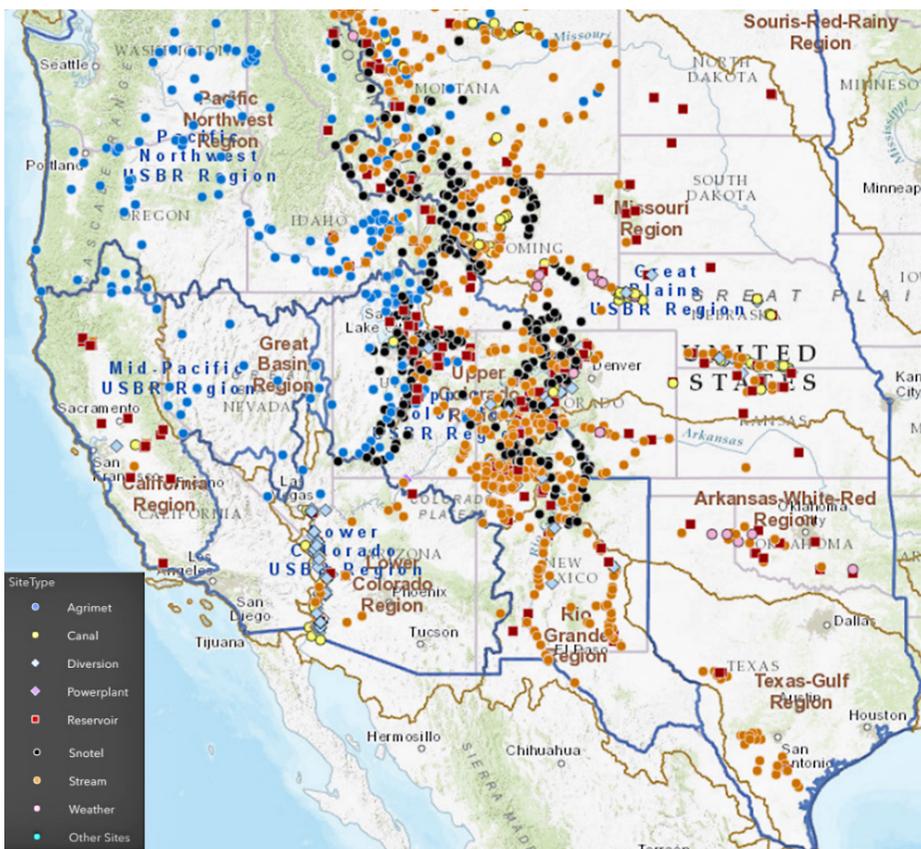
“Integrate currently fragmented water information into a connected, national water data framework and leverage existing systems, infrastructure and tools to underpin innovation, modeling, data sharing, and solution development.”

–Advisory Committee on Water Resources

Through Science and Technology (S&T) Program appropriations, Reclamation is addressing the requirements of the President’s Executive Order—Making Open and Machine Readable the New Default for Government Information and the Open Water Data Initiative (OWDI). Reclamation is taking steps to improve the management of the agency’s water and related data, and to ensure that data is more comparable across locations, more easily found, and more readily shared with other agencies, stakeholders, and the public.

To support sound use of appropriations in pursuit of these goals, Reclamation formulated an internal Open Data Team (ODT) in FY 2015 with bureau-wide representation. The ODT is identifying bureau-wide needs and strategic recommendations that may be implemented through a mix of technology, tool development, and demonstration activities. The ODT is considering goals with respect to multiple water and water-related data domains, including: reservoir operations and river flows, hydropower, species recovery and river restoration, lands, structures, etc.

Initial activities are focused on providing foundation for better decision-support by modernizing data standards and data management systems. An important example of this foundational activity is the *Reclamation Water Information System—Proof of Concept Project* launched in April 2016. The goal of this pilot is to demonstrate the conversion of Reclamation’s disparate sources of time series water data to a machine-readable resource that can be disseminated to our stakeholders and the general public through a web portal, under the guiding principles of data stewardship and open-sourced information technology.



