

# RECLAMATION

*Managing Water in the West*

## **Science and Technology Program – Science Strategy – FY2018-FY2021**

**Research and Development Office  
Science and Technology Program**



**U.S. Department of the Interior  
Bureau of Reclamation  
Research and Development**

**February 2017**

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# Introduction

Established in 1902, the Bureau of Reclamation is best known for the dams, powerplants, and canals it constructed in the 17 western states. Today, Reclamation is the largest wholesaler of water in the country; bringing water to more than 31 million people, and providing one out of five Western farmers (140,000) with irrigation water for 10 million acres of farmland that produce 60% of the nation's vegetables and 25% of its fruits and nuts.

Reclamation is also the second largest producer of hydroelectric power in the United States. Fifty-three powerplants annually provide more than 40 billion kilowatt hours generating nearly a billion dollars in power revenues and produce enough electricity to serve 3.5 million homes.

Today, Reclamation is a contemporary water management agency with a Strategic Plan outlining numerous programs, initiatives and activities that will help the Western States, Native American Tribes and others meet new water needs and balance the multitude of competing uses of water in the West. Reclamation's operations are carried out by five Regions and supported by program offices. 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. As Reclamation carries out its mission, it encounters a variety of scientific and technical issues.

The Bureau of Reclamation Research and Development Office's (R&D) Science and Technology (S&T) Program supports research to help overcome these scientific and technical issues.

The mission of the Science and Technology Program is to:

*Advance Reclamation's technical abilities to manage, develop, and protect water and related resources in an environmentally and economically sound manner.*

The vision of the Science and Technology Program is to:

*Address the full range of technical issues confronting Reclamation water and power managers and their project stakeholders through innovative development, applied, and demonstration research.*

The goals of the Science and Technology Program are:

1. Develop cost-effective solutions for the technical and scientific problems affecting accomplishment of Reclamation's mission, while leveraging funds with other research entities to advance research in a collaborative manner.
2. Build and strengthen scientific and engineering capacity for Reclamation in order to advance the most relevant research and demonstration projects for Reclamation.
3. Communicate those solutions to Reclamation offices, other water and power management officials, and the general public in order to build partnerships with other water and power management agencies and stakeholders.

The Science and Technology Program is comprised of four major elements that are described in more detail later in this document.

- Research and Development Projects
- Water and Power Technology Prize Competitions
- Technology Transfer
- Dissemination and Outreach

## **How will the S&T Program use this document?**

This document provides information for our researchers and partners on the highest priority research areas and categories that the S&T Program will be seeking research proposals on in the annual call for proposals from fiscal year 2018 through fiscal year 2021. An attempt has been made to strike a balance between describing research areas and categories that will be stable for four years, providing a consistent target for researchers and developing significant momentum in generating innovations, and the desire to have flexibility to adjust priorities on an annual basis that can address new or emerging needs. By developing the research needs in a separate document on an annual basis, this will allow the S&T Program to strike this desired balance.

# What is the Process to Develop the S&T Program Science Strategy?

S&T Program priorities through fiscal year (FY) 2017 were established in a variety of ways based on administration requests and other internal processes. During FY 2016 and FY 2017 the S&T Program engaged in a transparent and objective process to update science needs and research priorities for future funding opportunities. As a starting point, Research and Development Office staff reviewed the past general areas and priority areas to determine the current relevancy and priority of these areas. A draft structure was then developed to transition the past general areas and priority areas into a more effective and organized system.

A bureau-wide meeting in the fall of 2016 provided an opportunity for Reclamation Directorates to review and comment on the revised list of research areas and categories. Following a revision of the research areas and categories based on the feedback at the bureau-wide meeting, an external review is being conducted using input from agencies represented on the Council of the Environment and Natural Resources (CENRS) Subcommittee on Water Availability and Quality (SWAQ). The primary goals of this external review are to identify potential duplication of efforts and additional opportunities for research collaboration around these new priorities.

After the external review, another round of revisions to the draft will be completed and ultimately Reclamation's Science Advisor, Dr. David Raff, will provide the priority document to the Bureau of Reclamation Commissioner for concurrence or alternate direction. The priorities identified in the remaining sections below reflect this process and will guide the S&T Program research projects from fiscal year 2018 through fiscal year 2021.

