



— BUREAU OF —  
RECLAMATION

# Climate Change Adaptation Strategy



## Acronyms and Abbreviations

BIL	Bipartisan Infrastructure Law
CCAS	Climate Change Adaptation Strategy
D&S	Directives and Standards
DWPR	Desalination and Water Purification Research
ESA	Endangered Species Act
FY	Fiscal Year
HCP	Habitat Conservation Plan
HydrOS	Hydropower Optimization System
MWh	megawatt-hours
NEPA	National Environmental Policy Act
NDRP	National Drought Resilience Partnership
R&D	Reclamation's Research and Development Office
Reclamation	Bureau of Reclamation
RISE	Reclamation Information Sharing Environment
S&T	Reclamation's Science and Technology Office
SECURE	Science and Engineering to Comprehensively Understand and Responsibly Enhance
West	Western United States
WWCRA	West-Wide Climate Risk Assessment

# Table of Contents

<b>4</b>	<b>Climate Change Adaptation Strategy</b>
<b>10</b>	<b>Goal 1: Increase Water Management Flexibility</b>
<b>14</b>	<b>Goal 2: Enhance Climate Adaptation Planning</b>
<b>19</b>	<b>Goal 3: Improve Infrastructure Resilience</b>
<b>24</b>	<b>Goal 4: Expand Information Sharing</b>
<b>28</b>	<b>Partnerships</b>

Cover photo: Lake Mead, Nevada

# Climate Change Adaptation Strategy

The Western U.S. (West) is experiencing severe water resources impacts due to climate change. These impacts have caused unprecedented water management conditions rendering historical practices insufficient to meet our future needs. Water management challenges under climate change are here now and are impacting a significant number of Americans by threatening communities, economies, and cultures. For instance, in the Colorado River Basin, studies show the ongoing drought is unprecedented in over 1,000 years. Nationally, the annual acreage burned by wildland fires has roughly quadrupled in recent decades. Extreme weather, such as the 2021 Northwest heat wave, is bringing wide-ranging impacts, including serious public health consequences. These conditions are being driven and exacerbated by human-caused climate change.

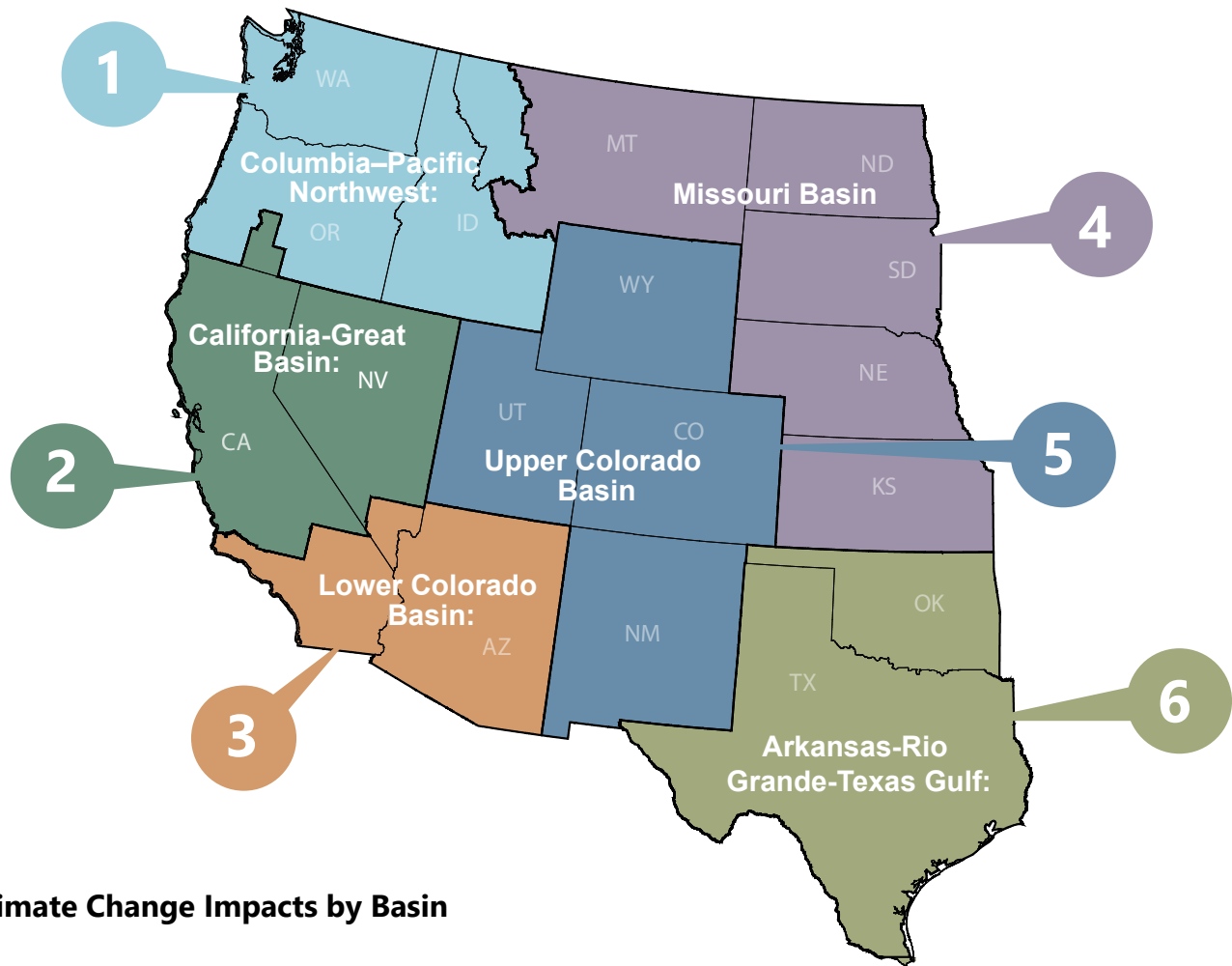
The Bureau of Reclamation (Reclamation) is the Nation's largest wholesaler of water and

second largest producer of hydropower. Climate change—including current and projected conditions—strikes at the core of Reclamation's mission to deliver water and generate power in an economically and environmentally sound manner in the interest of the American public.

Drought fueled by climate change impacts the quantity and quality of water available to meet competing objectives. Below-average inflows and depleted reservoir levels reduce allocations and deliveries to customers, degrade production of clean energy via hydropower facilities, and make it difficult to meet flow and temperature targets for threatened and endangered species. Similarly, the changing dynamics of wildfire create acute and long-term challenges for water management. Fire has the potential to damage water and power infrastructure, and burned watersheds can experience radical changes that impact water quality and runoff characteristics.



**Drought fueled by climate change impacts the quantity and quality of water available in the West.**



### Climate Change Impacts by Basin

- 1. Columbia-Pacific Northwest: Earlier Runoff**  
 Warming temperatures have moved peak snowmelt to earlier in the year, complicating water management and the ability of suppliers to meet competing demands.
- 2. California-Great Basin: Decreased Snowpack**  
 With peak runoff occurring earlier in the year, water resources are increasingly stressed in the late summer months.
- 3. Lower Colorado Basin: Record Drought**  
 Prolonged drought has resulted in record-low storage levels on Lake Powell and Lake Mead, key hydropower generators for much of the Southwest.
- 4. Missouri Basin: Increased Precipitation**  
 In June 2022, devastating floods in Montana destroyed homes and transportation infrastructure, including the North Entrance Road to Yellowstone National Park.
- 5. Upper Colorado Basin: Shifts in Streamflow Regime**  
 Earlier peak streamflow has stressed water supply in summer months, increasing the likelihood of conflict.
- 6. Arkansas-Rio Grande-Texas Gulf: Record Temperatures**  
 Temperatures throughout the region are expected to rise by an additional 4 to 10° F by the end of the 21st century, increasing evaporation from surface reservoirs.