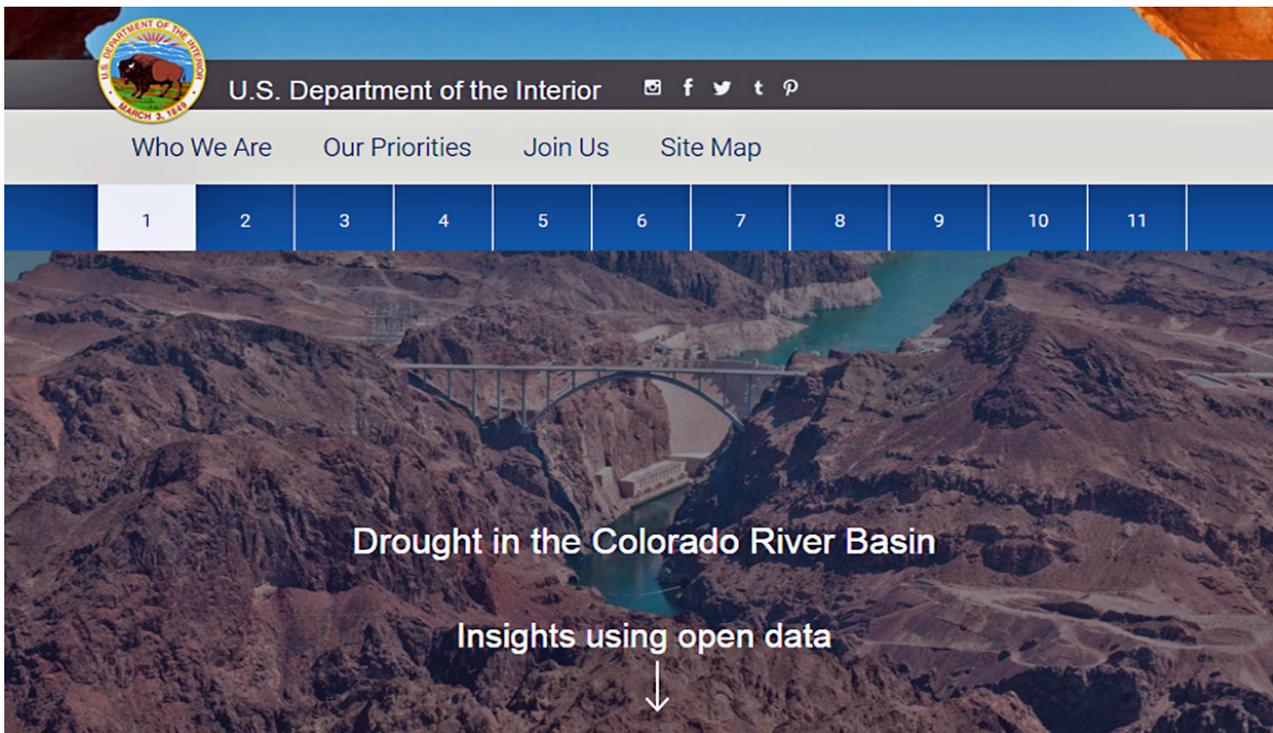
RWIS water monitoring sites map.

The RWIS system will serve as a proof of concept for a possible future long-term operational system incorporating the full range of water data types managed by Reclamation. This pilot is being implemented by a bureau-wide team, including reservoir data specialists, information technology engineers, and information security experts. The pilot will provide a concept-level, Reclamation-wide system for sharing water related time series data from each of Reclamation's five Regions. The system will include a public facing website, a web portal with a web service, map interface, and query interface, and supporting system IT infrastructure.

Reclamation and Interior partners released **the Colorado River Drought Visualization Tool** in December 2015, another example of an open data product. The visualization is part of a multi-agency effort to showcase the usefulness of open data (i.e., data provided in a discoverable, sharable, and machine-readable format) by exploring the current 16-year drought and its effects on the Colorado River Basin. The tool blends a narrative of the drought with interactive graphics and data.

The Reclamation Water Information System is a pilot effort to develop a consolidated reservoir water database and to make data available through an interactive map. Once completed in the second quarter of 2017, the website will allow stakeholders to:

- *Search for water data by location or data type with the query tool*
- *Get raw datasets as input for models and analysis via downloads or a web service*
- *Use the web service URL to feed data to users' own applications*



Colorado River Drought Visualization, www.doi.gov/water/owdi.cr.drought/en/index.html.