Following the Commissioner's Office concurrence of this document, an Annual Implementation Plan for this Science Strategy will be developed to support the annual call for proposals. Each spring, the S&T Program seeks research proposals from BOR employees through an annual call for proposals. The call for proposals requests detailed information about a project's research strategy, the benefits to Reclamation Regions, expected impacts and outcomes, and other information to support a relevancy and technical review that enables the S&T Program to select the best projects for funding each year. Within the call for proposals, the S&T Program identifies the highest priority research needs that researchers may choose to submit proposals to address. The Annual Implementation Plan will communicate these highest priority research needs within each research category, which are identified through multiple ongoing processes, as discussed later in this document. This annual process will allow for shifts in emphasis based on emerging needs or accomplishments from work funded in these research areas. The R&D Office will engage with subject matter experts from the Regions and other Directorates for input on adjustments to the research needs. The Annual Implementation Plan will then be presented each February at the Commissioner's Office briefing prior to the release of the call for proposals.

# Fiscal Year 2018-2021 Science Priorities

The table and narrative descriptions below represent the S&T Program’s priority research areas and categories for fiscal year (FY)-2018-2021.

Research Area	Research Category
<b>Water Infrastructure (WI)</b>	<ul style="list-style-type: none"> <li>● Dams</li> <li>● Canals</li> <li>● Pipelines</li> <li>● Miscellaneous Water Infrastructure</li> </ul>
<b>Power and Energy (PE)</b>	<ul style="list-style-type: none"> <li>● Hydro Powerplants</li> <li>● Energy Efficiency</li> <li>● Pumping Plants</li> <li>● Non-Hydropower Renewables</li> </ul>
<b>Environmental Issues for Water Delivery and Management (EN)</b>	<ul style="list-style-type: none"> <li>● Water Delivery Reliability</li> <li>● Invasive Species</li> <li>● Water Quality*</li> <li>● Sediment Management</li> <li>● River Habitat Restoration</li> </ul>
<b>Water Operations and Planning (WP)</b>	<ul style="list-style-type: none"> <li>● Water Supply and Streamflow Forecasting</li> <li>● Water Operations Models and Decision Support Systems</li> <li>● Open Data*</li> <li>● Climate Change and Variability</li> </ul>
<b>Developing Water Supplies (WS)</b>	<ul style="list-style-type: none"> <li>● Advanced Water Treatment</li> <li>● Groundwater Supplies</li> <li>● Agricultural and Municipal Water Supplies</li> <li>● System Water Losses</li> </ul>

\*Cross-cutting research areas

## Research Areas and Category Descriptions

**Water Infrastructure (WI):** Improve the resiliency of Reclamation water storage, water delivery, and facilities by producing or advancing effective solutions, tools, and practices that Reclamation facility managers can use to cost effectively maintain, modernize, and extend the life of Reclamation’s aging infrastructure. These should be related to Reclamation’s operations and maintenance responsibilities.

### Research Categories:

1. **Dams (WI1):** Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, service life, and safety.
2. **Canals (WI2):** Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, service life, and safety.
3. **Pipelines (WI3):** Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, service life, and safety.
4. **Miscellaneous Infrastructure (WI4):** Examine and develop tools, methods, practices, and strategies to improve condition assessment, repair and maintenance, reliability, efficiency, service life, and safety.

**Power and Energy (PE):** Develop and advance solutions, tools, and practices that improve the reliability, efficiency, and safety of Reclamation’s hydropower facilities in order to reduce costs and increase energy supplies. Develop tools and strategies to increase energy supplies through renewable energy development and energy efficient practices and policies within Reclamation pumping plants and other facilities in support of Reclamation’s operations and maintenance responsibilities.

### Research Categories:

1. **Hydropower Plants (PE1):** Examine and develop tools, methods, practices and strategies to improve safety, operations and maintenance, reliability, efficiency, outage time, and output.
2. **Energy Efficiency (PE2):** Examine and develop tools, methods, practices and strategies to improve energy efficiency at Reclamation buildings and non-hydropower facilities.
3. **Pumping Plants (PE3):** Examine and develop tools, methods, practices and strategies to improve safety, operations and maintenance, reliability, efficiency, and outage time.
4. **Non-Hydropower Renewable Energy (PE4):** Examine and develop tools, practices, and strategies for generating and using non-hydro renewable energy within Reclamation including solar, wind, geothermal, and other forms of non-hydro renewable energy.