The Climate Change Adaptation Strategy (CCAS) presented in this document affirms Reclamation’s commitment to bring leading science and engineering to this significant challenge. Reclamation is working to astutely respond to the issues of today and diligently prepare for those to come. To do this, we are building upon over a decade of Reclamation’s investments in climate science and studies that have yielded tools, data, and experience to respond appropriately. This foundation, coupled with new infusions of funding and priority—such as the authorizations included in the Bipartisan Infrastructure Law (BIL)—provide the basis and means for responsible, necessary action.

The scope of this undertaking is far-reaching, and the gravity could not be greater. We recognize that an effective and appropriate response to climate change is broader than Reclamation. It must be deliberate and collaborative—in lockstep with partners and stakeholders—including power customers and water users, State and Tribal governments, Federal agencies, non-governmental organizations, and the public. With this broad coalition, we have the expertise to monitor and understand changes, the innovation to mitigate impacts, and the will to take meaningful action.

Reclamation’s CCAS supports implementation of:

- Science and Engineering to Comprehensively Understand and Responsibly Enhance (SECURE) Water Act, P.L. 111-11, Section 9503
- Executive Order 13990: “Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis”
- Executive Order 14008: “Tackling the Climate Crisis at Home and Abroad”
- Secretarial Order 3399: “Department-Wide Approach to the Climate Crisis and Restoring Transparency and Integrity to the Decision-Making Process”
- Department of the Interior’s Climate Adaptation and Resilience Plan



**The increasing extent of wildland fires is creating critical challenges for water management.**

These efforts demonstrate Department of Interior and government-wide emphasis and priority for taking impactful action to secure and protect our Nation and natural resources for generations to come. Reclamation is, and will continue to be, highly engaged in Department efforts related to climate change, ensuring a coordinated and efficient response to the climate crisis.

Building upon previous Reclamation climate adaptation efforts, this CCAS is focused around four goals:

- Increase water management flexibility
- Enhance climate adaptation planning
- Improve infrastructure resilience
- Expand information sharing

Reclamation’s process to identify strategic activities under each strategy goal began with assessing status and current capabilities, followed by identification of opportunities to advance practices and strengthen our approach to addressing climate change in our mission, and to further invest in climate resilience to benefit Reclamation’s customers, partners, and the American public. The process involved engaging Denver directorates including Chief Engineer Organization (including Hydropower, Research and Development, and Water Resources Planning Office), Dam Safety & Infrastructure, Policy & Programs, and Technical Service Center, as well as region organizations. The result is an agenda of strategic activities. The following table outlines these activities, along with anticipated benefits. This agenda aligns with Reclamation efforts already underway, including many made possible through the BIL.

## Goal 1. Increase Water Management Flexibility

**Example Effort Underway:** \$8.3B over 5 years (2022 to 2026), including \$260M in 2022 for major rehabilitation and replacement of infrastructure, \$210M for development of new water supplies, \$160M for water conservation and efficiency improvements, and \$200M for water reuse and recycling projects

Actions	Benefits
Develop Lakes Powell and Mead Operational Guidelines	Establishes robust operating criteria to provide the Colorado River system the stability, certainty and flexibility needed to manage future challenges
Enhance hydropower operational efficiencies	Generates more renewable energy and conserves water
Develop water treatment and water conservation technologies, and improve approaches to achieving environmental compliance in water delivery management.	Increases water supplies and capacity to cope with the risks of climate change and variability from floods to droughts
Advance the application of watershed monitoring, water availability forecasting, and water management decision-support tools and products to increase climate resilience and adaptation	Modernizes tools and methods and increases capacity to understand and adapt to the impacts from climate change

## Goal 2. Enhance Climate Adaptation Planning

**Example Effort Underway:** Colorado River Basin Drought contingency planning efforts - \$300M authorized, \$50M in FY22 BIL

Actions	Benefits
Build climate resilience through planning and environmental review processes	Increases early-phase planning engagement with stakeholders on climate change, and supports inclusion of a quantitative climate change analysis in planning and environmental reviews
Develop guidance and methods for consideration of climate change in decisions	Supports climate resilient planning across a range of Reclamation activities
Work with stakeholders to assess climate change impacts on a basin-wide scale	Expands the types of climate change impacts considered in basin studies and provides additional support to stakeholders for climate adaptation planning

## Goal 3. Improve Infrastructure Resilience

**Example Effort Underway:** Analysis of climate impacts and identification of climate-resilient measures in planning and design of capacity restoration for Delta-Mendota and San Luis canals

Actions	Benefits
Operationalize Climate Change in Hydropower	Strengthens hydropower reliability, sustainability, and resilience when operating at lower lake levels impacted by drought and climate change
Review climate change in design	Increases climate resilience in planning and final design of water and hydropower infrastructure
Estimate extreme precipitation and runoff leading to dam failure under climate change	Advances dam safety and protection of downstream public safety by improving the community's ability to identify climate change effects on flood risks and potential dam failure
Incorporate climate change impacts and considerations in infrastructure investment decision-making	Builds climate resilience into infrastructure investment decisions
Incorporate climate change science into operations and maintenance processes	Ensures the reliability of Reclamation project benefits
Facilitate non-Federal hydropower development	Generates renewable hydropower at otherwise non-powered Reclamation Project facilities, providing development and revenue opportunities for stakeholders
Modernize technologies to build climate resilience into infrastructure asset management and hydropower	Improves infrastructure and increases capacity to cope with the risks of climate change and variability from floods to droughts
Consider and include climate change risk in value studies	Incorporates climate risk considerations into planning and design processes
Assess wildland fire risks for Reclamation infrastructure and water bodies	Develops strategies to protect water infrastructure from the effects of wildland fire



## Goal 4. Expand Information Sharing

**Example Effort Underway:** Launched new science-based [Addressing Drought Across the West Portal](#)

Actions	Benefits
Share quality-assured practices, information, and data to support operationalizing climate change	Supports acting now based on the reliable aspects of historical and future climate change information
Provide access to future climate and hydrology projections that are current, localized, and quality-assured	Provides Reclamation, partners, and stakeholders access to recent and quality-assured climate change information
Invest in climate literacy to develop technical capacities	Enhances awareness of climate change principles and impacts, and provides base understanding needed to operationalize climate change in Reclamation’s mission
Derive additional value from existing power datasets to optimize hydropower facility maintenance strategies	Reduces power facility outages and costs, and increases hydropower facility reliability
Develop a Recovery and Restoration Community of Practice	Encourages climate change consideration within community efforts to recover threatened and endangered species and restore rivers and ecosystems
Develop incentives for engagement with stakeholders in water contracting negotiations	Raises awareness about climate change impacts on water supplies, and improves water operations and planning
Disseminate guidance and requirements for incorporating climate change into environmental reviews	Equips environmental reviewers with methods to address climate change in environmental documents

# Goal 1: Increase Water Management Flexibility

To better cope with climate change as it happens, Reclamation will continue efforts to increase water management flexibility. This includes improvements to reservoir operations to cope with changing hydrologic conditions through Reclamation's WaterSMART Basin Studies Program, and providing cost-share funding to non-Federal recipients for water delivery system improvements through Reclamation's WaterSMART Grants Program. In addition to these activities, Reclamation will pursue other strategic efforts to update water and hydropower operating criteria; develop new water and power technologies; and advance tools that serve water and power operations. Through these efforts, Reclamation is increasing the effectiveness of operations and the availability of Reclamation project water. As a result, Reclamation will have more water management flexibility to respond to a changing climate.

## Update Operational Guidelines

As the worsening drought crisis in the Colorado River Basin—amplified by climate change—

continues to impact communities across the West, Reclamation's Upper Colorado Basin Region, Lower Colorado Basin Region, and Chief Engineer Organization are working with Tribes, Federal and non-Federal partners, and stakeholders to develop updated Lake Powell and Lake Mead operational guidelines by 2026. The effort involves long-term planning and analysis of Colorado River system conditions for decades into the future. A key challenge for these efforts is accounting for climate change during the envisioned implementation timeframe for any new operating criteria, including climate change impacts that have occurred up until present and additional impacts anticipated in the future. Successful incorporation of the wide-range of future uncertainty, including climate change, will be essential to the development of a new and robust set of operating criteria for Lakes Powell and Mead. The new criteria will provide the Colorado River system with the stability, certainty, and flexibility needed to manage future challenges.



