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RECLAMATION

# Knowledge Stream

Research and Development Office

*Innovation at Reclamation –  
Research & Development Office  
Overview*

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# Message from R&D

Welcome to the Spring 2022 issue of the Knowledge Stream! In this issue, we provide an overview of Research and Development (R&D) Office and Programs. As the Bureau of Reclamation (Reclamation) carries out its mission, a variety of scientific and technical challenges are encountered that benefit from innovation activities. The R&D Office invests in such innovation through the Desalination and Water Purification Research (DWPR) Program and the Science and Technology (S&T) Program, both of which help to advance Reclamation's technical abilities to manage, develop, and protect water and related resources in an environmentally and economically sound manner. Additionally, the R&D Office houses several other programs: the Reclamation Geographical Information Systems (GIS) Program, the recently authorized Snow Water Supply Forecasting Program, the S&T Prize Competitions Program, and the Open Water Data Program. Included in this issue, you will find articles about:

- Internal and external R&D Office Program partners
- Newer R&D Programs
- The S&T Program's annual research Call for Proposals
- The S&T Prize Competitions Program and recent competitions
- The DWPR Program and projects
- R&D efforts to transition from promising research and prize solutions to application

## About the *Knowledge Stream*

The *Knowledge Stream*, published by the Bureau of Reclamation's Research and Development Office, is a quarterly magazine bringing mission-critical news about the agency's innovations in the following:

- S&T Program
- DWPR Program
- Prize Competitions Program
- Open Water Data Program
- Reclamation GIS Program
- Technology Transfer...and more

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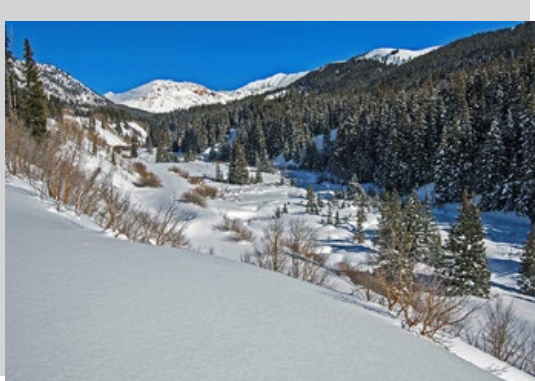
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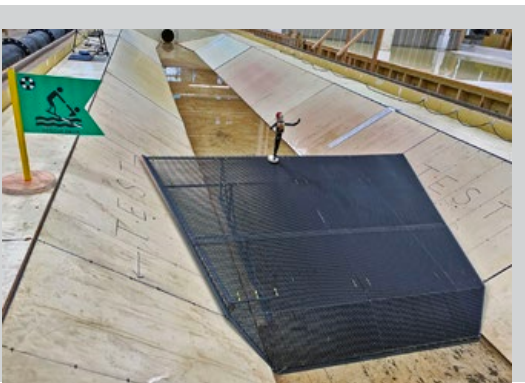
usbr.gov/research

*For more information on articles within this issue, please contact the listed author or John Whitler.*



Snow Water Supply Forecasting Program

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Canal Safety Challenge

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*Front Cover: Scenic photo of Shasta Dam, California.*

*Back Cover: Photo of Glen Canyon Dam penstocks, showing low water levels in Lake Powell, Arizona.*

*The information being offered herein represents the opinion of the author(s) and is not a statement of fact about Bureau of Reclamation findings or conclusions.*

# Community Needs

## Examples of Successful Internal and External Partnerships

By **John Whitley, Jen Beardsley, & Yuliana Porras Mendoza**  
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The R&D Office works with a wide range of partner organizations. A few of these partners were asked how R&D Programs contribute to their work and Reclamation’s mission.

### Science and Technology Research Support for Reclamation Regions

#### Columbia-Pacific Northwest Region

In the Columbia Pacific Northwest Region, the Middle Snake Field Office is utilizing the Bureau of Reclamation’s (Reclamation) Science and Technology (S&T) Prize Competition Program and other S&T Programs to investigate trashracked intake structure debris mitigation and removal concepts. Under the S&T Prize Competition Program, the contractor, Yet2, conducted a worldwide solicitation of entities who have, or are developing, debris mitigation and/or removal technologies. These results will be vetted and narrowed down to a short list, which will be cost analyzed and hydraulically modeled as part of the recently initiated S&T project 22017. The field office will then identify an economic means by which to safely and effectively remove/mitigate the increasing amount of debris that accumulates on the Black Canyon Diversion Dam intake structure.



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#### California-Great Basin Region

S&T Program funding for California Great Basin research projects adds significant value to the region in understanding the science while advancing our mission of providing water and power in a sustainable manner. During fiscal year 2022, the S&T Program funded eight new and continuing projects in this region, including those for algae-resistant linings for canals and other water resource structures; maintaining canal capacity and delivery feature reliability through the use of ultraviolet aquatic vegetation control; a methodology for rockwad velocity and predator habitat; enhancing Reclamation’s watershed model to predict post-fire sediment delivery to reservoirs and assessing management actions; evaluating the release of mercury from sediment and dredging of Lahontan Reservoir waters; and evaluating water temperature modeling and prediction in the Sacramento River Basin.



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## Lower Colorado Basin Region

Reclamation’s Lower Colorado Basin continues to partner with the Research and Development (R&D) Office for multiple initiatives and has expressed its appreciation for the opportunity to be involved in researching and developing innovation solutions through the Desalination and Water Purification (DWPR) and S&T Programs. As the region endures prolonged drought, water resource issues have been exacerbated and require innovative technologies and research to help address and mitigate the impacts. Partaking in these programs offered by the R&D Office has helped the region carry out its mission responsibilities by using state-of-the-art tools and methods in day-to-day operations and periodic maintenance activities. Much of the recent research conducted in the region has focused on advancing methods for water planning and operations, developing water supplies, and exploring ways to combat environmental issues caused by extended drought.

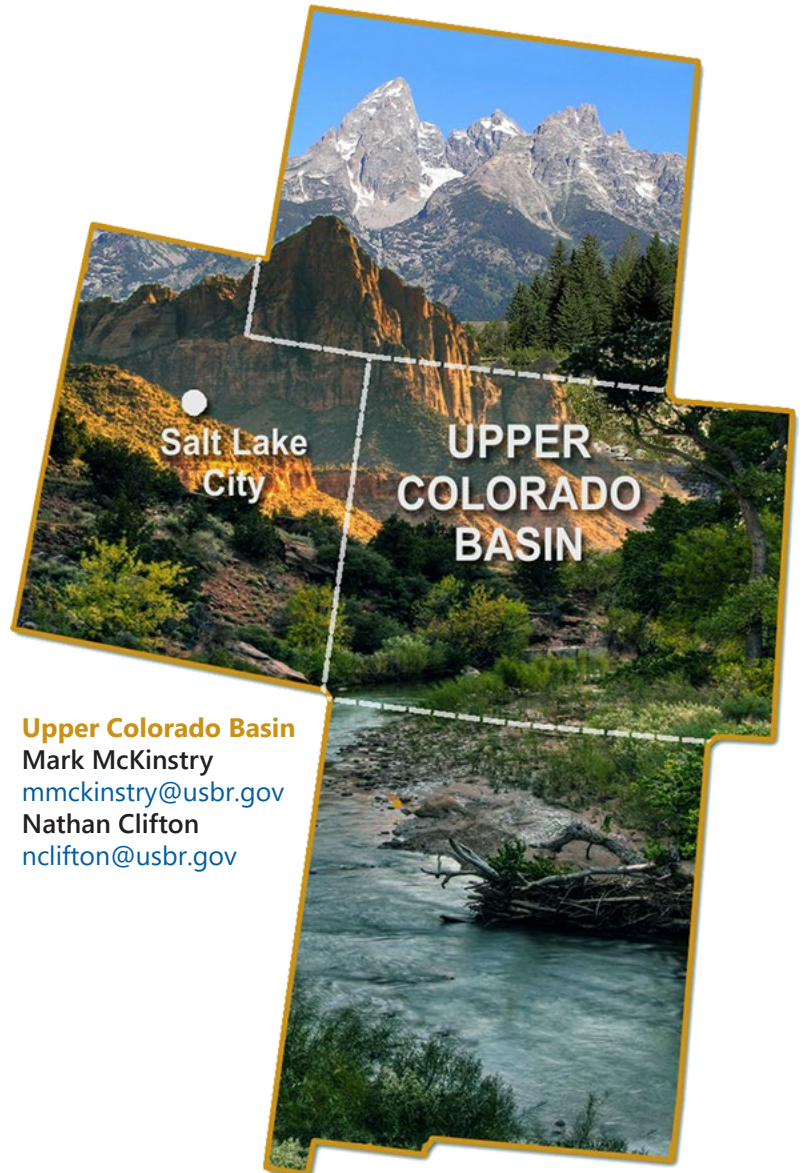


### Lower Colorado Basin

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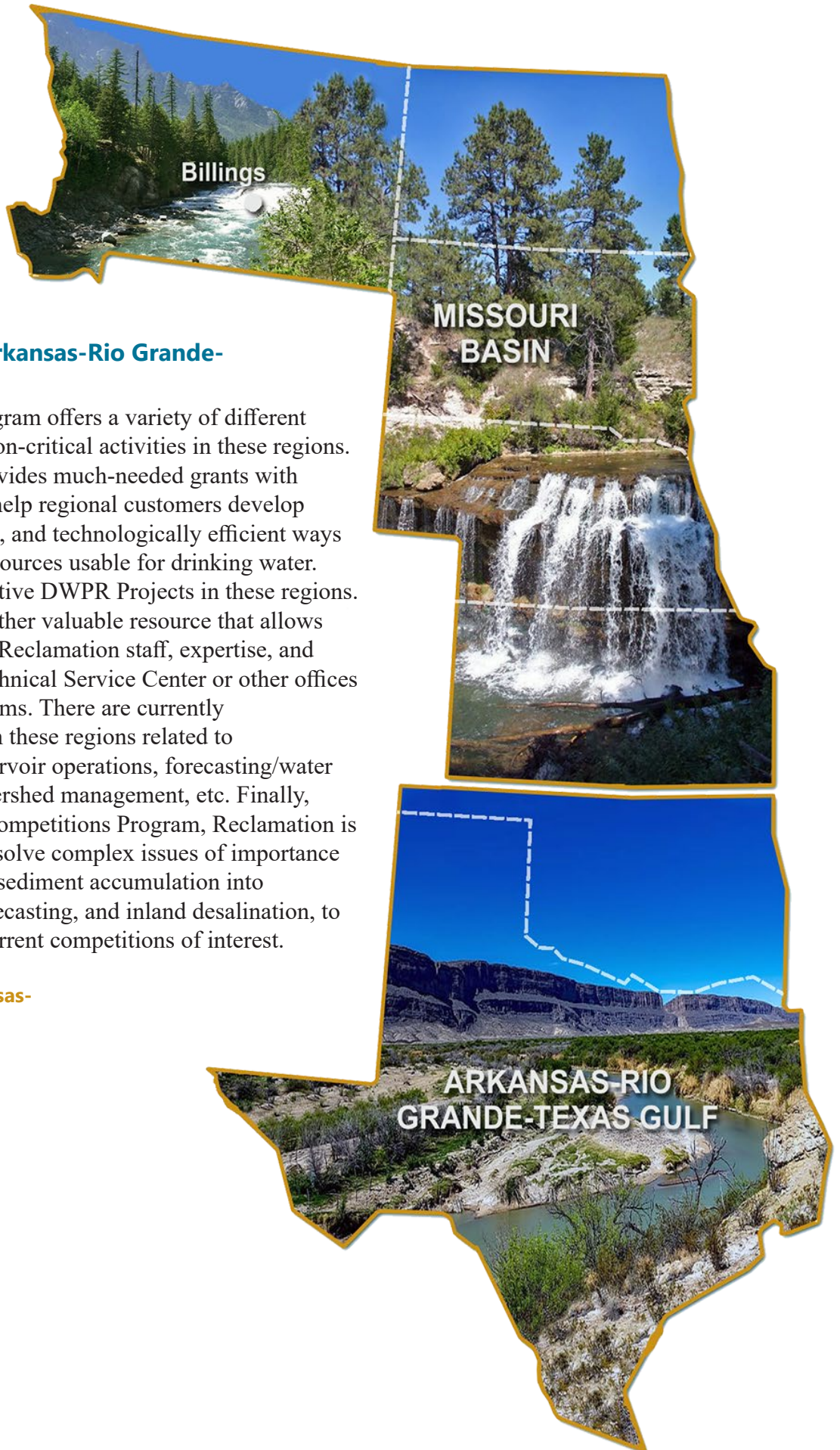
## Upper Colorado Basin Region