**Environmental Issues for Water Delivery and Management (EN):** Improve the reliability of Reclamation water deliveries by producing effective solutions, tools, and practices that Reclamation water managers can use to address water state and federal environmental compliance and court orders.

**Research Categories:**

1. **Water Delivery Reliability (EN1):** Improve the reliability of Reclamation water supplies by finding innovative means to address aquatic and terrestrial ecosystem and species needs while still meeting water delivery contracts.
2. **Invasive Species (EN2):** Develop and improve techniques for managing aquatic and riparian invasive species that consume Reclamation water supplies or impede Reclamation water deliveries, or harm threatened or endangered species.
3. **Water Quality (EN3):** Develop and advance tools and practices that Reclamation has the mission responsibility and authority to use in managing water quality issues that are (1) linked to reclamation operations and (2) could impact the reliability of Reclamation water deliveries if not addressed.
4. **Sediment Management (EN4):** Develop and improve sediment management solutions and tools that improve the reliability and sustainability of water deliveries from Reclamation reservoirs and associated river systems, and improve habitat conditions for threatened and endangered species.
5. **River Habitat Restoration (EN5):** Develop and improve aquatic habitat management solutions and tools that improve the ability to comply with regulatory requirements or mitigation measures assigned to Reclamation programs including channel improvements, floodplain connectivity, channel complexity, and riparian vegetation enhancement.

**Water Operations and Planning (WP):** Develop solutions and tools that help Reclamation water managers make effective reservoir and river system operational and planning decisions. Improve the integration, evaluation, understanding, and presentation of critical data and information.

**Research Categories:**

1. **Water Supply and Streamflow Forecasting (WP1):** Develop and improve solutions and tools to forecast and monitor water supplies, including hydrologic events, and water demands.
2. **Water Operations Models and Decision Support Systems (WP2):** Develop and improve reservoir/river system operations and planning models and decision support systems in order to optimally manage water delivery and use for Reclamation.
3. **Open Data (WP3):** Develop methods and tools to improve management of Reclamation's water and related data to make it more comparable across locations, more easily found, and more shareable with other agencies, stakeholders, and the public.

4. **Climate Change and Variability (WP4):** Develop methods and tools to increase adaptive management and flexibility in the planning, design and operations of Reclamation's facilities in a variable and changing climate, including management through drought and floods.

**Developing Water Supplies (WS):** Develop, enhance, and protect water supplies for Reclamation stakeholders with new technologies, solutions, and practices that expand, liberate, or conserve water supplies.

**Research Categories:**

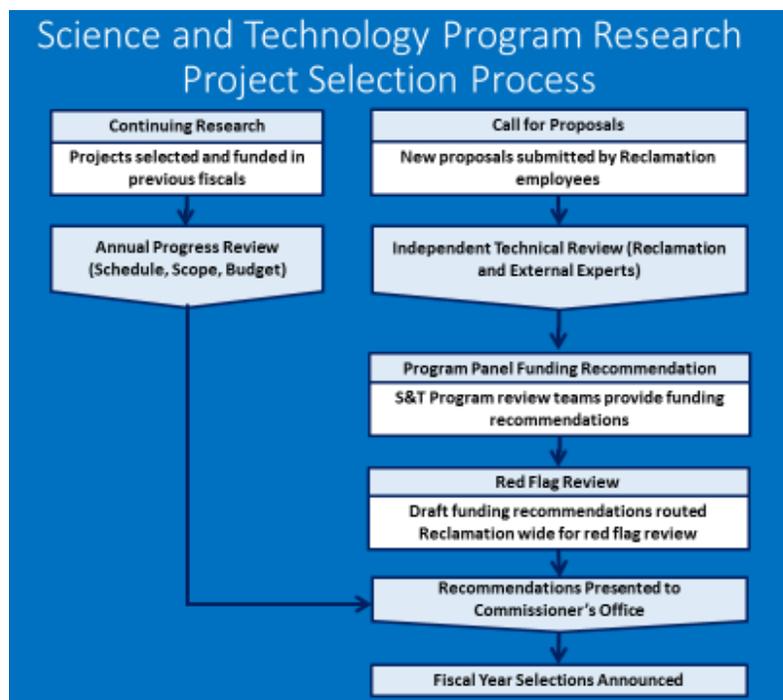
1. **Advanced Water Treatment (WS1):** Develop technologies, methods, tools and approaches to advance the treatment of impaired water sources that allow Reclamation to better utilize existing supplies, increase existing Reclamation supplies through augmentation, or prolong existing Reclamation supplies by expanding or developing non-traditional supplies from an outside source such as impaired groundwater or surface water.
2. **Groundwater Supplies (WS2):** Develop and improve solutions and tools that advance and optimize groundwater storage and conjunctive groundwater/surface water storage and use for Reclamation projects.
3. **Agricultural and Municipal Water Supplies (WS3):** Develop and improve solutions and tools that automate, measure, and deliver agricultural water resulting in liberated water or a cost savings for Reclamation or its stakeholders.
4. **System Water Losses (WS4):** Develop and improve solutions and tools that conserve water and/or reduce water losses, in Reclamation water storage and delivery systems.