Twelve of the world's largest pumps lift water over 280 feet up from the reservoir (Franklin D. Roosevelt Lake) created by Grand Coulee Dam in Washington into a feeder canal and Banks Lake (pictured here). This water is then delivered to over 10,000 farms.

## Invest in Technology Innovations

Developing and deploying new technologies will help Reclamation maintain the reliability of its water and power systems by maximizing the ability of these systems to operate under changing climate. Reclamation invests in technology innovation in multiple mission areas, including water infrastructure, power and energy, environmental issues in water delivery management, water operations and planning, and developing water supplies. Innovation occurs on an ongoing basis, steadily yielding new technologies and outputs from concluding research. To enhance these efforts, Reclamation leverages partnerships with Federal and non-Federal collaborators and from within Reclamation's Chief Engineer Organization, Policy and Programs Directorate, and Regions. Two current technology innovation implementing actions include:

- **Enhancement of hydropower operational efficiencies.** Reclamation continues to pursue opportunities to enhance and deploy its Hydropower Optimization System (HydrOS) at its power facilities. The system creates water conservation benefits by requiring less water passage through the powerplant for given power generation targets. Also, HydrOS increases hydropower generation by providing optimal hydropower unit loading levels and commitment recommendations to powerplant operators, enabling them to maximize efficient generation of clean energy within their powerplants. Analysis shows that where it has been implemented, HydrOS has delivered 1.75 percent plant efficiency improvement on average. These efficiencies have contributed to over 100,000 megawatt-hours (MWh) in annual incremental generation and additional generation benefits are expected in future years. HydrOS can be used to inform long-term planning and forecasting conducted by Power Marketing Administrations, as well as river basin optimization efforts. Reclamation leverages partnerships with Department of Energy and Power Marketing Administrations to enhance HydrOS effectiveness and applications.



Low reservoir levels at Lake Mead. Colorado River Basin along the Nevada/Arizona border.



There are 17 generators in the Hoover Dam Powerplant in Nevada. When all are operating together at maximum capacity, they can produce about 2,080 megawatts—enough power for 1 million homes.

- **Investment in water supply development.** Developing technologies to create new water supplies is a key strategy for addressing the challenges of drought and climate change. Reclamation focuses on improving access to non-traditional water resources—e.g., seawater, brackish groundwater, municipal wastewater, and produced waters from oil and gas activities—by investing in water treatment-based solutions. Reclamation invests in water supply development by:
  - o Providing financial assistance for non-Federal research and development.
  - o Investing in internal water treatment innovation led by Reclamation engineers and water treatment specialists.
  - o Hosting technology development clients at its research facilities, including the Brackish Groundwater National Desalination Research Facility in Alamogordo, NM, and Water Quality Improvement Center in Yuma, AZ.

Products include technologies, methods, and tools developed in collaboration with managers and experts from Reclamation, other Federal agencies, and non-Federal partners.

These treatment solutions help Reclamation and its Western water partners address water scarcity challenges and become more fit to cope with the evolving risks of climate change.

In August 2022, Reclamation announced the investment of over \$310 million for Title XVI Water Reclamation and Reuse Program projects using primarily Bipartisan Infrastructure Law funds. These funds will support planning, design, and construction activities for 25 non-Federal water reuse projects. Combined with non-Federal funding contributions, selected projects will result in over \$1.2 billion in infrastructure investments to develop local, drought-resistant water supplies.

### **Advance Decision-Support Tools for Water Operations and Planning**

In addition to updating operating criteria and investing in technology innovation, Reclamation is enhancing its water management flexibility and climate resilience by investing in the advancement of decision-support tools in water operations and planning. Reclamation’s Research & Development Office and Water Resources Planning Office provide opportunities for internal engineers, scientists, and specialists to work with external partners and pursue advancements.



**Reclamation funds numerous innovative water projects. For example, the Pure Water Oceanside facility is an advanced water purification program that purify recycled water to create a new, local source of high-quality drinking water. The facility will produce enough water to provide more than 30 percent of Oceanside, California’s water supply and reduce dependence on water from the Colorado River.**

These projects are in the fields of hydrologic monitoring, modeling, and forecasting; hydraulics; and ecohydrological analysis. The results are used to support short-term operations and long-term planning. By modernizing such tools and methodologies, Reclamation is increasing its capacity to cope with the risks of climate change and variability, from floods to droughts. Highlights include:

- Support of regional reservoir operations pilots and science application efforts to better harness new techniques in weather and water monitoring and forecasting.
- Collaboration with Federal and non-Federal partners in forecast-informed reservoir operations.
- Development and demonstration of emerging technologies in snowpack measurement that will improve seasonal water supply forecasting to benefit planning for irrigation, municipal, and instream water uses.
- Hosting of prize competitions to crowdsource solutions on challenges in hydrologic monitoring, modeling, and forecasting. Recent Reclamation prize competitions have successfully garnered novel solutions performing better than Federal benchmarks in sub-seasonal to seasonal climate and streamflow forecasting. Ongoing competitions are seeking solutions to challenges in accelerating hydraulic model speeds for more rapid decision-support. These solutions will advance Reclamation's ability to estimate snow-water equivalent across the West, and improve the cost-effectiveness of operating ground-based precipitation devices in remote areas.



**Reclamation's Brackish Groundwater National Desalination Research Facility in Alamogordo, New Mexico.**



**Reclamation works with partners to improve the accuracy of water supply forecasts by evaluating current and emerging snow measurement technologies for the Western U.S.**

## Goal 2: Enhance Climate Adaptation Planning

New tools are needed to support the consideration of climate change within Reclamation planning activities and related environmental reviews, including reviews under National Environmental Policy Act (NEPA), Endangered Species Act (ESA), and other regulatory requirements. This includes appraisal and feasibility studies, asset management, operations and maintenance, major rehabilitation and replacement, dam safety, restoration, and other types of water supply planning studies.

Reclamation has long required consideration of climate change in planning processes, as recognized in its Directives and Standards (D&S) for *Climate Adaptation Policy* (CMP-P16) and for *Water and Related Resources Feasibility Studies* (CMP 09-02), which require that climate change be considered in feasibility studies. However, due to the uncertainty associated with climate change projections, it is a common practice in water resources planning and related environmental

review to continue to base assumptions of future conditions on the observed past. Often this includes the observed climate variability of the past in the absence of consensus approaches to assess future variability.

With broad consensus among the scientific community that the earth is warming, there is a need to incorporate agreed-upon climate change assumptions as a foundational consideration within our planning and environmental review processes. New approaches (e.g., technical guidance, tools, and data) are needed to ensure that the investment and policy decisions we make now build resilience to climate change.

### **Build Climate Resilience Through Planning and Environmental Review Processes**

To build climate resilience through planning and environmental review processes, Reclamation will expand consideration of climate change within planning processes for implementation studies.



Climate change is impacting droughts, causing them to become more severe, more frequent, and longer in duration (see [Reclamation's 2021 SECURE Water Act Report](#) for a more detailed explanation). As a result, water managers planning for drought need to look beyond the last 100 years of documented stream gage measurements to plan for drought.

For instance, Reclamation's Washita Basin Project Reservoir Operations Pilot Study relied on both paleohydrology (tree rings) to look at wet and dry periods going back 600 years, and future climate projections to identify new drought scenarios to provide benchmarks for reduction of water deliveries during drought in Oklahoma.

The photograph at left shows Foss Reservoir taken in March 2015 at the end of a drought. The image shows three intakes, two of which are dry and the third covered by 6 inches of water.