The S&T Program has been an extremely valuable asset for the Upper Colorado Basin. It has allowed them to further their ability to fulfill Reclamation’s mission of providing water in the West. This region is currently experiencing one of the worst droughts on record. The S&T Program has funded research throughout the region, including everything from new methods/technologies of estimating reservoir evaporation to expanding our understanding of the science of snowpack, runoff, and weather modification interactions. With less water available and the ever-increasing demand for water and power in this region, the S&T Program, and the research performed through it, will be vital in managing the resources available in the future. The drought has further emphasized the need for the DWPR Program and its cost share, as the region’s need to be more efficient with available resources has expanded due to the current drought. The need for the Program is expected to increase, with several of major reservoirs at record low water levels and average to low runoff predicted for the coming season.



### Upper Colorado Basin

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### Missouri Basin and Arkansas-Rio Grande-Texas Gulf Regions

Reclamation’s R&D Program offers a variety of different avenues to support mission-critical activities in these regions. The DWPR Program provides much-needed grants with favorable cost-shares to help regional customers develop innovative, cost-effective, and technologically efficient ways to make impaired water sources usable for drinking water. There are currently 10 active DWPR Projects in these regions. The S&T Program is another valuable resource that allows these regions to draw on Reclamation staff, expertise, and laboratories from the Technical Service Center or other offices to solve important problems. There are currently 14 active S&T projects in these regions related to infrastructure safety, reservoir operations, forecasting/water availability, wildfire/watershed management, etc. Finally, through the S&T Prize Competitions Program, Reclamation is using crowd sourcing to solve complex issues of importance to the regions, including sediment accumulation into reservoirs, snowpack forecasting, and inland desalination, to name just a few of the current competitions of interest.

#### Missouri Basin and Arkansas-Rio Grande-Texas-Gulf

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## S&T Prize Competition Support for Reclamation and Other Federal Agencies

### Reclamation's Technical Service Center

**Janet White – Chief, Engineering and Laboratory Services Division**

The Technical Service Center's laboratory groups have enjoyed working closely with the R&D Office on prize competitions by helping identify topics of interest and providing subject matter experts to judge competitions. We have even tested prototypes for several of the competitions in our laboratories!

### U.S. Department of Energy – Water Power Technologies Office

**Dana McCoskey – Manager, Environmental Technologies**

The Water Power Technologies Office and Reclamation partnership on the Fish Protection Prize allowed us to cast a larger net to identify and evaluate a wide range of solutions sourced from all types of solvers – the public, technology developers, small businesses, private sector companies, and researchers. By providing prize winners with no-cost, technical support from the Pacific Northwest National Laboratory, winners were able to establish proof-of-concept validation for their ideas or testing to accelerate technology performances evaluations. This has led to new and continuing collaborations between solvers and lab researchers, and solvers are leaving the lab with information on what works, how to refine their designs, and new intellectual property which can accelerate future investments in R&D and commercialization.

### Federal Highway Administration Resource Center

**Scott Hogan – Senior Hydraulic Engineer**

The Federal Highway Administration (FHWA) and Reclamation collaboration on SRH-2D development (since 2013) has had significant positive impact on the transportation hydraulic industry. As a result of the improved application and benefits, 2D hydraulic modeling has become more widely used to support more accurate hydraulic modeling for improved bridge design, bridge scour analysis, and foundation protection. It is great to see the continued advancement of the SRH-2D program through the Divide and Conquer prize competition.

### U.S. Army Corps of Engineers – Engineer Research and Development Center

**Travis Dahl – Research Hydraulic Engineer –**

U.S. Army Corps of Engineers (USACE) staff from multiple district offices and the Engineer Research Development Center – Coastal and Hydraulics Lab have been partnering with Reclamation on the Guardians of the Reservoir prize challenge since 2017. The USACE is continually searching for efficient, low-cost sediment management solutions for its portfolio of over 400 reservoirs. By partnering with Reclamation, the USACE is able to leverage additional resources to progress new technologies that could be used to extend reservoir life for a lower cost, in a shorter time, and with less environmental impacts than some current technologies. Future implementation of any of these solutions will help the USACE restore and maintain projects the public has come to depend on.

## DWPR Pitch to Pilot Support for Private Industry Partners

### Garver, LLC

**Eric Dole, PE, PSAP – Water and Energy Practice Lead**

The Reclamation-funded DWPR “Pitch to Pilot” Desalination Research Project was a refreshing way to solicit research ideas and select awardees. From the “Concept Proposal” to the “Pitch,” our team at Garver, LLC (Garver), had to give Reclamation staff (and citizens of Alamogordo, New Mexico) at the BGNDRF. Reclamation worked with Garver through the COVID-19 pandemic by extending the schedule and budget. This research opportunity has opened several doors, not only for Garver, but also for Red Rocks Community College, as they partnered with Garver to research disruptive desalination technologies that consume less power.



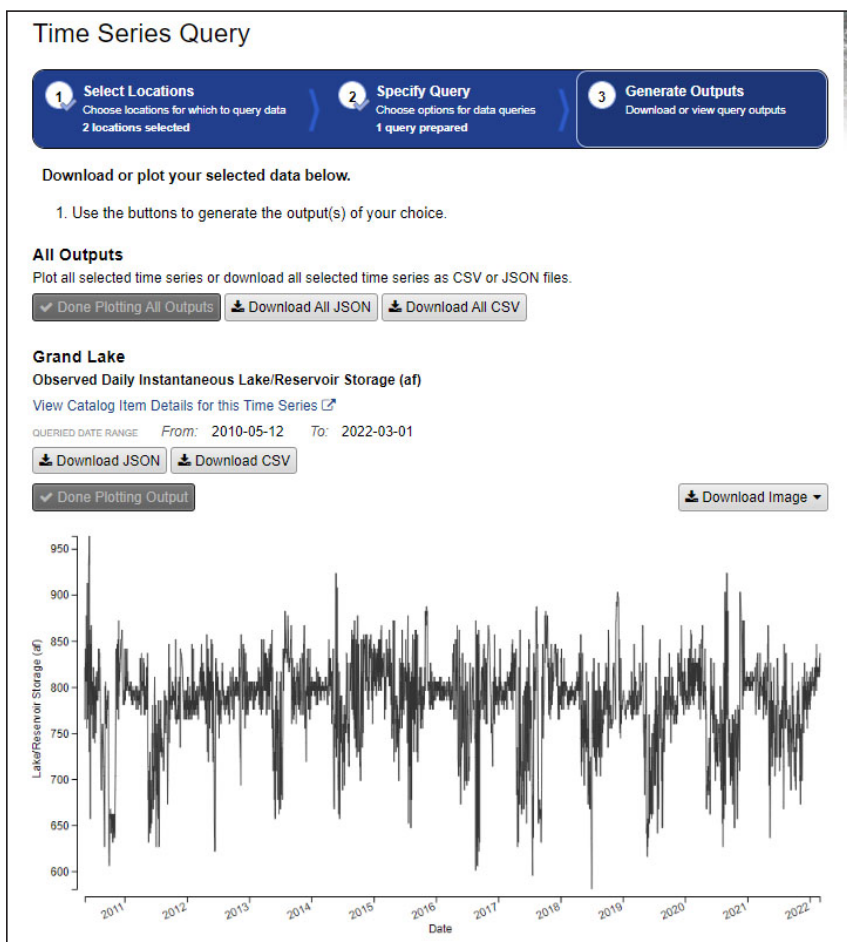
# Key Perspectives

## Recent Additions to R&D Office Programs

By Ken Nowak, Allison Odell, & Greg Gault

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The Research and Development (R&D) Office applies science and technology to advance the Bureau of Reclamation's (Reclamation) mission to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. This involves a diversity of research topics and programs that have evolved over the years to meet emerging needs and new initiatives. This article provides an overview of three newer R&D Programs: the Open Water Data Program, the Snow Water Supply Forecasting Program, and the Reclamation Geographic Information Systems (GIS) Program.



Screenshot from RISE showing the output of a query of Grand Lake storage in acre feet for May 12, 2010 to March 1, 2022. Also shown are options for downloading the data as a JSON or CSV file as well as downloading the plot image for use in reports/presentations.

### Open Water Data Program

In 2016, the Science and Technology Program received funding for a new initiative focused on making Reclamation's water and related mission data open – meaning publicly discoverable and available in standardized, machine-readable formats. A major component of this initiative focused on developing a Reclamation-wide open data publishing platform, which resulted in the launch of the [Reclamation Information Sharing Environment \(RISE\)](#) in 2020. RISE provides public access to all types of publishable data that Reclamation generates in its water, power, and related mission activities. RISE enables Reclamation offices and programs to easily share data from water and power management operations, planning studies, field and monitoring activities, research projects, and more. Data subjects include reservoir conditions, water delivery, hydropower generation, invasive species, threatened or endangered species, habitat conditions, water quality, and other mission-related

topics. Data types include observed and modeled time-series data, geographic information, reports, models, analytical products, and more. The RISE system consists of a data catalog, time-series query interface, map interface, public application programming interface (API), other public website components, an internal data and content administration interface, and underlying databases and APIs. RISE also provides public hosting for data visualization and analysis applications developed by programs and offices.