# Strategic Approach to Address Science Priorities

## Program Elements

The S&T Program uses four program elements, including research and development projects, water and power technology prize competitions, technology transfer, and dissemination of research results to spur innovation and transform it into solutions for Reclamation water and water related resources managers, our stakeholders, and the larger water resources community of practice.

**Research and Development Projects:** Program projects address a wide range of science and technical challenges facing Reclamation water and power managers spanning Reclamation’s mission. Identification and prioritization of research needs under each area is guided by input from Reclamation end-users and informed by perspectives from partner agencies and stakeholders. The program invites research projects through internal research solicitation and external research brokering. Internally solicited research funding is awarded to employee’s bureau wide, based on proposal relevancy to Reclamation mission and technical merit. Every proposal is reviewed by independent technical reviewers from within and outside of Reclamation. Additionally the proposals are reviewed for technical and relevancy by a program panel that makes funding recommendations for Commissioner’s concurrence.



Projects address any of the five research areas and typically have strong cost-sharing and collaboration with Reclamation end-users, stakeholders, other agencies, and/or universities. External research brokering complements the internal research solicitation and is managed to be

responsive to agency science priorities that evolve over time and typically cross-cut the five research areas. Such brokering often involves leveraging external expertise and specialized collaborative capabilities, which enables targeted research that more rapidly addresses priority science needs, and complements progress achieved through the internal research solicitation. Brokered research is implemented through contracts, cooperative agreements, interagency agreements, and technology transfer agreements as needed.

**Water and Power Technology Prize Competitions:** Reclamation is using [prize competitions](#) to harness the innovative capacity of the American public and private sectors to solve problems related to Reclamation's mission and stakeholder interests. Prize competitions complement traditional research by providing an innovation tool that can help find breakthroughs or overcome technical obstacles or complexities. Prize competitions have a proven track record in the private sector for accomplishing game-changing results for both large and small problems. NASA, DOE, DOD and a host of other agencies are also now successfully using prize competitions under the America COMPETES Act and other authorities. Reclamation is implementing prize competitions by forming collaboration with other federal agencies that have a shared interest in the solutions we seek. This approach leverages complementary Federal capabilities, catalyzes interagency working relationships to solve joint problems, and leads to solutions that have a broader impact across the mission of multiple Federal agencies, the stakeholders we collectively serve, and overall public good. Multi-agency collaborations have been formed in [three areas central to Reclamation's mission: Infrastructure Sustainability, Water Availability, and Environmental Compliance](#).