Reclamation’s planning implementation studies—e.g., preliminary, appraisal, and feasibility studies—are used to evaluate potential alternatives and proposed actions to address water resources problems where there is a Federal interest in the implementation action. Environmental reviews accompany planning processes, including evaluating the impacts of proposed alternatives on the human environment under NEPA, and evaluating the impacts to federally-listed endangered or threatened species, or critical habitat, under the ESA.

Reclamation’s D&Ss for *Water and Related Resources Planning* (CMP P09), *Water and Related Resources Appraisal and Special Studies* (CMP 09-01), *Water and Related Resources Feasibility Studies* (CMP 09-02), and *Planning for Major Rehabilitation and Replacement of Existing Assets* (CMP 09-04), will be revised to require Reclamation to:

- Engage with stakeholders in the project formulation and design phases, before formal planning begins, to prioritize climate resilient building opportunities, challenges, and costs;
- Incorporate a quantitative climate change analysis in planning and environmental review processes, as appropriate, including: (1) identifying problems, needs, and opportunities; (2) inventorying existing resources; (3) formulating action alternatives; (4) forecasting future conditions to evaluate action alternatives for feasibility; and (5) in the case of a NEPA or ESA study, analyzing the environment of the area(s), species, or habitat to be affected or created by the alternatives considered.

These changes will add detail to current requirements by specifying that climate change is to be considered and quantified at each step of the planning process—from the development of baseline conditions to the development and evaluation of alternatives—and within environmental reviews, as appropriate. Before formal planning begins, Reclamation can engage stakeholders and project partners on how climate

change could impact proposed solutions to water management issues. Once a planning activity has been initiated, the formulation and review of alternatives, and the development of baseline conditions, will include a climate change analysis to ensure that proposed actions are climate resilient.

#### *Develop Baseline Conditions*

Both planning and environmental analyses require the development of baseline conditions over the period of analysis—typically 100 years for a planning analysis—to compare and assess the impacts and benefits of proposed action alternatives. Baseline conditions must reflect not only past climate, but also how the climate is changing to ensure that the impacts of a changing climate are reflected in the selection of climate resilient recommended actions.



Reclamation engaged irrigators, city managers, and conservation groups to complete the Deschutes River Basin Study in 2019. The partners developed modeling scenarios of future conditions that allowed stakeholders to better understand potential future flows in the basin. Further, the study fostered working relationships that provided a firm foundation for subsequent progress in the basin through the ongoing Habitat Conservation Plan (HCP). The HCP is part of an ESA incidental take permit application needed by irrigation districts and the City of Prineville, Oregon.

Photograph shows an Oregon spotted frog. Much of the work in the upper Deschutes River Basin is centered around improving habitat for this species, while meeting other demands for water (photograph courtesy of U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office).

## **Enhance Climate Adaptation Planning by Developing Guidance and Methods for Consideration of Climate Change**

To enhance climate adaptation planning, Reclamation will also develop guidance and methods for consideration of climate change in investment and policy decisions. The West-Wide Climate Risk Assessment (WWCRA) Team is developing general, broadly applicable guidance that can be used as a starting point for Reclamation staff to incorporate climate change information across a range of activities—from design and construction to long-term water supply planning. The goal of the general guidance is to make climate analysis methods more widely available across the organization; help staff determine the adequacy of data; address uncertainty; and address current and future risks associated with climate change.

Additionally, Climate Change Case Studies, a new activity of Reclamation's WaterSMART Basin Studies Program, supports staff's efforts to incorporate climate information within specific Reclamation decisions. The case studies currently underway address a range of issues, including storage, dam safety, salinity estimation for ESA action, operations, and planning. Case studies will be selected annually to develop and refine

Reclamation's climate analysis, and results will be compiled into guidance to support future analyses within the areas addressed.

## **Build Climate Resilience Into River and Ecosystem Restoration Activities**

Reclamation helps maintain healthy ecosystems and protect Federally listed fish, wildlife, plants and designated critical habitat affected by Reclamation facilities through a range of programs and activities. For example, Reclamation has numerous river restoration and enhancement efforts ongoing across the West that have 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).

Reclamation will continue to use the best available information and science when assessing the potential future state of the affected environment in NEPA analysis. Where possible use the information developed during the NEPA review to make the actions and affected environment more resilient to the effects of a changing climate.

New climate change guidance will help Reclamation identify the most reliable climate change information (e.g., temperature projections), and identify methods to address remaining uncertainties so that we can make climate resilient decisions. For example, to develop a cost-benefit ratio for a project to raise a dam, Reclamation must determine the benefits of additional water supplied through the increased storage capacity. To calculate these benefits, we need to identify a reliable range of future water supplies in the basin. Historical water supplies cannot be relied on to estimate future water supplies because climate change is impacting the hydrologic cycles and patterns of the

past. Additionally, projections of future precipitation using global climate models can give us a range of potential future scenarios, but these projections are uncertain and our current planning processes frequently require a specific water supply estimate, rather than a range of potential future conditions.

New guidance will help us identify a path forward. For example, could we rely on a combination of temperature and precipitation projections, plus other socio-economic indicators and a risk-based analysis to give us enough certainty to develop a cost-benefit ratio in this case?



Reclamation will develop best practices and tools to build climate resilience into river and ecosystem restoration activities. Best practices for restoration activities can be used to help guide program participants in identifying and implementing restoration projects that will build resilience to climate change. For example, best practices could support activities that:

- Incorporate climate analysis to ensure selected projects function as planned in a changing climate.
- Restore forested lands and improve watershed health to reduce impacts in reservoirs and improve water security.
- Reconnect floodplains and improve water infiltration to improve groundwater storage, reduce flooding risk, and help prepare for drought.
- Restore river processes to improve habitat connectivity.
- Promote natural, low-cost, and sustainable solutions that can be implemented quickly to improve restoration outcomes and resilience in traditionally disadvantaged communities.

### **Work with Stakeholders to Assess Climate Change Impacts on a Basin-Wide Scale**

Reclamation works with stakeholders to assess climate change impacts on a basin-wide scale through its WaterSMART Basin Studies Program. Basin studies are stakeholder-driven studies to:

- Assess population growth.
- Evaluate changes in water use patterns and other factors.
- Identify long-term water supply and demand imbalances caused by climate change.
- Develop strategies to address water supply and demand imbalances.

The Basin Study Program was initiated in 2009 and Reclamation has funded a total of 27 basin studies in 15 Western States since the program's start.



**The Bird Track Springs reach of the Grand Ronde River in Oregon has been heavily degraded by multiple historical practices resulting in poor aquatic and floodplain habitat. Reclamation, along with Federal and Tribal partners, is implementing a habitat enhancement project in the area. One activity is the placement of large logs, as seen in this image, to help retain banks and provide habitat for fish.**