In support of continued expansion of open data at Reclamation and to increase efficiency and effectiveness of data dissemination activities, including RISE and other data sharing websites and processes, the Reclamation Open Data Team was rechartered in 2021. The team includes representatives from each region, the Technical Service Center, the Information Resources Office, Policy and Programs, the Power Resources Office, Dam Safety and Infrastructure, and Public Affairs. Key activities of the team in 2022 included inventorying existing data sharing mechanisms used by Reclamation, reviewing open data laws and policies (e.g., the OPEN Government Data Act) to identify areas that may require Reclamation policy or guidance, sharing information about open data with Reclamation staff, management, and leadership, and advising the Open Data Team.

Open Water Data Team contact information:

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There are a number of ways you can engage with RISE and broader Reclamation open data efforts. If you're looking to publish your data in RISE, there are [detailed guidance and tools](#) available, plus a network of RISE data publication liaisons who can walk you through the process and support you along the way. Get started with publishing using the RISE Data Administration User Interface (<https://rise.bor.doi.net/>). For help with publishing or to connect with a RISE liaison, contact [data@usbr.gov](mailto:data@usbr.gov). You can also join the [RISE Data Publication Microsoft Team](#) for periodic updates and training opportunities. If you have ideas about how RISE could better serve the needs of Reclamation, the annual [S&T Call for Proposals](#) accepts research proposals related to enhancing RISE to meet new and unique data publishing needs. To connect with your region or directorate's Open Data team member, contact Allison Odell, the Team Lead, at [aodell@usbr.gov](mailto:aodell@usbr.gov). For more information on RISE and open data, visit the RISE website (<https://data.usbr.gov>) or see the [September 2020 issue of the Knowledge Stream](#).

## Snow Water Supply Forecasting Program

Reclamation, on behalf of the United States Secretary of the Interior, is implementing the recently authorized Snow Water Supply Forecasting Program (P.L. 116-260, Sec. 1111). Snow is a critical component of our Nation's water supply, particularly in the Western United States, where over half of the streamflow is derived from snowmelt. The Program aims to improve activities, such as snowpack measurement, to improve water supply forecasts and water management, expand snow monitoring in existing and new river basins, and develop and use new snow measurement tools. In support of program framework development, Reclamation collaborated with partner agencies to produce a report for Congress on emerging snow monitoring technologies. It describes the benefits of snow monitoring, reviews a range of snow monitoring technologies, and describes how partner agencies will coordinate to implement the program. Specifically, Reclamation will formalize and convene a Partner



*Looking upstream at the East Fork Arkansas River, near the base of Freemont Pass in Colorado.*

Agency Council to maximize program impacts by leveraging investments and providing a forum for information exchange related to the use of snow monitoring in water management and water supply forecasting. The program is authorized for fiscal years 2022–2026, with a program implementation report due to Congress at the end of 2024.

## Reclamation Geographic Information Systems Program

The Reclamation GIS Program was established in early 2019 in the Water Resources Planning Office and, in late 2021, reorganized under the R&D Office in the Chief Engineer’s Organization. The GIS Program joins other data-centric programs and activities, including the Associate Chief Data Officer and the Open Data Team. The function of the GIS Program is to coordinate activities related to the creation, maintenance, delivery, and use of geospatial data and associated analytical products required to carry out Reclamation’s mission. In collaboration with the other data programs, the GIS Program is responsible for ensuring high-quality geospatial data assets are available and accessible to all levels of Reclamation, its partners, and the public.

The goals of the GIS Program are to ensure accountability and effective development and management of Reclamation’s geospatial data and technology resources, strengthen collaborative activities and partnerships internally and externally, and to enhance efficiency and improve productivity of GIS staff by coordinating regular GIS training opportunities. Program goals are facilitated through the Reclamation Geospatial Advisory Council, a group of GIS coordinators representing each region and Denver directorate. The council collaboratively coordinates GIS-related activities across

Reclamation in direct support of its mission, playing an essential role in geospatial data governance and standardization, GIS services coordination, geospatial software management, GIS training, and much more.

In 2020, the GIS Program began establishing a cadre of GIS data managers in the regional and area offices to improve geospatial data management and to support the Asset Registry Project while complying with new legislative requirements of the Geospatial Data Act of 2018 (P.L. 115-254). Collaborating with the Associate Chief Data Officer and the Open Data Team, the GIS Program is actively working to make Reclamation’s vast geospatial assets more findable, accessible, interoperable, and reusable.

The GIS Program leverages Reclamation’s enterprise GIS, known as BORGIS, and a new cloud-based companion GIS system, BORGIS Cloud, that will be hosted in the U.S. Department of the Interior’s GeoPlatform. Together, these geospatial technology platforms enable the delivery of field to enterprise data solutions in which data updates made in the



*Left: Alex Duwe, GIS Specialist; Right: Paul Martin, GIS Coordinator, Missouri Basin.*

field can be reflected in dashboards in near-real time. The two key applications are eGO and Tessel, designed by eGO-GIS for Everyone Enterprise Geospatial Operations. [eGO](#) is a one-stop-shop web application for finding all things GIS in Reclamation, such as links to launch Tessel, as well as resources like mapping guidance, map libraries, and GIS technical support resources. One notable feature is the ability to enter the name of a Reclamation facility into the “Search” function, which then returns links to an interactive web map zoomed to the facility’s location.

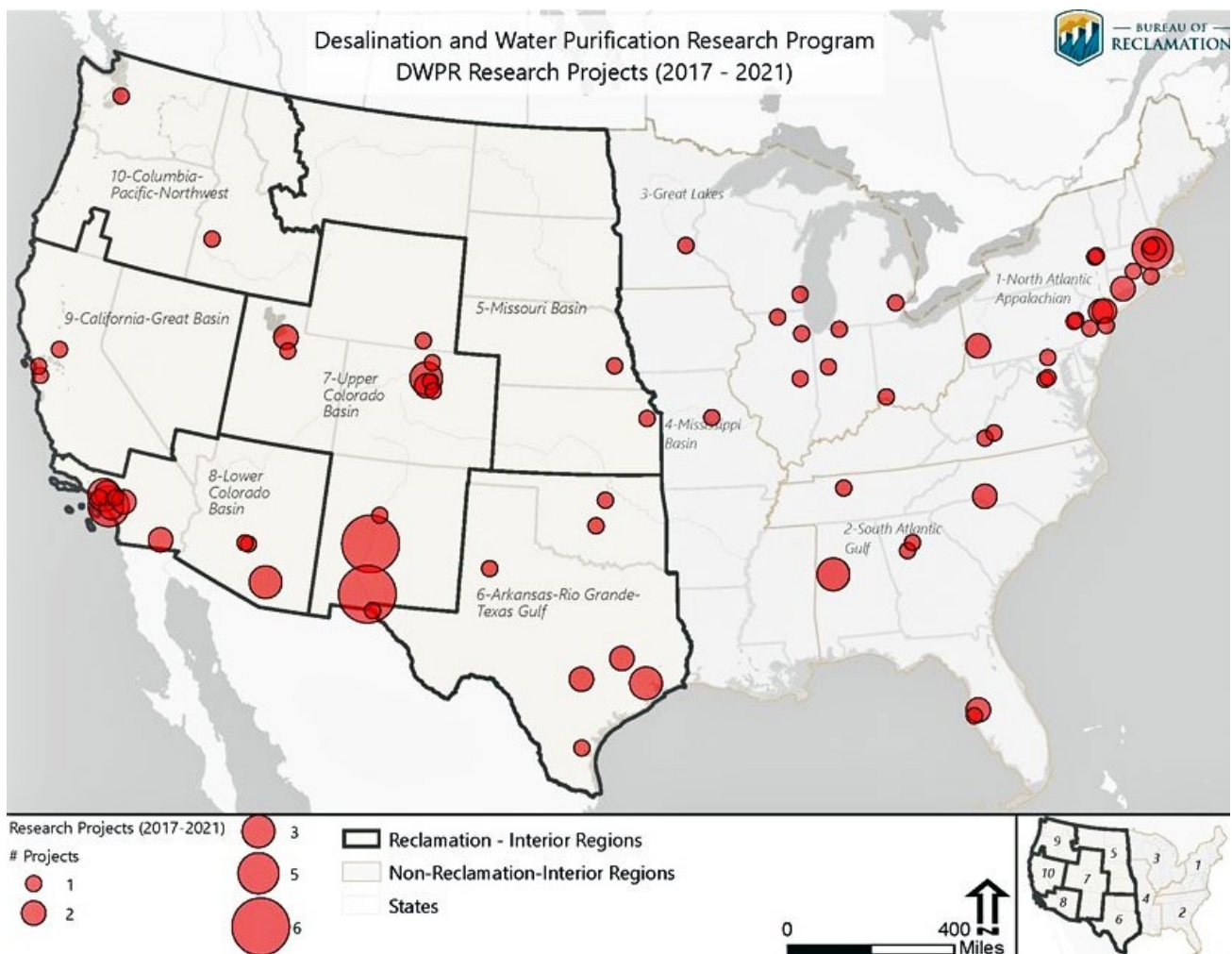
Tessel is an interactive data-driven web mapping platform hosted on BORGIS that combines commercial software with custom developed functionality. [Tessel Enterprise](#) delivers a view of Reclamation’s major assets in map context along with a suite of widgets to add data, filter and summarize data, change base maps, markup tools, and print. Tessel serves as a platform for business-driven, custom-developed instances, including: [Tessel Modeled Inundation Analysis](#) and [Tessel ShakeMaps](#).