Next steps include developing similar foundational pilots for other data domains (e.g., hydropower, species recovery and river restoration, lands, structures, etc.) and development and demonstration of tools that operate on these foundational consolidated data resources to provide improved resource management decision-support.

Coordinate Climate Adaptation Activities with Partners and Stakeholders

SECURE Water Act Report

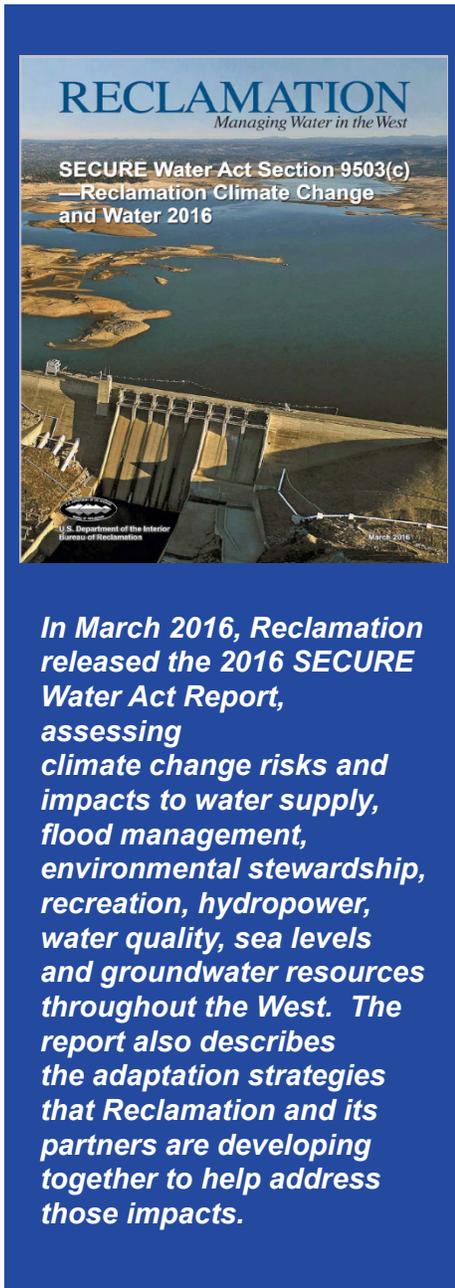
Section 9503 of the SECURE Water Act, Subtitle F of Title IX of P.L. 111-11, requires that Reclamation report to Congress every five years on implementing climate change adaptation activities. Reclamation released our second report to Congress on March 22, 2016. The report focuses primarily on summarizing the effects of climate change on water resources, adaptation strategies identified in build climate resilience through collaborative Basin Studies, and coordination with stakeholders to implement climate response actions in Western U.S. river basins.

The report provides a comprehensive summary of findings from across Reclamation, including 12 Basin Studies. Key findings include:

- In all western river basins, warming is expected to result in more rainfall-runoff during the cool season rather than snowpack accumulation, leading to increases in December-March runoff and decreases in April-July runoff —thereby reducing reservoir storage available in the summer season.
- The timing and quantity of runoff are expected to continue to be impacted by the changing climate. Together with changes in the magnitude and timing of the demands for water and energy, this will impact the ability of existing water infrastructure and water management practices to satisfy competing water demands.