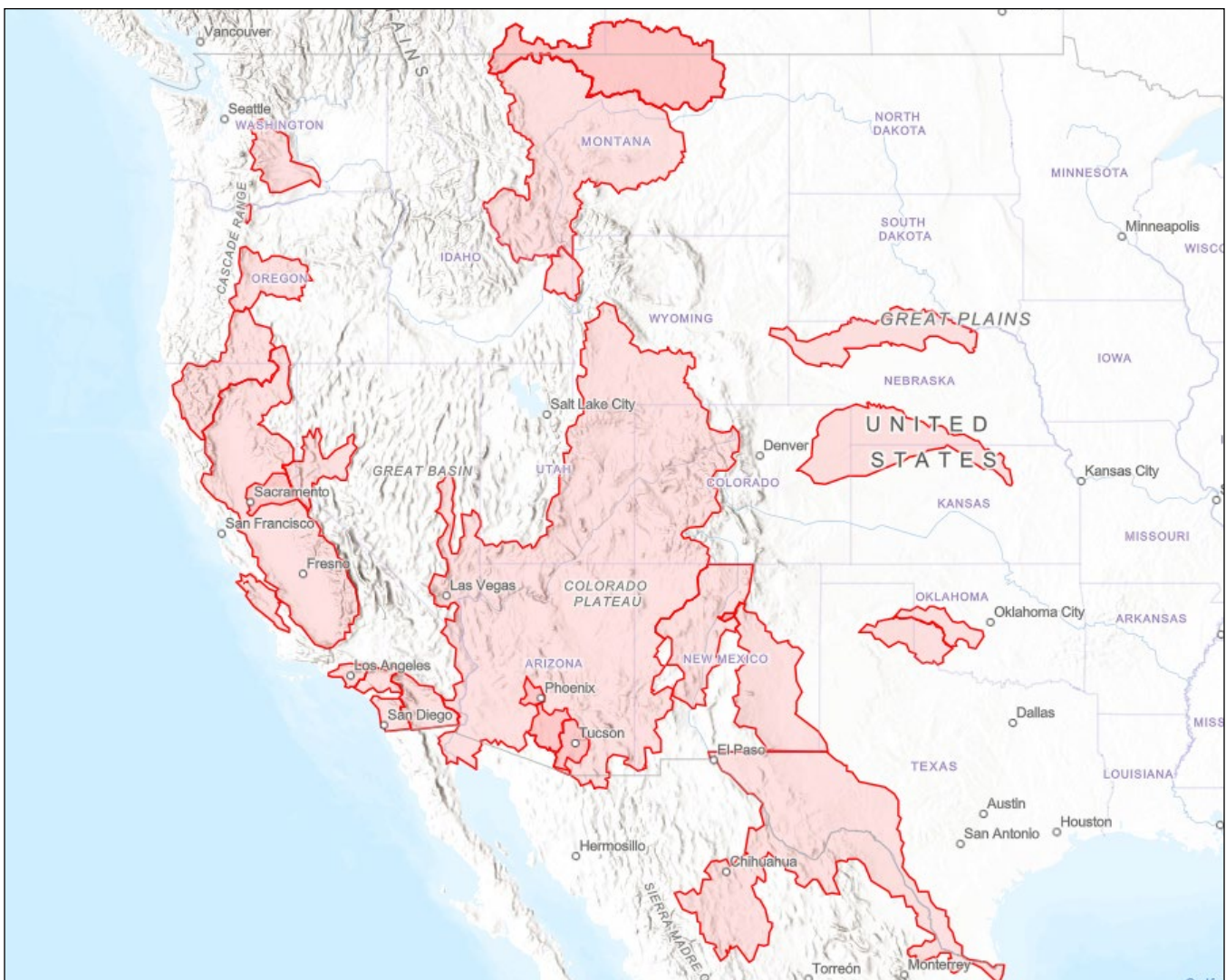
Reclamation has recently received new congressional authorities and additional appropriations for projects to maintain healthy ecosystems and protect federally-listed fish, wildlife, plants, and designated critical habitat. These projects will be completed in partnership with non-Federal stakeholders through financial assistance programs. BIL funding for restoration projects over the next 5 years (2022 to 2026) includes:

- \$250 million for the Aquatic Ecosystem Restoration Program, Public Law 116-260, Section 1109
- \$100 million for Multi-benefit Projects, BIL Section 40907
- \$100 million for the Cooperative Watershed Management Program, BIL Section 40907
- \$100 million for nature-based solutions for Environmental Water Resources Projects, BIL Section 40907

Of the 27 basin studies, 17 are complete and 10 are still underway. Through these studies, Reclamation has fostered strong relationships with non-Federal entities across the West.

These relationships have built a technical foundation that directly contributes to many collaborative follow-on efforts, including eight water management pilots, two basin study updates, and efforts led directly by Reclamation's non-Federal partners. The basin studies establish a common understanding of hydrology within a basin that—together with the relationships formed through these partnerships—helps avoid conflicts over water and promotes ongoing collaboration among the partners.

To further support Reclamation's work with stakeholders to assess climate change impacts on a basin-wide scale, we will revise the D&S for Basin Studies (WTR 13-01), adopted in 2016, to broaden the types of climate impacts considered in basin studies. Revisions will include impacts currently affecting water managers, such as prolonged droughts and unpredictable and increasingly severe precipitation events. In addition, the team will consider changes needed to operationalize climate change and acknowledge current, as well as future, impacts of climate change.



Locations of river basins addressed by Reclamation basin studies across the West.

## Goal 3: Improve Infrastructure Resilience

Most of Reclamation's water and power projects were constructed over 50 years ago. The earliest projects now exceed 100 years in age. Continued operation of these facilities is a testament to the original engineering and construction, as well as years of diligent maintenance. To ensure these projects continue to provide benefits to the American public, Reclamation is committed to improving the resilience of our infrastructure in the face of a changing climate. Toward this end, Reclamation will build on a legacy of infrastructure management and operations and maintenance, and leverage funding and resources provided through BIL in support of these efforts. Fulfilling this commitment will require scientific research to understand current and future conditions, and modern engineering to fortify infrastructure as conditions continue to evolve. In pursuit of this commitment, Reclamation will embark on strategic activities in hydropower, dam safety, infrastructure investments, and innovation.

### Hydropower

As climate continues to grow warmer, one of the anticipated risks across much of the West is aridification (or trending towards increased dryness) of the landscape. Aridification causes reduced runoff and more frequent drought conditions—all contributing to lower reservoir water levels (see [Reclamation's 2021 SECURE Water Act Report](#) for a more detailed explanation). The hydropower community is interested in what lower reservoir water levels mean for future operations and maintenance of hydropower facilities.

To address this risk, Reclamation will operationalize climate change consideration in hydropower activities. Specifically, Reclamation will refine operating guidance to account for drought and climate change impacts on hydrology and reservoir water levels. Also, operating guidance will be updated to strengthen



Generators inside the powerplant at Palisades Dam, Idaho.

hydropower reliability, sustainability, and resilience when operating at lower lake levels. Under this activity, Reclamation will assemble power facility information on water levels and ranges of importance to hydropower generation. Then, we will compare this information against projected water level conditions to assess operating risks.

Through this assessment, Reclamation will identify where further testing or analysis is needed, introduce technology innovation to help manage such risks, and, ultimately, work toward better documentation and outreach on low water level operating limits and guidance.

In addition to this priority activity, Reclamation will continue to work with partners to expand the number of hydropower generation facilities across the West. Reclamation will facilitate non-Federal hydropower development on Reclamation lands through its Lease of Power Privilege Program. The program aims to support the generation of renewable hydropower at more Reclamation Project facilities, and to increase development and revenue opportunities for stakeholders.

### **Dam Safety**

Reclamation is dedicated to operating the dams under its management in a safe manner. Dam safety is maintained through regular and continuous inspections for safety deficiencies; dam analyses using current technologies; and, if needed, corrective actions based on current engineering practices. Activities include site evaluations to quickly identify dams that pose

an increased threat to the public, and quickly completing related analyses to expedite corrective action decisions to safeguard the public and associated resources.

Climate change poses potential implications to the hydrologic hazards (or flood risks) experienced at these dams. Hydrologic hazards depend on the precipitation and hydrology drivers that cause rare and extreme floods, and such drivers vary by facility. Given these potential implications, Reclamation is currently working to improve its methods and capabilities for estimating extreme precipitation and runoff leading to dam failure under climate change. Doing so is expected to help Reclamation:

- Better quantify hydrologic hazards under a changing climate.
- Improve decision-making on the potential for dam failure stemming from changing floods.
- Increase safety for communities living downstream of dams.
- Lead the dam safety industry in developing methods and techniques for incorporating climate change considerations into dam safety efforts.