**Technology Transfer:** Reclamation's Technology Transfer activities are aligned with the October 28, 2011 Presidential Memorandum on Accelerating Technology Transfer and Commercialization of Federal Research in Support of High Growth Businesses and are authorized by the Federal Technology Transfer Act. In response, the S&T Program pursues a variety of joint venture research partnership agreements with the private sector, including Cooperative Research and Development Agreements (CRADAs), Materials Transfer Agreements (MTAs), and Facility Use Service Agreements (FUSA), among others, where industry will play a role in maturing and transforming research results into a useable, manufactured product that can be supplied to Reclamation and the broader water management community. CRADAs allow both parties to combine their facilities and expertise on joint-venture research, and include provisions to manage intellectual property in mutually beneficial manners. In addition, Reclamation uses federal technology transfer authorities to protect federal inventions and license them to U.S. industry which creates jobs and helps U.S. industry better compete in global markets.

**Dissemination of Research Results:** Disseminating research results, beyond the technology transfer activities described previously, targets a wide audience of Reclamation end-users, stakeholders, and others across the federal and non-federal water resources community of practice. The R&D Office follows [Reclamation's Peer Review Policy](#), and all scientific information disseminated by the R&D Office will undergo some level of peer review. If the scientific information to be peer reviewed does not meet the peer review policy's definition for Highly Influential Scientific Assessments or Influential Scientific Information, then the minimum requirement is for the information to undergo at least one independent technical review. The R&D Office utilizes a contemporary knowledge management system to support research dissemination and improve research workflow through the [S&T Program's website](#).

Features include providing open access to program products, data collections, research reports, and educational resources via print, electronic, and social media.

## Integration of Program Elements

Each of these elements is complimentary and can work in tandem to address a high priority science need. Knowledge gained from traditional research and development projects can be used to inform the design of a technology prize competition, and the knowledge gained from a technology prize competition can inform the next steps of traditional research. Technology prize competitions provide a tool that solicits ideas, concepts, and solutions from the public. With the world connected through the internet, technology prize competitions are an effective tool that allows all the smart people in the world to help solve your problem. Technology prize competitions can be especially effective for problems that do not have market forces that incentivize solving the problem, tough and stubborn problems, and problems that become stuck during research and development projects.



Technology transfer activities allow Federal agencies to team-up with the private sector, combine our resources, and pursue solutions of mutual interest. CRADAs, MTAs, and FUSAs also provide the ability to protect partner, federal, and mutually developed intellectual property. Technology transfer and technology prize competitions can also be used complimentary to accomplish more together than either authority can do on its own.

The S&T Program works to educate the research community about the attributes of each tool. This enables researchers to better plan the overall project workflow to strategically use these tools to solve water problems and deliver the solutions to the end-user. The rest of this section focuses on implementation of research and development projects and not the other S&T program elements.

## Research Need Identification

To identify these research needs, the S&T Program uses multiple approaches for receiving input from within and outside of Reclamation. Reclamation leadership is engaged in two ways. First, the Regional Directors are provided an opportunity to identify their highest priority research needs each year. These Regional Director Needs are then listed in the call for proposals so that researchers can propose projects that address these needs. Second, Reclamation's Commissioner's Office is engaged each year before the call for proposals is issued to receive feedback and concurrence on the priority research needs to be communicated in the call for proposals.

At the staff level, the S&T Program also coordinates with subject matter experts in Reclamation Regions and other Directorates to understand their research needs. One way this coordination occurs is through research road mapping, which involves internal and external entities that provide input on where research is needed for a given topic. There is often then a prioritization of these needs and a formal research roadmap document is completed. The most advanced example of this for the S&T Program is within the Water Infrastructure Area, where research roadmaps have been completed and peer reviewed Dams, Canals, and Pipelines (ongoing).

The S&T Program also identifies research needs through coordination with external partners. This includes partners at the federal, state, and local level, described in more detail below. One example of a partnership that supports the development of collaborative research needs is with the US Army Corps of Engineers (USACE). Reclamation and USACE's Engineering Research and Development Center brought its directors, discipline leads, and researchers together to form a collaborative partnership in March 2014. The team developed a charter to steer joint research efforts in the areas of infrastructure sustainability, ecohydraulics, and invasive species. Its goal is to develop and foster inter-governmental research and development teams to produce and infuse solutions for common agency challenges involving water resources infrastructure and environmental stewardship. An annual meeting occurs to discuss this partnership and identify potential research needs that would benefit from collaboration. Additional partnership activities are described below.