# Desalination and Water Purification Research

## Program Overview

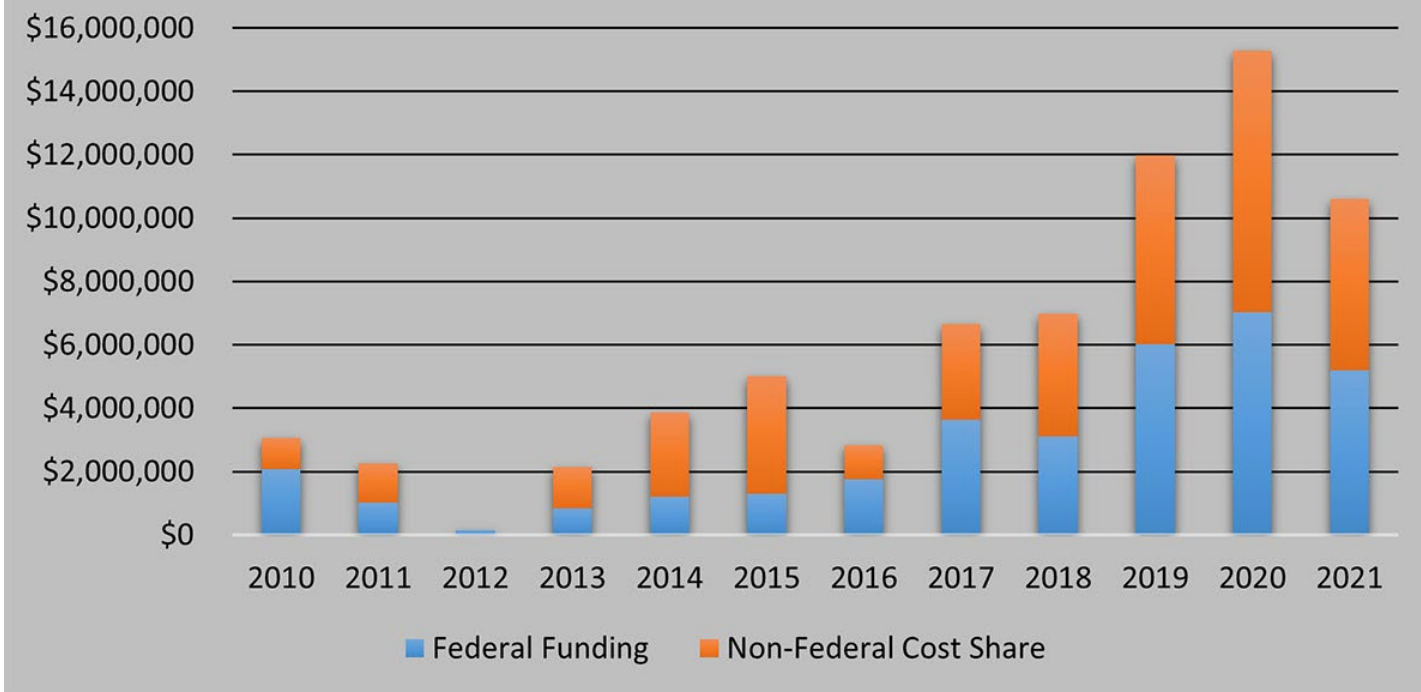
By Yuliana Porras Mendoza & Andrew Tiffenbach  
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The Bureau of Reclamation (Reclamation) has been funding water treatment research for nearly 70 years with the inception of the U.S. Department of the Interior’s Office of Saline Water in the 1950s. The various offices and programs within Reclamation leading this work have continued to evolve throughout the decades. In 1996, the Water Desalination Act allowed for the creation of Reclamation’s [Desalination and Water Purification Research \(DWPR\) Program](#), which funds researchers nationwide on the development of improved water treatment technologies for augmenting water supplies. DWPR aligns with Executive Order 14008, “Tackling the Climate Crisis at Home and Abroad,” by investing in development and application of advanced water treatment technologies that expand access to otherwise unusable water resources, thereby increasing water supply flexibility under the risks of long-term climate change and shorter-term drought. Investing in such technologies leads to development of climate-resilient, cost-effective, and low-impact solutions that bolster the ability of Reclamation, its customers, and stakeholders to cope with stresses of climate change.



DWPR Research Project Locations.

## DWPR Project Funding



DWPR Project Funding Levels.

Through DWPR funding, research sponsors partner with Reclamation to address a broad range of desalting and water purification needs. Reclamation is interested in research with widespread benefits widespread and those in which private-sector entities are not able to make the full investment and assume all the risks. Reclamation is also interested in research that has national significance—where the issues are of large-scale concern and the benefits accrue to a large sector of the public. The DWPR Program leverages investments from other Federal and non-Federal entities to facilitate the advancement and deployment of new technologies. [Knowledge generated from this investment](#) is made available to communities, organizations, and industry. Broad participation from the research and development (R&D) community nationwide underscores how that community’s interests align with Reclamation’s desalination and water purification innovation objectives—resulting in a highly competitive funding processes for promising R&D proposals.

The DWPR Program objectives include developing improved methods of desalination, increasing energy efficiency water treatment processes, and reducing the costs and environmental impacts of treating impaired waters, including but not limited to, seawater, inland brackish groundwater, municipal wastewater, and produced waters from oil and gas extraction activities. Through the Program’s two competitive external Notice of Funding Opportunities (NOFOs), “Research” and “Pitch to Pilot,” Reclamation awards R&D cooperative agreements to non-Federal recipients nationwide. Under the “Research” NOFO, laboratory-scale projects are eligible to receive up to \$250,000 in Federal funds for projects lasting up to 2 years, and pilot-scale projects are eligible to receive up to \$800,000 in Federal funds for projects lasting up to 3 years. Under the “Pitch to Pilot” NOFO, pilot projects are eligible to receive up to \$200,000 in Federal funds for projects lasting up to 18 months.



# Featured Research: Massachusetts Institute of Technology

By Saied Delagah  
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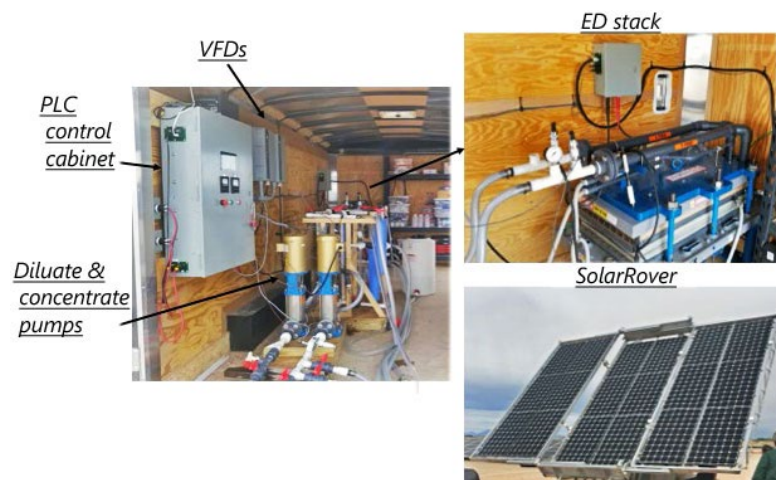
Dr. Amos Winter and his team at the Massachusetts Institute of Technology (MIT) have been working to solve the Bureau of Reclamation's (Reclamation) off-grid water needs since 2014. They explored desalination systems that can treat and/or desalinate inland brackish groundwater using solar energy to power electro dialysis (ED) and ED reversal (EDR).

In March 2014, the United States Agency for International Development partnered with Reclamation to launch the Desal Prize, incentivizing teams to create environmentally sustainable, small-scale brackish water desalination systems that could provide potable water for humans and crops in developing countries. The MIT team developed the first generation of these projects to improve EDR-based technology and to simplify, automate, and maximize water recovery. Their photovoltaic (PV)-powered EDR system won first place in the Desal Prize competition.

The MIT team has been working on various Desalination and Water Purification Research (DWPR) agreements from Reclamation to improve the concept and ultimately reduce the cost of off-grid desalination for community-sized desalination systems.

**System-Level Cost and Performance Optimization for Photovoltaic-Powered Electro dialysis Reversal Desalination** (2018; completed). The goal was to optimize costs for solar-powered EDR systems; this work included investigating and modeling various desalination system architectures. The work modeled relationships among power, energy, operation time, and cost of PV and EDR subsystems. With the developed model and optimization framework, the benchmarked village-scale PV-EDR system analysis indicated that the optimum PV-EDR system could reduce capital costs by 44 percent from the rule-of-thumb system design. The MIT team also created updated EDR behavior models and tested a laboratory-scale prototype that uses carbon electrodes as a foundation for reducing the cost and environmental impact of brackish water desalination systems by efficiently using renewable energy sources.

**Pilot Testing Cost- and Performance-Optimized Photovoltaic-Powered Electro dialysis Reversal Desalination Systems** (2018; completed). The goal was to validate cost- and performance-optimized architectures for community-scale, off-grid, solar-powered EDR brackish water desalination systems; this project tested pilot-scale, time-variant PV-EDR prototypes at the Brackish Groundwater National Desalination Research Facility (BGNDRF) based on the previous lab-scale research. This project validated that these methods reduce costs for potable water production by more than 40 percent from non-optimized PV-EDR architectures. The pilot-scale production also demonstrated the feasibility of voltage and flow control systems for PV-EDR and the time-variant system's high effectiveness for using variable solar power to produce water efficiently. The improved conversion from variable solar power to freshwater could help produce the same amount of water during the daytime, when the sun is available, indicating a further 10- to 20-percent cost reduction associated with battery storage in the traditional static-operated systems.



*The time-variant PV-EDR system built in BGNDRF, Alamogordo, New Mexico.*

### **Pilot Testing Dynamic Optimized, Photovoltaic-Powered, Time-Variant Electrodesialysis Reversal Desalination System** (2019; in development).

This pilot project is testing cost- and performance-optimized architectures for time-variant, voltage- and flow-controlled, community-scale, PV-powered EDR brackish water desalination systems. These innovations are predicted to lower the capital cost of community-scale (10 cubic meters per day) PV-EDR systems by approximately 60 percent from current technology and design practices. The pilot focuses on refining MIT's time-variant ED stack voltage and pumping control to maximize how often the system can adjust its behavior (predicted to reduce system costs by an additional 5–10 percent). After this, the pilot will test MIT's system-level cost and performance optimization theory in the lab, and then at BGNDRF, and integrate a novel, fully cost-optimized ED stack (predicted to reduce the stack cost by 80 percent).



### **Multi-Market Pilot of Low-Cost, Time-Variant Electrodesialysis Reversal Desalination Systems With Optimized Brine Management** (2021; in development).

MIT's Global Engineering and Research (GEAR) Lab has created community-scale, PV-powered time variant electrodesialysis reversal (TEDR) systems that reduce capital cost by about 50 percent from conventional practice and achieve price parity with equivalent-sized on-grid reverse osmosis (RO) systems in India, while reducing wasted water by one-half. The MIT team will also include SUEZ Water Technologies & Solutions, the market leader in ED unit manufacturing, to aid in customizing and minimizing the cost of TEDR systems. These innovative on- and off-grid TEDR systems have substantially lower operating expenses than RO systems, making them attractive for Tribal and rural communities can often cover capital expenses from grants or donors, but are responsible for ongoing operating costs.

This project will help move this low-cost, brackish water desalination with optimized brine management from an academic prototype to a commercial product for rural and Tribal communities. MIT will engage local communities, including the Navajo Nation, to incorporate stakeholder-driven needs into system design and service models, aided by our collaboration with Reclamation experts on Tribal water issues.

Concentrate management costs pose a major barrier to inland brackish water desalination. This project also supports GEAR Lab and the Wright Lab at the University of Minnesota (UMN) to optimize custom brine management solutions for each pilot location. Following this DWPR-funded project, a company will be set up to commercialize affordable (PV)-TEDRBM solutions customized to the U.S. small water treatment market. Through a private foundation, funding is already in hand to fully support this commercialization and startup effort.