**In summer of 2022, Reclamation broke ground on this \$1B project, the largest Safety of Dams project to date, at B.F. Sisk Dam located on the west side of California’s Central Valley. Reclamation’s Safety of Dams Program started in 1978 to ensure its dams do not present unreasonable risk to people, property, and the environment.**



**Portions of the Delta Mendota Canal have been damaged due to land subsidence resulting from over-pumping of aquifers in response to climate change-driven surface water shortages.**

## Infrastructure Investments

Reclamation, together with the State of California, is evaluating extraordinary maintenance work to restore the capacity of the Delta-Mendota and San Luis Canals lost to subsidence due to over-pumping of groundwater aquifers driven in part by climate change-induced surface water shortages. Pursuant to recently-issued directives addressing planning for major maintenance activities, Reclamation and the State of California will include analysis of climate-change impacts in the planning and design of the fix, along with identification of climate change adaptation measures within the alternatives, to ensure the continued reliability of this critical water delivery infrastructure, on which a substantial portion of the country's agricultural production depends.

Reclamation regularly engages customers, partners, and stakeholders on proposed infrastructure investments, which may involve development of new facilities as well as repair, rehabilitation, and upgrade of existing facilities. Climate change poses a variety of risks for infrastructure, including:

- Precipitation changes that impact hydrologic and hydraulic hazards under which facilities need to operate.
- Warming effects on materials and operating environments.

- Climate change effects on watershed conditions that may impact facilities (e.g., aridification that increases the prevalence of drought and risk of wildland fire).

To address such risks, Reclamation is developing ways to incorporate climate change impacts and considerations into infrastructure investment decision-making. This requires the development of methods for considering climate change information in the planning and prioritization of capital investment and repair needs. More specifically, this requires:

- Developing approaches to characterize climate change risks for Reclamation infrastructure assets.
- Incorporating those risks into justifications for infrastructure investments and improvements.
- Demonstrating that informed infrastructure investments will help mitigate the economic and environmental consequences of climate change



**At 30,000-acres, the Big Notch Project is the largest floodplain salmon rearing habitat restoration and fish passage project in California history. Photograph of breaking ground ceremony.**

In addition to this priority activity, Reclamation will engage Federal partners and professional engineering societies to review climate change in design. The goal of this engagement is to promote consistent approaches toward increasing climate resilience in the planning and final design of water and hydropower infrastructure. Also, Reclamation will seek new ways to incorporate climate change science into its infrastructure operations and maintenance processes to enhance Reclamation's ability to carry out its mission.



Reclamation, with support from CAL FIRE's Tuolumne-Calaveras Unit, conducted a 100-acre prescribed burn at New Melones Lake in northern California. The controlled burn was used to reduce wildfire risk, help with visitor safety, and protect Reclamation assets.

## Innovation

As more intense droughts, higher temperatures, and forest diseases increase, there is an increased risk of wildland fire in the West. Wildland fires can impact infrastructure through increased sedimentation or harm to water management facilities. As Reclamation continues to manage lands surrounding its infrastructure and water bodies, staff need to know where fuels management would be most beneficial.

Motivated by these changing conditions, Reclamation will apply assessment and management innovation to address wildland fire risks for Reclamation infrastructure and water bodies. Assessments will inform innovative approaches to protect water infrastructure from the effects of wildland fire. These approaches include:

- Using geospatial information and tools to identify locations of highest risk for wildland fire.
- Developing adaptation strategies related to fire fuels management, reservoir operations, etc.
- Targeting investments to optimize infrastructure protection.

Another area of infrastructure management innovation relates to value studies that Reclamation routinely applies during infrastructure planning and design processes. Value studies are part of Reclamation's culture. Consequently, introducing climate change terms, concepts, risks, and adaptation strategies to value study teams would help Reclamation strengthen its climate-informed risk approach to infrastructure planning and design. To that end, Reclamation will pursue actions to educate value study facilitators on climate risk and how it can, and should, be incorporated into Reclamation's construction projects.

Lastly, as Reclamation manages infrastructure assets in the face of present and future challenges—e.g., aging, drought, climate change, wildland fire, and other stressors—we recognize that we will need newer, better, faster, safer, and more cost-effective ways to navigate these challenges. Reclamation will develop such opportunities through continued investment in science and technology activities to modernize technologies to build climate resilience into infrastructure investments and hydropower. Doing so will improve infrastructure reliability and service life, reduce costs for Reclamation and its partners, and increase capacity to cope with the present and future risks listed above.



This 5-million-pound universal testing machine is located in Reclamation's Concrete and Structural Laboratory. In support of Reclamation projects, it is capable of testing the structural strength of large-size specimens, such as concrete piers.



A wide-head turbine from Hoover Dam.

## Goal 4: Expand Information Sharing



Adequate preparation for climate change requires timely access to essential data and information. In addition, it is critical to invest in climate literacy and organizational capacities to share and use data, information, and tools to help us adapt to climate change and build resilience. Expanding information sharing is key to addressing climate change impacts that are compounded by drought, aging infrastructure, diminishing water supplies, and increasing environmental and aquatic ecosystem challenges. Investing in information sharing allows Reclamation to support the Presidential Memorandum *"Restoring Trust in Government Through Scientific Integrity and Evidenced-Based Policymaking,"* and Reclamation's commitment to building and using evidence for effective program management and strategic decision-making, as outlined in the Foundations of Evidence-based Policymaking Act of 2018.

Reclamation's unifying priority action throughout this Climate Change Adaptation Strategy is to normalize—or operationalize—how Reclamation considers climate change across a range of water and power decisions. This range of decisions can inform what associated data and tools need to be developed and shared as part of the goal to enhance information sharing. To that end, Reclamation seeks to share quality-assured practices, information, and data to support operationalizing climate change.

While Reclamation and its partners have made much progress on developing adaptation

practices, we still need improved practices, data, and information for a diversity of applications. Applications of climate change data and information vary by resource management situation, including water supply, flood risk, infrastructure, hydropower, environmental resource management, or other interests. For example, a given aquatic ecosystem restoration action may depend heavily on future temperature and low streamflow possibilities, whereas a given infrastructure action designed for flood risk management may depend heavily on future assumptions about wet weather extremes.

Reclamation will work with partners to develop quality-assured climate change information and data. Then, we will work to make the information available and provide training and leading practices to support application of the information through Reclamation's Climate Change Community of Practice. Climate change data and information needs and leading practices for application will be tailored by resource management situation as listed above. This tailored information will speak to the unique challenges, partner interests, and processes for implementing those planning and decision-making situations. Reclamation is making early progress on this priority activity by enlisting help from Reclamation's West-Wide Climate Risk Assessments Team to develop guidance. Also, Reclamation is supporting climate change case studies led by regional and area office staff that support development and pilot application of guidance specific for various resource management situations.

### **Efforts to Provide Data Services, Information Portals, and Visualization Tools**

These strategic activities start with ensuring that Reclamation, partners, and stakeholders have access to the quality-assured climate change information necessary for adaptation planning.



To that end, Reclamation will continue to pursue collaborative efforts with Federal and non-Federal partners to provide access to future climate and hydrology projections that are current, localized, and quality-assured. Reclamation's collaborative efforts include continuing work with partners to sustain and enhance the [Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections](#) online data archive. Through this project, Reclamation supports government, private-sector, and educational assessments of climate change vulnerabilities and adaptation strategies by providing free, open, and easily accessed data

on future climate and hydrology across the contiguous U.S. Launched in 2007, the online data archive contains multiple generations of future projections. To date, the archive has served roughly 75 terabytes of information, over 5,000 unique customers, and nearly 100,000 data requests.

In addition to providing information on future climate and hydrology, Reclamation will continue to provide private and public sector organizations enhanced open access to Reclamation's assessment information on climate change vulnerabilities and adaptation opportunities in major Western U.S. river basins.