## Research Project Implementation

The S&T Program monitors the progress of the funded research projects through quarterly reports and closeout requirements. At the end of a research project, the PI must complete a research report that documents the results of the project and is peer reviewed by at least one subject matter expert. The S&T Program then posts these final reports on the S&T Program website. Additionally, for many of our projects, a research bulletin is created and posted to the S&T Program website as well. Research bulletins summarize project results and identify project impacts or potential impacts that may be realized because of the research. Each quarter, the S&T Program publishes a [Knowledge Stream](#) magazine to provide program participants and stakeholders an update related to ongoing or completed research projects.

## Research Project Impact

When a research project is complete, there are often additional next steps needed to transition the results to implementation. This is a critical step to ensure the research makes an impact to Reclamation's mission. The nature of research is such that not all projects return successful results. So the key for the S&T Program to make an impact is identifying the projects with good results and helping transition those to implementation. While this implementation step is built into the project plan for some projects, it is often outside the scope of a research project to see the results implemented. This is why partnerships are critical to a project, as these partners are often the end user of the results and information being generated by the projects.

## Science and Technology Program Partners

As mentioned previously in the report, [partnerships](#) are a key element to the success of an S&T Program research project in order to benefit Reclamation's mission. Partnerships are identified by researchers in their proposal and are a key element to the proposal selection scoring criteria. During fiscal year 2017, the S&T Program started the year with 174 active research projects, funded with FY 2014 – 2016 appropriations, totaling \$10.94 million in Reclamation funding for the projects. These 174 projects also had \$11.56 million in partner contributions. These contributions may be cash or in-kind support and can come from within Reclamation, from other federal agencies or non-federal partners such as universities and state and local governments.

Partners are identified by the researchers as they develop their proposals and the S&T Program staff is actively coordinating with other entities seeking partnership opportunities for projects of mutual interest.

### Reclamation Partners

Reclamation's Regional and Area Offices provide a significant portion of the cost share for funded projects each year, understanding that solutions developed through S&T research and development projects are intended to benefit multiple programs and water systems with Regional and Area office jurisdictions. In addition, other Directorates also contribute cost share, such as the Power Resources Office, the Technical Services Center, Safety Security and Law Enforcement (Dam Safety), Information Resources and Policy and Administration.

### Federal Agency Partners

The S&T Program partners with a number of other federal agencies, including other bureau's within the Department of Interior. In fiscal year 2017, some of these federal partners included: Bureau of Land Management, National Renewable Energy Laboratory, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Department of Agriculture (Agricultural Research Service), U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration, National Park Service, NIST, U.S. Forest Service, Department of Energy, and NASA.

### Non-federal Agency Partners

There is a wide variety of non-federal partners that may participate on an S&T Program funded research project. In fiscal year 2017, some of the non-federal partners we worked with are highlighted below.

**Universities**

Texas A&M University, Brigham Young University, University of Wyoming, New Mexico State University, Massachusetts Institute of Technology, Drexel University, University of Denver, University of Arizona, North Dakota State University

**Local Municipalities and Agencies**

Maricopa County (AZ), City of Los Angeles, Resource Conservation District of the Santa Monica Mountains, Denver Urban Drainage and Flood Control District, Truckee Carson Irrigation District, Sonoma County Water Agency, Truckee Canal Irrigation District, City of Lawton (OK), City of San Diego, Yuma County Agricultural Water Coalition, and Central Arizona Water Conservancy District

**Tribes**

Chickasaw Nation, Hopi Tribe, Yurok Tribe

**State Agencies**

California Department of Water Resources, Colorado Salinity Control Forum, Desert Research Institute, Texas Water Development Board, Texas Water Science Center

**Private For-profit or Non-profit Entities**

BASF, Lafarge, Desek Ltda, National Center for Atmospheric Research, Crane Materials International, Crane Materials International, Instream Energy Systems Corp., Emergy Hydro, LLC, CEATI, Council for Watershed Health, Friends of the Los Angeles River, The Nature Conservancy, Geosyntec Consultants, DOW, Carollo Engineers

## Science and Technology Program Contacts

To request additional information about the S&T Program or to discuss partnership opportunities, please email [research@usbr.gov](mailto:research@usbr.gov).