# Halting Salt Accumulation in a Sewershed from Cooling Towers

By Eric Dole, PE, PSAP – Garver, LLC  
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## The Problem

Contaminating our precious water supply with saltwater can be easy, but removing it isn't! As shown on the figure below, salt comes from a variety of sources. Understanding the salt loading source in a watershed sets the stage for salinity management. Often, there are best management practices that can reduce salt loading to the watershed so treatment intensity can be reduced.



Watershed Salt Loading.

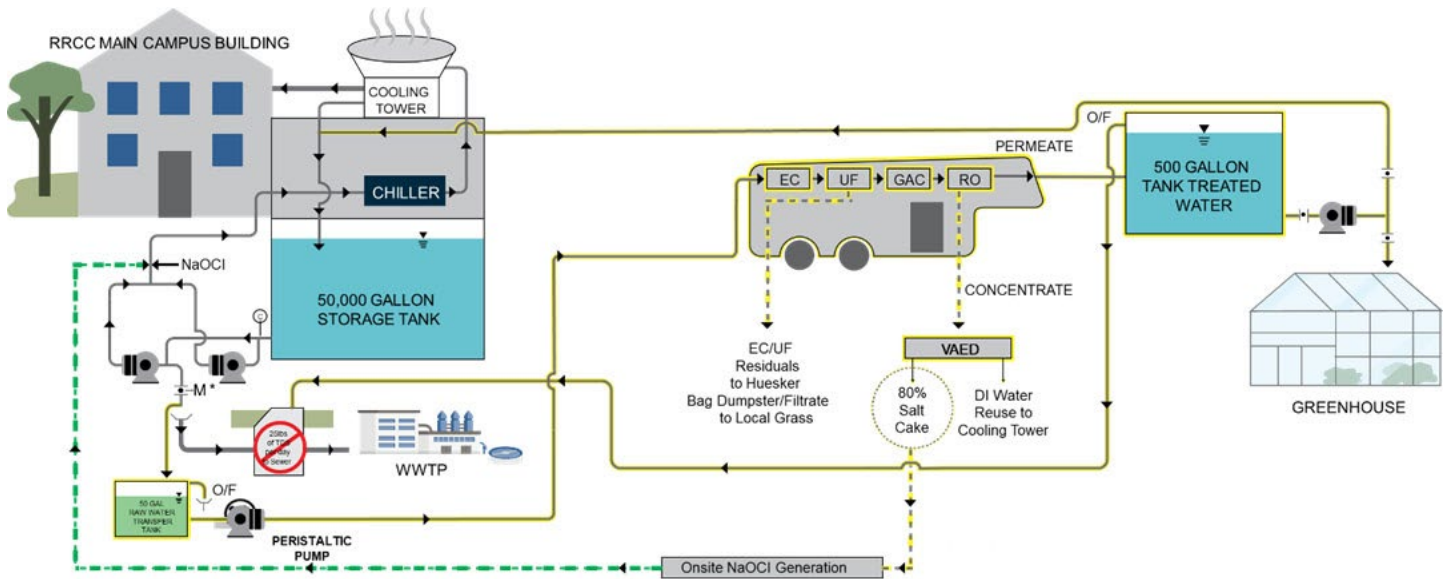
Cooling towers (CTs) are one of the major contributors of salt loading of local watersheds from CT blowdown. The majority of industrial and commercial cooling systems use evaporative CTs, especially in arid regions where evaporative cooling has the highest cooling efficiency and the water supply is scarce.

In 2019, Garver, LLC (Garver) (Denver Office) proposed researching an innovative process train to recover the saline blowdown from commercial and industrial CTs under Reclamation's "Pitch to

Pilot" desalination research funding. Garver was one of seven teams awarded part of the \$1.5-million "Pitch to Pilot" grant in November 2019 aimed at researching disruptive desalination technologies that consume less power than what is currently offered on the market. Garver teamed with several entities that played a significant role in project success: Red Rocks Community College, Dr. Mike Mickley, and several industry partners that collectively donated over \$480,000 of in-kind equipment, instrumentation, and labor.

## The Solution

Garver proposed researching a Zero-liquid discharge CT blowdown treatment train designed to recover saline wastewater. The train is sized to provide 1.5 gallons per minute of electrocoagulation (EC), ultrafiltration (UF), granular activated carbon (GAC), RO with vacuum-assisted electrodistillation (VAED) concentrate treatment. If successful, this approach will prevent high salinity wastewater from entering the sewershed while also reducing make-up water demand from the local distribution system. The figure below presents a process flow schematic of the treatment train and how it has been integrated into the existing CT system.



Garver's Process Flow Diagram.

The goal of this project was to prove that an EC/UF/GAC/RO/VAED treatment system can be effective in treating the high total dissolved solids (TDS) commercial CT blowdown from the 600-ton evaporative cooling system located at the Red Rocks Community College's Main Campus Building in Lakewood, Colorado.

## Study Conclusions

There is proof that the EC/UF/RO/VAED concept treatment train consistently achieved a high removal efficacy of target RO foulants. EC was a successful alternative mechanism for foulant precipitation, and it created ideal water quality for RO membranes without the use of antiscalants or pH depression. Throughout piloting, RO fouling was not noticed if a brief permeate flush was implemented. At the time of this article, the RO system was being challenged because the permeate rinse was not applied. Details of the RO performance under this stressed condition, as well as energy intensity numbers, are forthcoming. The custom clarifier and UF system used to manage EC floc met the treatment goals. The GAC system did not provide total organic carbon removal and was not a benefit to the process train.

A fully automated system would allow for longer runtime and a continuous operation. The VAED system consistently removed 98 to 99 percent of the TDS in the concentrate, even during the final stages of field testing, when greater than 99% of the solids were re-seeded in the flash chamber and not wasted; therefore, upcycling the concentrate to 186,000 milligrams per liter of TDS.

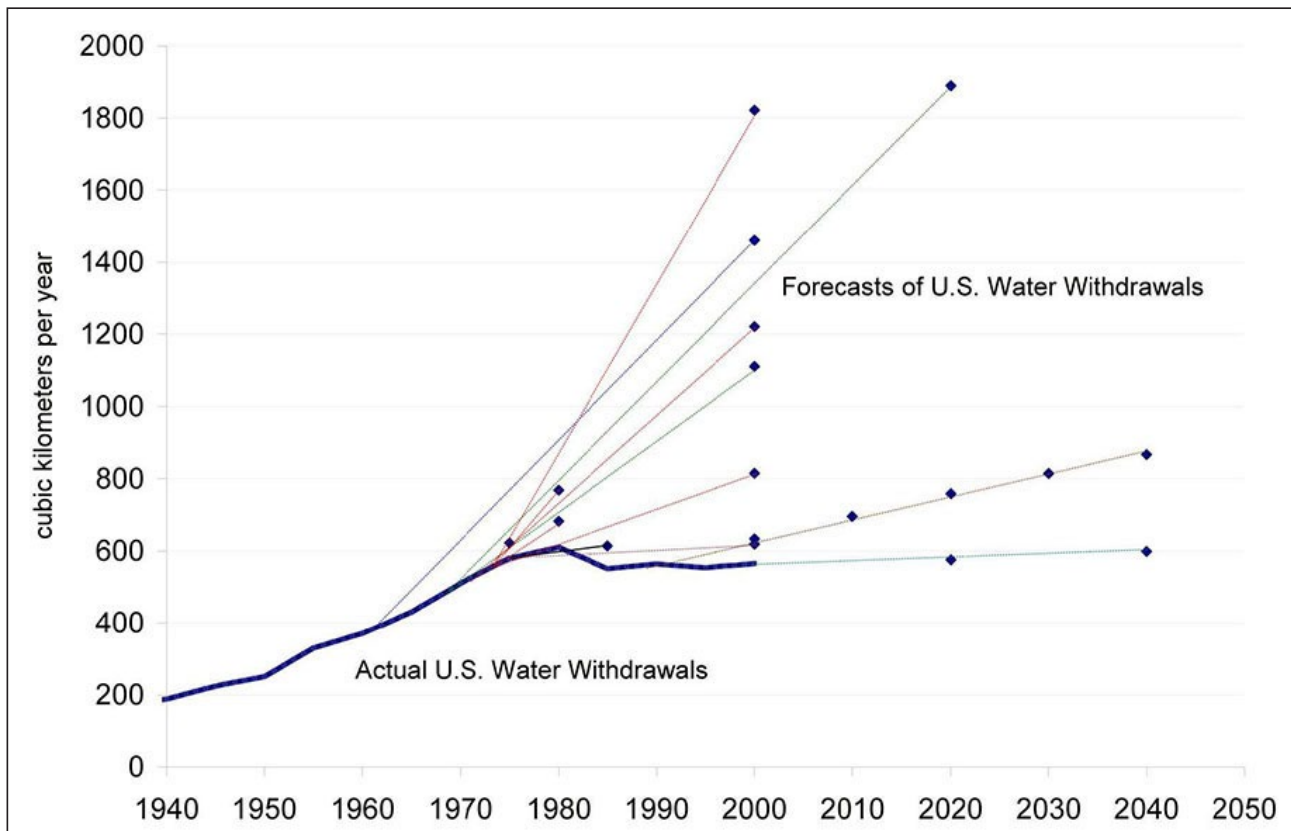
Although the EC and VAED performed well, more research behind the removal mechanisms, optimization of full-scale design constraints/capital costs/operational costs would be beneficial to the advancement of this technology as a commercialized solution to manage the salt loading from CTs or brackish water desalination applications.



# Strategic Directions

By Yuliana Porras Mendoza  
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As the Bureau of Reclamation continues to make investments in the funding of research in the area of desalination and water treatment, it also looks into the future. Water planners traditionally look into the future and make projections of future demands. These projections, in turn, become expectations about future water use with risks and benefits of their own. The figure below, obtained from the National Research Council 2008 publication “Desalination: A National Perspective,” shows different U.S. water projections made before 2005. The figure clearly shows every projection made before 1995 substantially overestimating future water demands. This overestimation is a result of poor assumptions such as (1) use would continue to grow at or above historical growth rates and (2) simple relationships exist among water use, population, industrial, commercial, and residential end-use intensity.