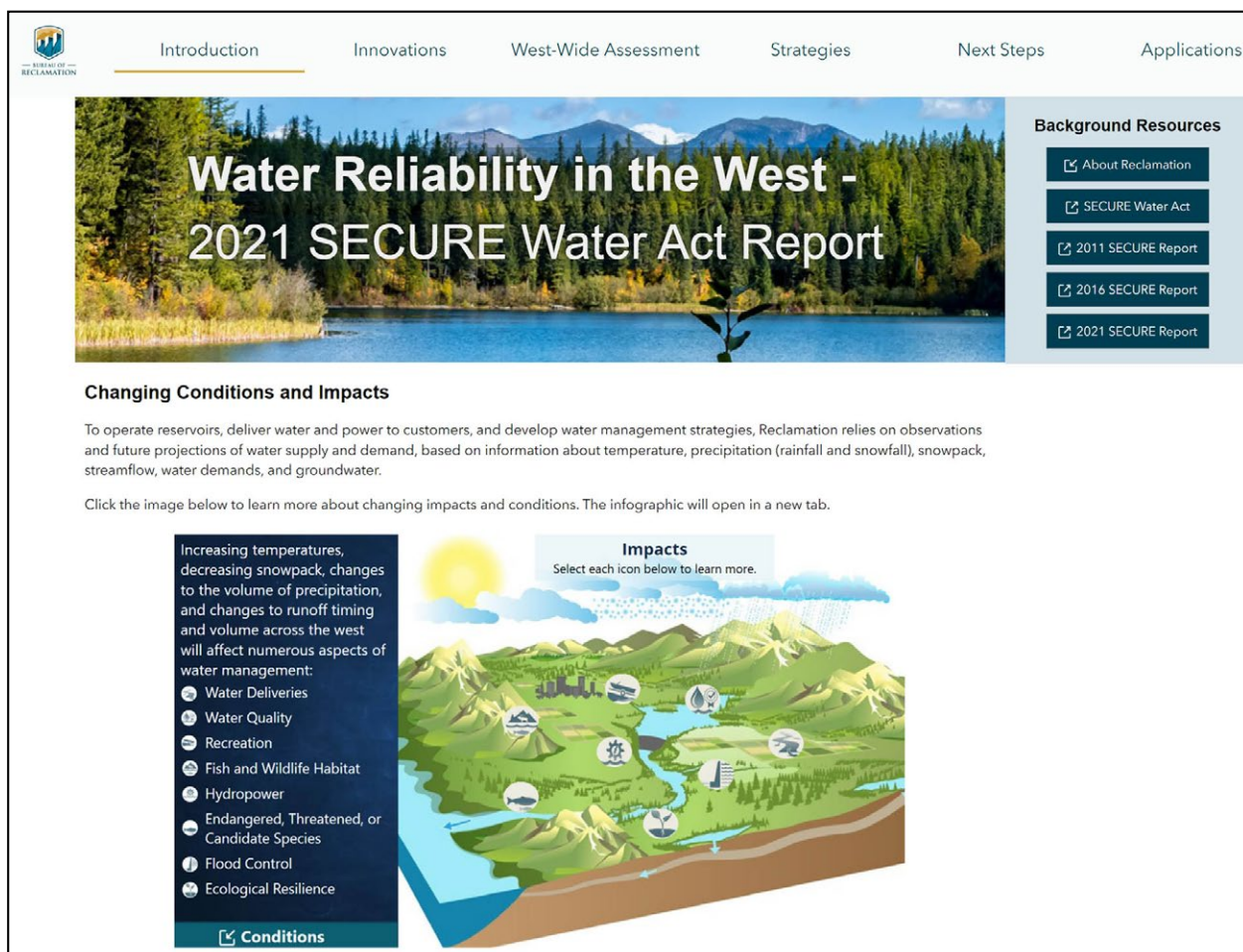
View of Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections online data archive.

Reclamation’s [Water Reliability in the West – 2021 SECURE Water Act Report](#) portal provides open public access to information describing Reclamation’s activities to assess climate change vulnerabilities and potential adaptation responses, as required by the SECURE Water Act. The 2021 report portal provides information about: (1) innovations since the 2016 report, (2) an updated assessment of west-wide future water supplies and demands under climate change, and (3) strategies to address future gaps in supplies and demands.

Further, Reclamation will continue to provide access to data and information on water and water-related data resources describing reservoir operations, hydropower, infrastructure, environmental, water quality, and other water management activities. This information is

provided through the [Reclamation Information Sharing Environment](#) (RISE) system. RISE is an open data system for viewing, accessing, and downloading Reclamation’s water and water-related data. With RISE you can:

- Find Reclamation data by searching the catalog or browsing the map.
- Search time series data for specific dates, parameters, and locations, then plot or download the data.
- Access machine-readable data and automatically integrate it into tools and analyses.
- View geospatial data on a map, download it for offline analysis, and get a web service connection to add this data to your own map.



**View of Reclamation’s Water Reliability in the West – 2021 SECURE Water Act Report online portal.**

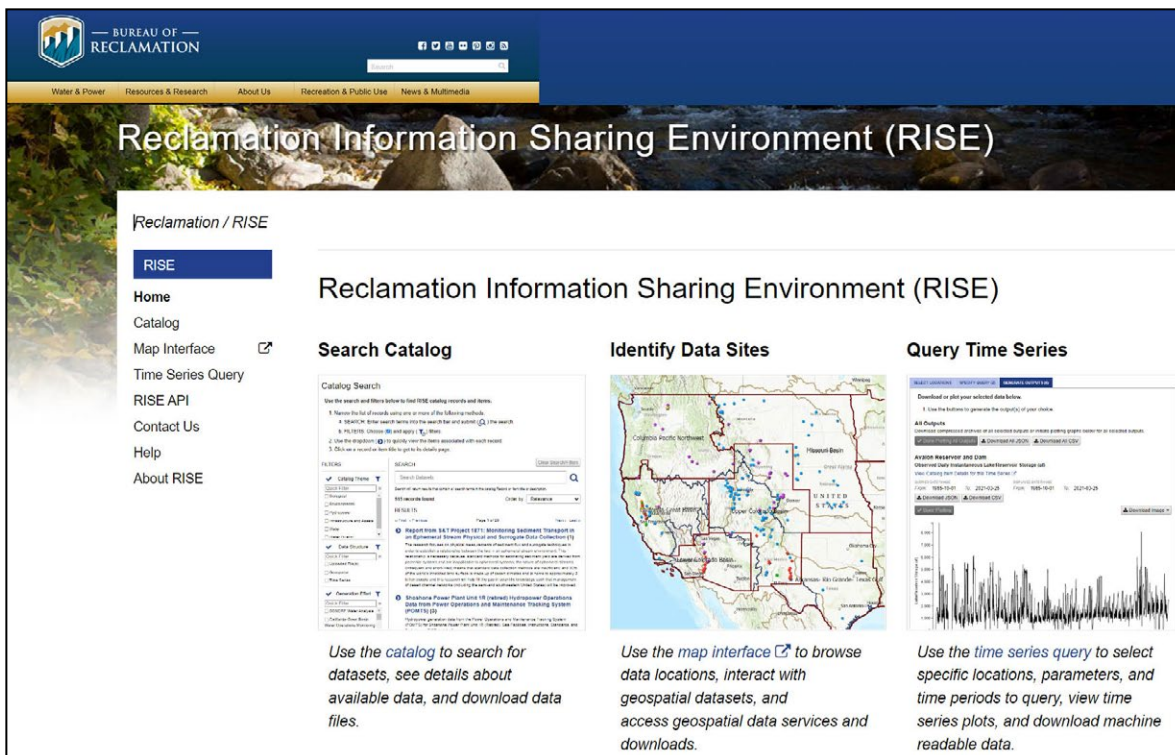
Also, Reclamation maintains an interactive dashboard of portals that allow planners, researchers, and the public to analyze and collaborate on a variety of water management issues and solutions that affect the West. An example portal is Reclamation’s [Addressing Drought Across the West](#) portal, which provides news and information to Reclamation customers and stakeholders about drought conditions and Reclamation’s response. These portals help Reclamation and its planning partners: (1) better interpret climate and water information, (2) use this information to inform adaptation strategies, and (3) communicate about climate and water with customers and stakeholders. Moving forward, Reclamation will expand development and application of data communication and visualization tools like these that synthesize data resources and connect them more closely to decision-support.