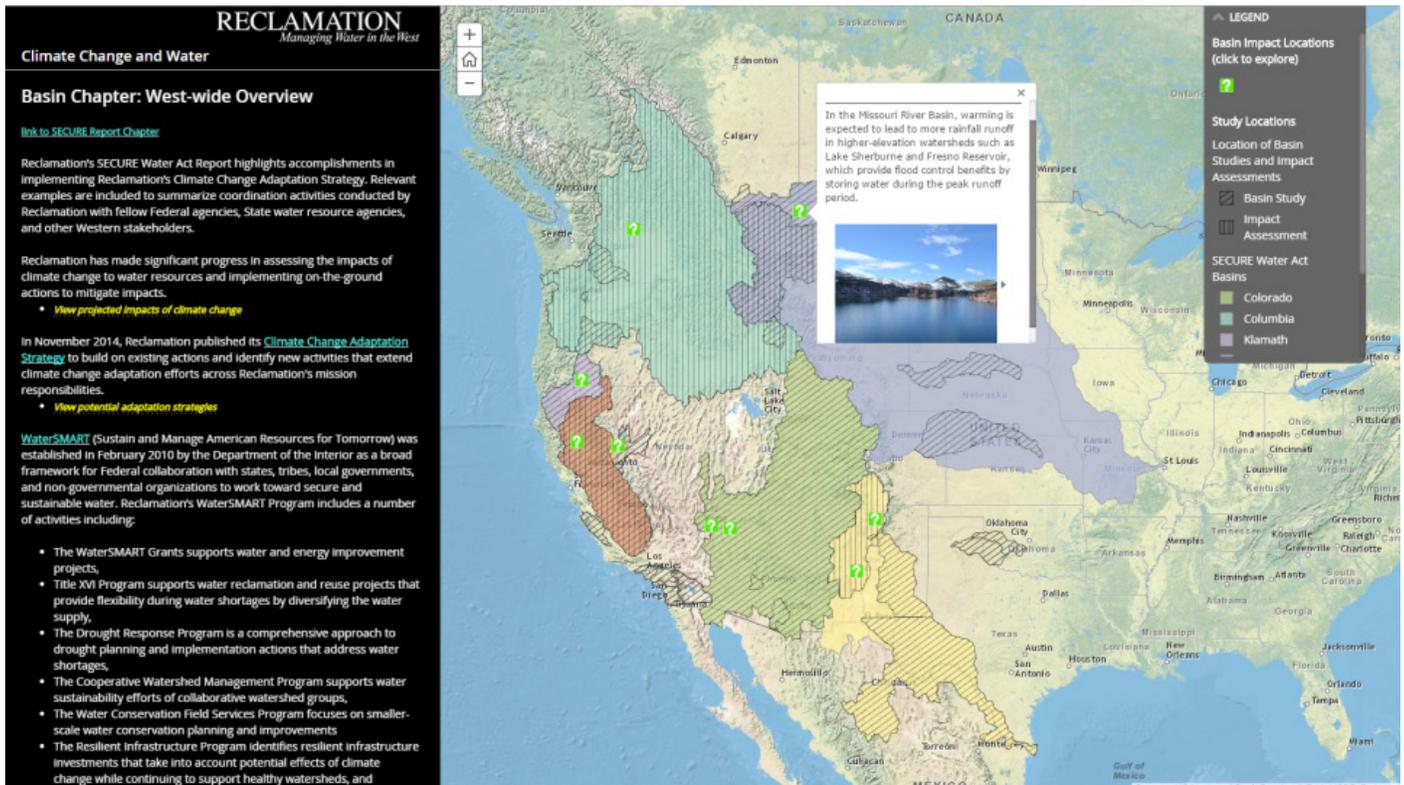
Reclamation, in consultation with stakeholders, has already begun to identify and develop a variety of adaptation strategies to address vulnerabilities related to drought and climate change in western river basins through the implementation of its Climate Change Adaptation Strategy.

Strategies to adapt to climate change include actions to augment water supply, manage demand, improve system operations, build ecosystem resiliency, and share data and information. The report also highlights activities being undertaken by Reclamation and its partners to implement some of those strategies, including accomplishments to date.



The SECURE Water Act has catalyzed collaboration between Reclamation and multiple stakeholders and has promoted the exchange of valuable technical assistance. With 24 Basin Studies now initiated, Reclamation has forged collaborative relationships in 15 of the 17 Western States with a diverse assortment of non-Federal partners, including state water resource agencies, tribal governments, regional water authorities, local planning agencies, water districts, agricultural associations, environmental interests, and cities and counties.

Reclamation also developed a web-based visualization of climate data that mirrors the narrative of the SECURE Water Act Report to Congress. The SECURE Water Act Report Data Visualization Tool displays projected changes in temperature, precipitation, and snowpack as well as bias-corrected and spatially downscaled surface water projections throughout the major river basins in the 17 Western States. The Data Visualization Tool is intended to act as a companion product that not only allows the public to access and interact with climate data, but also to download large climate-related datasets, technical assessment reports, and collaborative planning studies at one central site.



SECURE Water Act Report Data Visualization Tool: <http://tinyurl.com/SecureWater>.