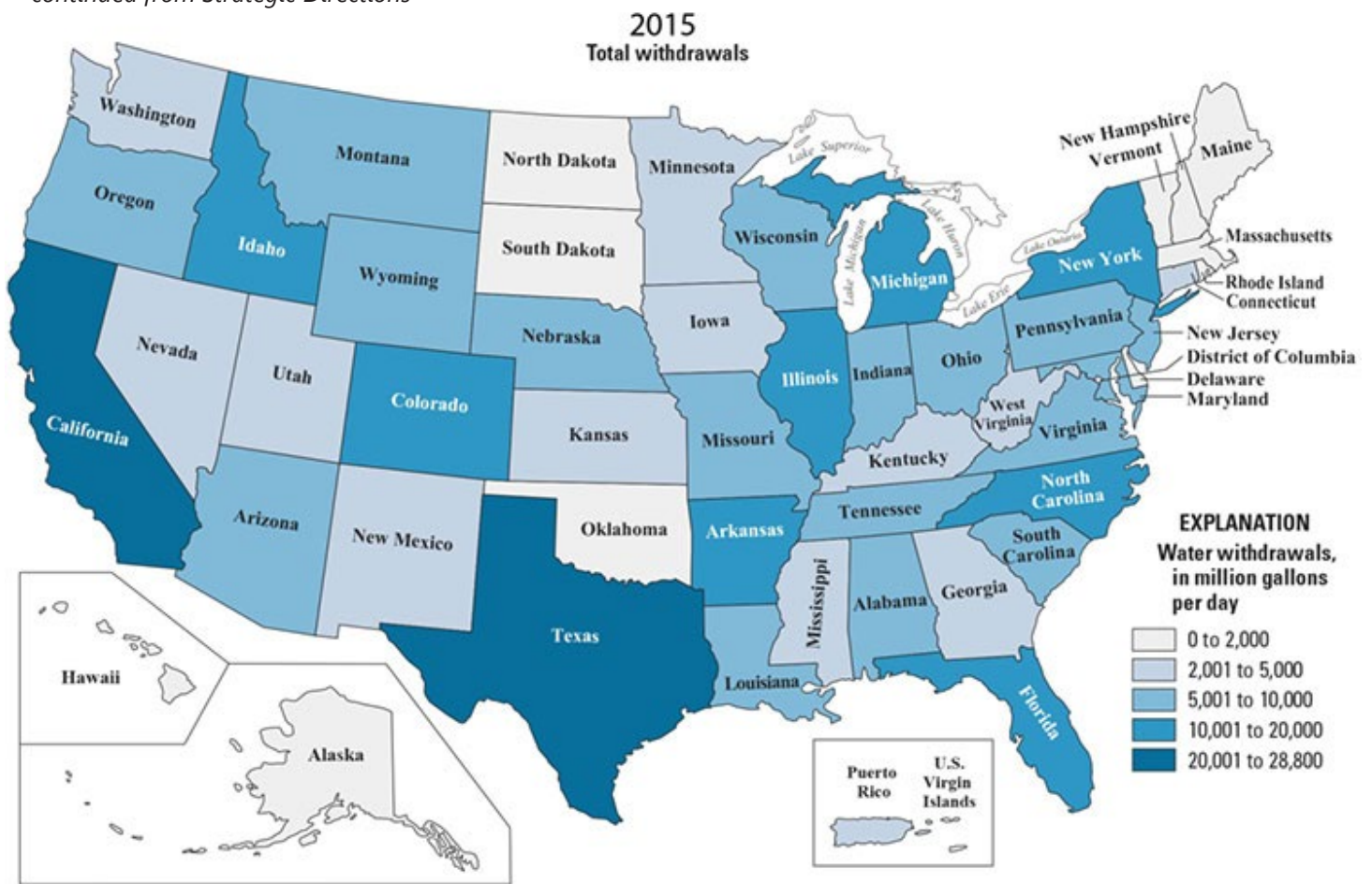
Projections of total U.S. water withdrawals since the 1960s. The points indicate projected withdrawals; the colored lines lead back to the date the projection was made. (SOURCE: [Desalination - A National Perspective 2008](#))

The United States Geological Survey (USGS) has been estimating water use for the United States every 5 years since 1950. The USGS also provides data on water use across the Nation, and their 2015 water withdrawal estimate was around 361,000 thousand acre-feet per year. The majority of the withdrawals come from surface water, accounting for 87 percent, with the remainder coming from saline sources. As surface water

continues to become scarce during periods of drought, saline sources become a more viable solution to meet demand. These impaired sources will require treatment to make them viable for use, and this is where the future of the Desalination and Water Purification Research (DWPR) Program will focus its efforts.

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Map of 2015 total water withdrawals. (SOURCE: USGS)

As the imbalance between demand and supply grows, the work being funded by the DWPR Program can provide answers and prepare us for a future in which impaired water sources become a major source of water withdrawals. These sources will require treatment to make them viable for use and will augment limited surface water supplies. The program is also investing in expanding our partnerships with other Federal and non-Federal stakeholders to leverage our limited funding resources toward finding solutions and increasing communication among those working in the area of water treatment. Great partnerships have already been formed, such as our continued work with the Water Treatment Interagency Federal Working Group and the National Alliance for Water Innovation (Department of Energy Desal Hub). Work also continues under the American Membrane Technology Association/Reclamation Fellowship Research Agreement and the New Mexico Water Resources Research Institute/Reclamation Research Agreement.

Moving forward into the next decades of the 21<sup>st</sup> century, the DWPR Program goal remains the same – to reduce the costs and environmental impacts of treating impaired and unusable waters for a beneficial use. The program will continue to focus on investments to advance the capabilities of water treatment technologies that will enable them to be used more broadly for the creation of new water supplies from nontraditional sources nationwide. The DWPR Program also will continue its support for the operation and maintenance of the Brackish Groundwater National Desalination Research Facility (BGNDRF), which hosts Federal and non-Federal research and development clients conducting bench-scale and pilot-scale demonstrations. After its first decade, and fast-approaching its second one, the BGNDRF continues to be a great resource for innovation and testing of technologies coming not only from across the Nation but also worldwide.

# Science & Technology Research

## Program Overview

By John Whitley  
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The Science and Technology (S&T) Program is one of several innovation activities that the Bureau of Reclamation (Reclamation) conducts to solve mission-related scientific and technical challenges. The S&T Program supports engineering innovation that promotes economic growth, supports maintaining and improving our water and power infrastructure, and spurs continued enhanced generation of energy. Program outcomes enable reliable water and power delivery to our customers, improve safety, limit the impacts of invasive species, and ensure that Reclamation can meet its environmental compliance responsibilities. The program leverages internal engineering and technical expertise, as well as external partnerships, to implement each research project and work in coordination with other types of innovation within the Research and Development Office, including research prize competitions and technology transfer engagements with industry.

Each year, the S&T Program invites Reclamation employees to submit research proposals as part of an annual Call for Proposals. These internally led efforts support the development of innovative solutions to Reclamation's most challenging issues and develop the capacity within Reclamation to gain knowledge and technical expertise supporting its core mission.

Although internally led, internal and external partnerships are emphasized to ensure the research team has the best expertise. Partnerships may include field representatives who are in position to use successful project results. The proposal review process relies on subject matter experts from each research area, as well as regional research coordinators, to evaluate all proposals based on technical merit and relevancy to Reclamation's mission. Selection criteria are used to rank the proposals, with a focus on addressing priority research needs, potential for developing an impactful solution, and partner contributions.

Research projects typically last 2 to 3 years; once complete, the research results are documented in a final report, and project data are added to the Reclamation Information Sharing Environment. The R&D Office uses a variety of outreach tools (Knowledge Stream magazine, bulletins, project webpages, research area summaries, and social media) to communicate those solutions to Reclamation offices, other water and power management officials, and the public in order to build partnerships with other water and power management agencies and stakeholders.

[S&T research projects](#) are aligned within a program structure that includes five research areas:



1. Water Infrastructure



2. Power and Energy



3. Environmental Issues for Water Delivery and Management



4. Water Operations and Planning



5. Developing Water Supplies

Within each research area, topical categories have been established to provide structure and organization to the area of interest for research projects. This program structure is described in the S&T Program 2022–2025 Innovation Strategy. A companion document, the Innovation Strategy Implementation Plan (ISIP), provides an annually updated list of challenges the S&T Program is targeting for funding. The annual ISIP allows for a flexible priority setting that's responsive to emerging needs. The R&D Office routinely engages with subject matter experts from the regions and other directorates for input on adjustments to innovation needs and priorities, including an annual request to Regional Directors to identify their top three [highest priority research needs](#), which are then published with the Call for Proposals materials.

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—continued from S&T Overview

In fiscal year 2022, nearly 200 active research projects are being funded across all 5 research areas. Information about these research projects can be found in research area summary documents posted on the S&T Program website. These documents also describe projects that were completed at the end of fiscal year 2021, with over 50 projects concluding. The volume of work conducted and completed each year is testament to the incredibly talented cadre of scientists and engineers that lead and support these research projects. Also deserving of recognition are the regional and research coordinators that support the S&T Program through their specialized technical expertise, knowledge of emerging issues and technological advancements, and partnerships within and outside Reclamation. The success of each research project is dependent on a vast network of individuals working together to support these innovation activities.

## Featured Research

By John Whittler

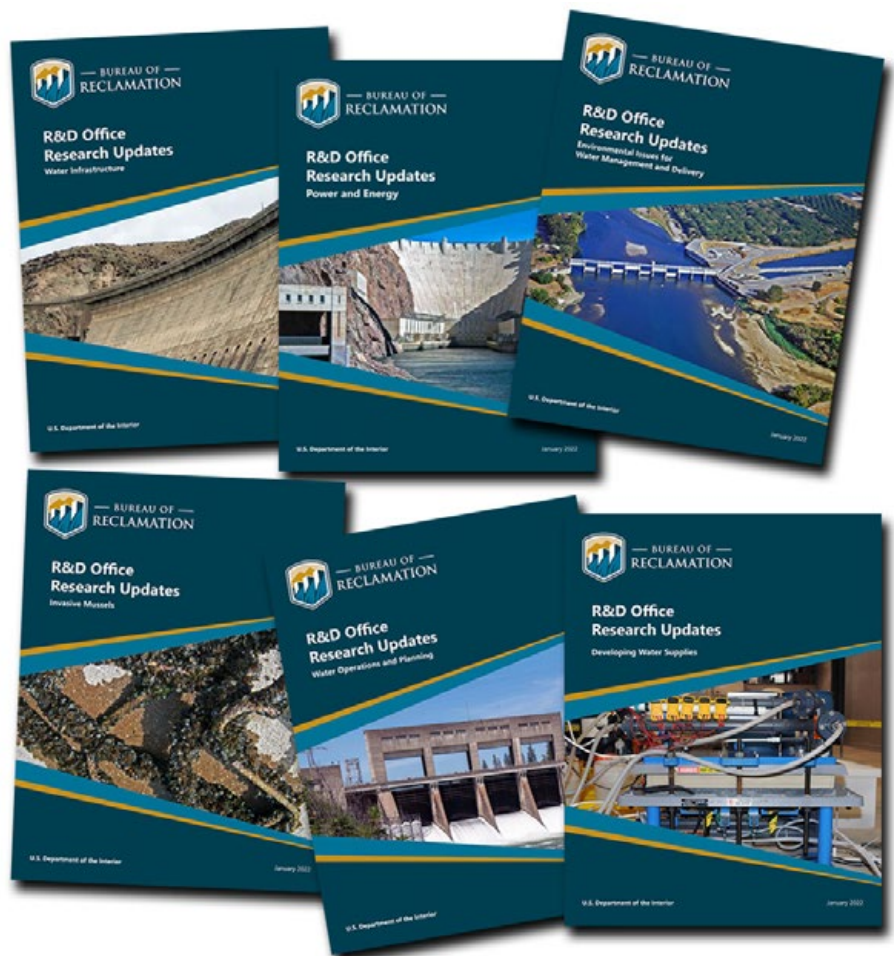
jwhittler@usbr.gov

During fiscal year 2021, the Science and Technology (S&T) Program funded 200 different research projects, and 50 of them were completed. In fiscal year 2022, the S&T Program is currently funding 180 different research projects across the 5 research areas listed below. With this large volume of funded projects, the program has developed a document that describes completed research projects, new research projects, and a table of all funded projects within each research area. These research area summaries are a very useful tool to review S&T Program research project activity that might be of interest to our internal and external partners.