### Investment in Climate Literacy

Investments in data services, information portals, and visualization tools build upon Reclamation’s

open-data initiatives underway since 2016. Looking ahead, Reclamation recognizes that, to support operationalization of climate change, it needs to invest in training staff in climate literacy and developing staff’s technical capacities. This investment in climate literacy will serve as a key complement to the aforementioned information sharing approaches.

Efforts to increase climate literacy will be strategically aligned with guidance and practices developed under the effort to operationalize our climate change response. Specifically, Reclamation will develop a curriculum on the leading practices developed to support climate change adaptation in the various resource management situations referenced earlier. Where possible, Reclamation will leverage external training curricula (e.g., that being developed by the Department of the Interior Climate Training Working Group) and learning services (e.g., U.S. Fish & Wildlife Service’s National Conservation Training Center).



View of Reclamation Information Sharing Environment (RISE) online portal.

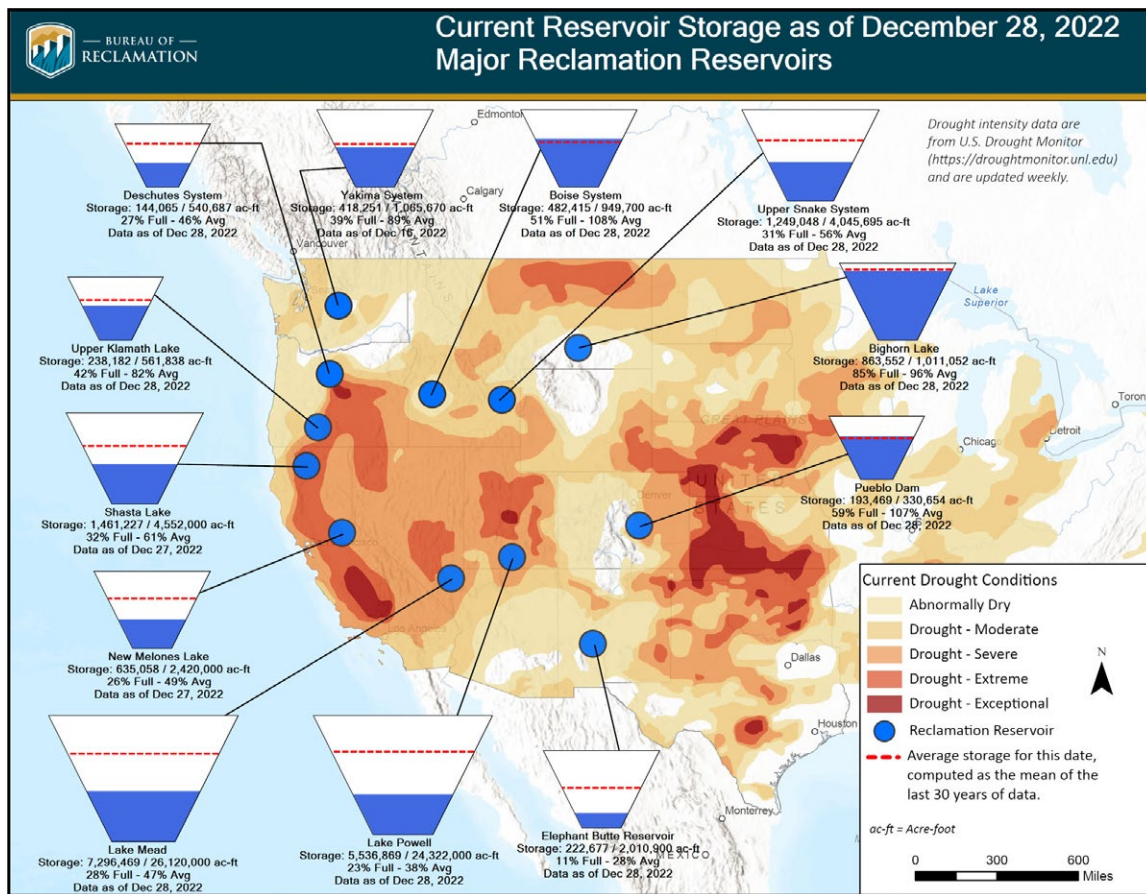
## Additional Activities to Operationalize Climate Change

Additional priority activities complementing operationalization of climate change—tailored for specific resource management situations and subcommunities—are described below:

- In hydropower, Reclamation will support the goals of reducing power facility outages and costs while increasing hydropower facility reliability. To this end, Reclamation will invest in ways to derive additional value from existing power datasets to optimize hydropower facility maintenance strategies.
- In water operations and planning, Reclamation will work to raise awareness about climate change impacts on water supplies and contribute to improved outcomes. Towards this goal, Reclamation

will engage water users and seek ways to incentivize improved operations and planning through water contracting.

- In species recovery and aquatic ecosystem restoration, Reclamation aims to encourage climate change consideration within such efforts. Specifically, Reclamation will engage the Recovery and Restoration Community of Practice via community-wide gatherings and new tools (e.g., Conservation and Stewardship Atlas).
- In environmental compliance, Reclamation will work to increase consideration of climate in the future affected environment. In particular, Reclamation will work with Federal and non-Federal partners to update internal guidance on how to incorporate climate change in environmental reviews.



View of reservoir storage diagram, available at Reclamation's [Addressing Drought Across the West](#) online portal.

# Partnerships

Climate change impacts everyone—from farmers and ranchers to city dwellers and Tribes. Due to these broad impacts, there is a growing need to mitigate the impacts of climate change and develop a long-term plan to facilitate conservation and economic growth.

Climate change strikes at the core of Reclamation’s mission to deliver water and generate power in the interest of the American public. However, Reclamation recognizes that resilient water management requires a collaborative approach with partners and stakeholders—State and Tribal governments, Federal agencies, and non-governmental organizations.

The Biden-Harris administration’s whole-of-government approach to addressing drought and confronting climate change is reflected in the BIL. The law includes important investments for the Western drought crisis by funding water efficiency and recycling programs, Tribal water settlements, and dam safety.

To address this growing crisis, the Department of the Interior is leading the Biden-Harris administration’s whole-of-government approach to drought mitigation. The Department is coordinating with partners across the Federal government, aiding impacted communities, and developing long-term solutions to mitigate impacts from climate change.

Last year, the White House launched an Interagency Drought Relief Working Group co-chaired by the Departments of the Interior and Agriculture. The Working Group regularly coordinates the disbursement of immediate financial and technical assistance. In addition, the group develops longer-term measures to respond to climate change and build climate resilience.

The President has also recommitted to strengthening the National Drought Resilience Partnership (NDRP). Formed in 2013, the NDRP brings together multiple Federal agencies to build

long-term drought resilience, including developing innovative science-driven actions to address water supply challenges.

Reclamation works cooperatively with States, Tribes, and local entities to plan for and implement actions to increase water supplies through attention to local water conflicts and investments to modernize existing infrastructure. It accomplishes this through programs such as Technical Assistance to Tribes, Water Storage and Conveyance development, Colorado River Drought Contingency Plan activities, ongoing asset management programs, including aging infrastructure investments, and the suite of WaterSMART programs. All of these provide funding, often with local cost shares, for on-the-ground projects to conserve water and conduct collaborative planning efforts addressing drought and climate change.

Lastly, Reclamation’s Research and Development Office (R&D) applies science and technology to advance the agency’s mission. R&D’s two programs—Science and Technology (S&T) and Desalination and Water Purification Research (DWPR)—address the technical obstacles related to Reclamation’s mission. These programs use a combination of internal projects, external calls for proposals, and prize competitions to support innovation. Innovations aim to address drought and climate change risks through enhanced monitoring, improved forecasting, and technology research to support development of new water supplies. In the past 6 years, R&D has launched 30 prize competitions and awarded more than \$3.5 million.

Reclamation’s strategy will and must be one of collaboration and determination, leveraging long-standing partnerships, forging new ones, and ensuring our response is vigorous and transparent, equitable and inclusive.