These documents are currently posted on the S&T Program website, and the links are included below:

- [Water Infrastructure](#)
- [Power and Energy](#)
- [Environmental Issues for Water Delivery and Management](#)
- [Invasive Mussels](#)
- [Water Operations and Planning](#)
- [Developing Water Supplies](#)

Within each research area, two projects are selected that will undergo a “return on investment of future projected benefits” if the results were to be implemented. One project per research area that has gone through the “return on investment” activity is described on next page:



## Science and Technology Program (S&T) Highlighted Research Projects



### **(WI) Geospatial Tool for Instrumentation Inventory and Collection and Evaluation of Readings**

**Problem:** Data collection and validation of routine readings lacked a geospatial inventory of instruments and real time data transmission.

**Solution:** The project developed and demonstrated two options for single-entry mobile apps with near real time evaluation of performance parameters.

**Impact:** The app allows personnel to locate instruments and enter readings on a mobile device, confirm they are within performance parameters, and transmit—all while in the field.

Total Federal Cost: \$0.10M

Benefit Cost Ratio: 11.4

### **(PE) Rotor Installed Corona Mapping of Stator Windings within Large Diameter Hydro Generators**

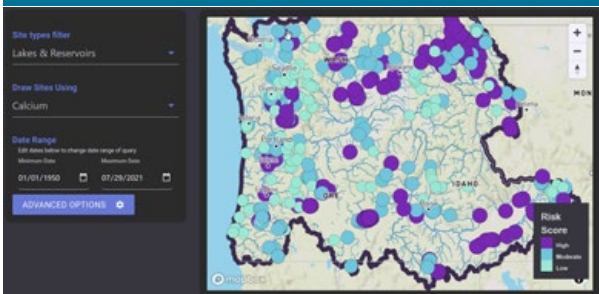
**Problem:** Partial discharge in stator windings can lead to damage and forced outages, and previous techniques were time-intensive or insufficient resolution.

**Solution:** Near field communication antennas mounted to the rotor can map partial discharge activity with slot level resolution through the stator winding.

**Impact:** Trending of partial discharge activity without the need to remove the rotor significantly reduces cost, hazards, and risks with obtaining the data.

Total Federal Cost: \$0.19M

Benefit Cost Ratio: 9.6



### **(EN) Risk Mapping for Mussel Infestation in the CPN**

**Problem:** Early detection of invasive mussels requires resource prioritization.

**Solution:** A web interface for predicting invasive mussel risk was developed in partnership with the USGS. The interface maps establishment risk based on Ca and pH which are continuously queried from the National Water Quality Portal.

**Impact:** Will improve efficiency of mussel control resource deployment, so the same dollars spent will have a greater impact and realize value.

Total Federal Cost: \$0.15M

Benefit Cost Ratio: 14.5

### **(WP) Merging high-resolution airborne snowpack data with existing long-term hydrometeorological observations to improve water supply forecasting**

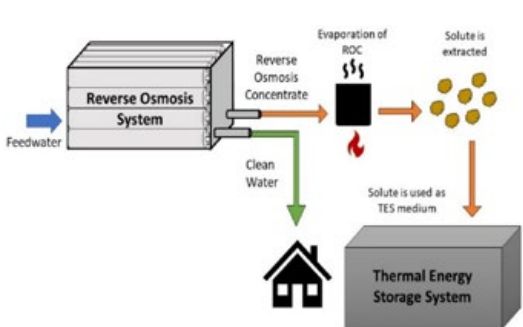
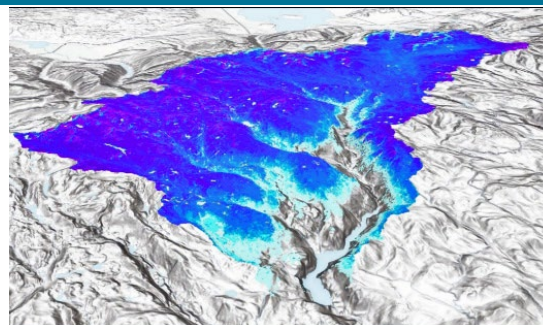
**Problem:** Aircraft lidar snow surveys provide high quality snow information but are a resource intensive data collection process.

**Solution:** Statistical models were developed to relate point station snow data with past aircraft lidar surveys to develop basin-wide snow water equivalent (SWE) estimates.

**Impact:** Models developed from this work can increase access to high quality basin wide SWE estimates and may decrease the frequency of needed aircraft lidar surveys.

Total Federal Cost: \$0.25M

Benefit Cost Ratio: 8.7



### **(WS) An Ultra-low-cost Thermal Energy Storage System using Reverse Osmosis Concentrate**

**Problem:** The reject of the reverse osmosis water treatment process (aka brine, concentrate) is a mixture of salts that are dissolved in high salinity water and is classified as an industrial waste with limited disposal options.

**Solution:** In this study, the feasibility of using reverse osmosis concentrate as a low-cost Thermal Energy Storage (TES) medium was explored by a techno-economic analysis.

**Impact:** It was shown that the normalized cost of TES using ROC salt content is in the range of \$6.11 to \$8.73 per kilowatt-hours depending on reverse osmosis concentrate processing methods.

Total Federal Cost: \$0.20M

Benefit Cost Ratio: 7.8

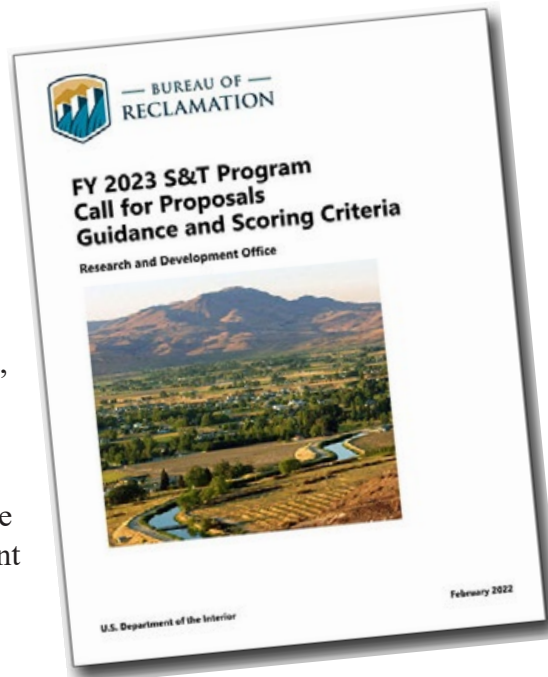
# Fiscal Year 2023 Call for Proposals

By John Whitley  
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As mentioned in the previous article, each year the Science and Technology (S&T) Program invites Bureau of Reclamation (Reclamation) employees to submit research proposals through an annual Call for Proposals. A guidance document was developed that describes the proposal content requested and the scoring criteria used to evaluate them. An information management system, RADIMS, is used to collect proposal information.

A variety of information is collected in the proposal, such as the key people working on the project and partners that will be supporting the project. If the project has a field component, the location of those activities is requested. Project details, such as the need, benefit, urgency, previous work, methodology, and communication plan, are also requested. Based on the proposal content, reviewers can evaluate the potential success of the proposed project and technical merit in supporting innovation at Reclamation. The proposal details also ensure that, if funded, the lead researcher has a solid project management plan foundation in place to carry out the proposed work.

Reclamation employees can get involved with a research proposal in a number of different ways. First, any employee can volunteer to be a lead researcher and submit a research proposal. Second, most research teams involve multidisciplinary teams and include numerous staff supporting specific aspects of a project. Third, any Reclamation employee can share an innovation need they are experiencing so the S&T Program can explore avenues to develop solutions. If the program doesn't know about the issues being experienced, those challenges may not get addressed in a timely manner. Fourth, Reclamation employees may serve as proposal reviewers, which are identified by S&T Program research coordinators. Finally, anyone at Reclamation can explore the use of research results to support innovation with challenges they may be experiencing. Since 2004, over 1,100 S&T research projects have been funded, yielding a vast network of knowledge.

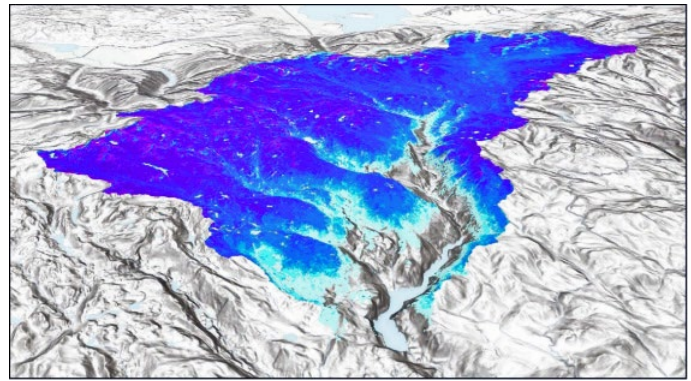


For fiscal year 2023, the Call for Proposals will be announced in early April through a Distribution E memorandum. Informational webinars, proposal training, and proposal development meetings are provided to help researchers submit the best possible proposals and increase their connection to conceivable project partners. A SharePoint site is developed to include all relevant proposal guidance links and meeting information. Proposal submissions are then collected in RADIMS through early June. During the months of June and July, proposals will be reviewed by subject matter experts. Funding recommendations will be provided to the S&T Program Manager and Senior Advisor for Research and Development. A red-flag review of selected projects will then occur through the Reclamation Leadership Team. Once the review is complete, a Commissioner's Office concurrence briefing is conducted to receive final approvals before researchers are notified of their proposal funding decision. Reclamation Public Affairs supports outreach to the public on the projects selected for funding.

# Project of the Year

By John Whitley  
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The Science and Technology (S&T) Research Project of the Year for fiscal year 2021 has been awarded to Lindsay Bearup of the Technical Service Center for her project titled “*Merging High-Resolution Airborne Snowpack Data With Existing Long-Term Hydrometeorological Observations to Improve Water Supply Forecasting.*” Lyndsay will receive a \$500 cash prize and \$10,000 to pursue the adoption of these results within the Bureau of Reclamation (Reclamation). The final report and data from the project are available at [www.usbr.gov/research/projects/detail.cfm?id=8116](http://www.usbr.gov/research/projects/detail.cfm?id=8116) and the Reclamation Information Sharing Environment (RISE) link <https://data.usbr.gov/catalog/4514>.



Projects nominated for Project of the Year were evaluated based on positive impacts to Reclamation and other Federal and non-Federal partners, efforts to address current U.S. Department of the Interior and Reclamation priorities, and the involvement of key partners. Over the past three years, Lindsay has explored the value of using existing Airborne Snow Observatory (ASO) measurements to support water supply forecasting in the Tuolumne River Basin. With relatively simple regressions, statistical forecasting using the combined ASO and station time series improved predictions of streamflow into the Hetch Hetchy Reservoir relative to the station-only estimates. Assimilating ASO in a calibrated Structure for Unifying Multiple Modeling Alternatives watershed model improved model volume forecasts, even with a relatively simple direct insertion approach that directly replaces the modeled snow states with the observations. Flights near peak snow water equivalent correct errors in winter precipitation and provide the most improvement in model forecast skill, while subsequent scenes provide less improvement and may even reduce model skill if not assimilated carefully.

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## The other projects nominated for Project of the Year included:



- Jacob Lapenna - *Rotor Installed Corona Mapping of Stator Windings within Large Diameter Hydro Generators*
  - S&T Project page link: [www.usbr.gov/research/projects/detail.cfm?id=19078](http://www.usbr.gov/research/projects/detail.cfm?id=19078)
  - RISE link: <https://data.usbr.gov/catalog/4504>

- Connie Svoboda - *Methodology to Determine the Presence of Submerged Hydraulic Jumps at Low-Head Hydraulic Structures*
  - S&T Project page link: [www.usbr.gov/research/projects/detail.cfm?id=21020](http://www.usbr.gov/research/projects/detail.cfm?id=21020)
  - RISE link: <https://data.usbr.gov/catalog/4631>



- Kendra Fallon - *Development of a Platform for Wildfire Incident Support and Evaluation of Post-Fire Impacts*
  - S&T Project page link: [www.usbr.gov/research/projects/detail.cfm?id=20019](http://www.usbr.gov/research/projects/detail.cfm?id=20019)
  - RISE link: <https://data.usbr.gov/catalog/4524>

- Saied Delagah - *An Ultra-low-cost Thermal Energy Storage System Using Reverse Osmosis Concentrate*
  - S&T Project page link: [www.usbr.gov/research/projects/detail.cfm?id=8133](http://www.usbr.gov/research/projects/detail.cfm?id=8133)



# Science & Technology Prize Competitions

## Program Overview

By Dale Lentz

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www.usbr.gov/research/challenges/

Prize competitions allow the Bureau of Reclamation (Reclamation) to focus on the difficult, persistent problems—research communities have made progress, but wider, community-based prize competitions could lead to even more breakthroughs. [Prize competitions](#) allow Reclamation to seek new and timely solutions from beyond the usual sources of potential solvers and experts. The potential solvers also now have new ways to showcase their solutions outside the standard contractual methods.

### Prize Competitions by the Numbers

- 32 competitions launched since 2015
- More than 45 partners (Government, State, Private. etc.)
- Over 200 solutions have received prizes
- More than \$4.5 million in prizes paid
- 19 prize-related Science and Technology research projects have been funded since 2019 (\$3.77 million)

Reclamation uses prize competitions to expand its solver base and achieve a variety of goals in the areas of infrastructure, water availability, and the environment. While prize competitions are not the right tool for every problem, they can serve as a mechanism for spurring and sourcing innovation. Reclamation competitions are advancing research and development issues that are best addressed through process and technological improvements to achieve more efficient operations of Reclamation facilities and improved management of water and related resources, in contrast to policy development, regulatory compliance, or other approaches. There have been advancements in areas such as eradicating invasive mussels, subseasonal forecasting, and protecting structures from corrosion.

Research and Development Office

Science and Technology (S&T) Program

Desalination and Water Purification Research (DWPR) Program

**Prize Competitions**

Upcoming Competitions

Accepting Submissions

Under Evaluation

Past Competitions

Prize Recap Archive

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Open Water Data

Technology Transfer


About

## Prize Competitions


**Upcoming Competitions**




**Accepting Submissions**




**Under Evaluation**



**Past Competitions**



Prize Competitions spur innovation by engaging a non-traditional solver community. Competitions can complement traditional research and target Reclamation’s most persistent science and technology challenges. Competitions use prizes to incentivize solvers to submit solutions and are open to a solver community that includes members of the public, businesses, and other organizations.



**ACCEPTING SUBMISSIONS**

Snowcast Showdown

Divide & Conquer: Modeling Large-Scale Hydraulics Faster

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**FEATURED RESOURCES**

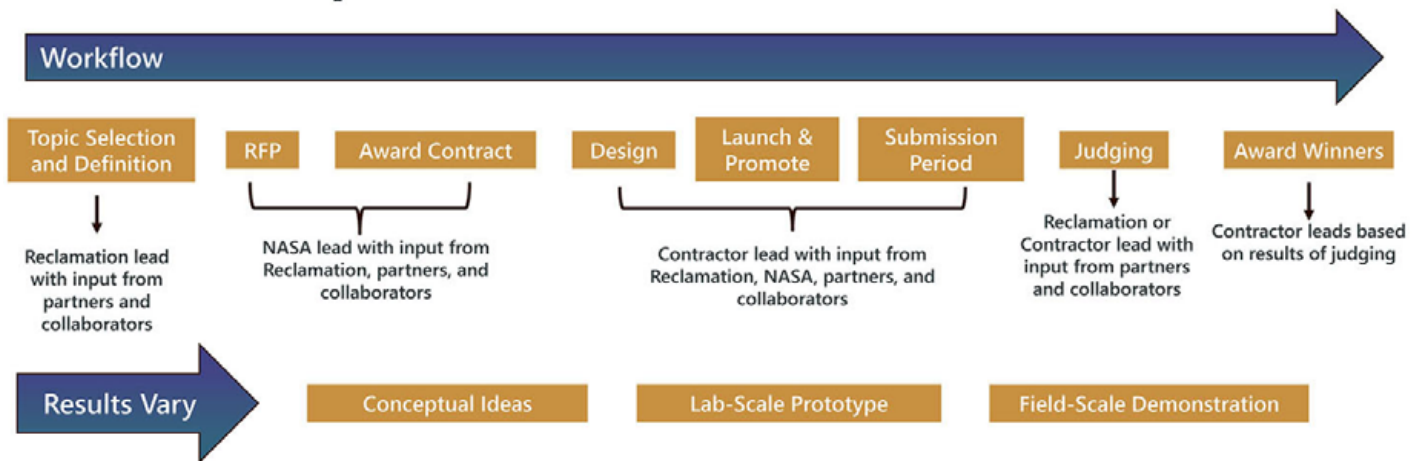
News

Prize Recap Archive

Prize Competition Handout



# Prize Competition Process



As the Prize Competitions Program grew, a process was developed to identify the key steps and resources necessary to run a competition. This process continues to iterate as Reclamation fine tunes its business model for conducting competitions. The program has increased the number competitions and the complexity of the challenges presented to the solver communities. For the first 5 years, Reclamation utilized the services of a single contractor to assist with formulating competitions, posting and amplifying the competitions, and interacting with solvers to complete verification of winner eligibility. Seeing the successes and emphasis to use the power of crowd sourcing, Reclamation partnered with the National Aeronautics and Space Administration’s (NASA) Center of Excellence for Collaborative Innovation to tap into their contracting mechanism, thus streamlining procurement of vendors to administer prize competitions and enabling Reclamation to engage the international solver community.

Initially, winning solutions consisted of a theoretical idea detailed in a report. Today, many of the prize competitions are multiphase and require the solvers

to develop a working prototype of their solution. For the Rust Buster prize competition, the top five solvers developed four new protective coating solutions and one novel approach to cathodic protection. For solvers who advanced to phase 2 of the Water America’s Crops competition, samples of their prototype canal lining were tested in Reclamation’s laboratory for effectiveness and durability.

Reduction-to-practice competitions are intended to advance solutions beyond just an idea on paper. Ideally, these competitions result in a developed prototype or concept application to show it can resolve the issue presented.

## How to Get Involved








- **Propose a prize competition idea**
- **Be a subject matter expert on a prize team**
- **Be a prize competition judge**
- **Provide technical support to solvers**
- **Field or facility locations for demonstration**
- **Test or mature solutions**
- **Amplify the competition**

**Contact Jen Beardsley at [prize@usbr.gov](mailto:prize@usbr.gov)**

## What is a technology search?

What is the current technology “state of the practice”? Is the technology I need commercially available? What is the current research and development in this area? These questions can all be answered in a few short months at a very low cost. Reclamation can contract technology searches through our prize partnership with NASA. The contractor uses a broad, deep, “scour the earth” iterative process for a landscape view of the technology in question. They then hone in on key prioritizing parameters and ensure high confidence in best-fit leads from across industries. Researchers from Reclamation guide the technology search during the several-month search period and, in return, learn what technology is available, how advanced is it, and how can we use it. A technology search is a great starting point to design a prize competition or research plan.

## Current Prize Competitions

Prize Competition	Link	Point of Contact
	<a href="http://www.usbr.gov/research/challenges/sediment-removal.html">www.usbr.gov/research/challenges/sediment-removal.html</a>	Jennifer Bountry
	<a href="http://www.usbr.gov/research/challenges/morewater.html">www.usbr.gov/research/challenges/morewater.html</a>	Andrew Tiffenbach
	<a href="http://www.usbr.gov/research/challenges/imperfection.html">www.usbr.gov/research/challenges/imperfection.html</a>	Bobbi Jo Merten
	<a href="http://www.usbr.gov/research/challenges/watercrops.html">www.usbr.gov/research/challenges/watercrops.html</a>	Evan Lindenbach
	<a href="http://www.usbr.gov/research/challenges/amps.html">www.usbr.gov/research/challenges/amps.html</a>	Erin Foraker
	<a href="http://www.usbr.gov/research/challenges/srh.html">www.usbr.gov/research/challenges/srh.html</a>	Jennifer Bountry
	<a href="http://www.usbr.gov/research/swe/index.html">www.usbr.gov/research/swe/index.html</a>	Ian Ferguson

## Recently Completed Prize Competitions

	<p><i>Rust Busters</i></p>	<a href="http://www.usbr.gov/research/challenges/corrosion.html">www.usbr.gov/research/challenges/corrosion.html</a>	Bobbi Jo Merten
	<p><i>Streamflow Forecast Rodeo</i></p>	<a href="http://www.usbr.gov/research/challenges/streamflowrodeo.html">www.usbr.gov/research/challenges/streamflowrodeo.html</a>	Ken Nowak
	<p><i>Improving Canal Safety</i></p>	<a href="http://www.usbr.gov/research/challenges/canalsafety.html">www.usbr.gov/research/challenges/canalsafety.html</a>	Evan Lindenbach

## Prizes Recap

By Ian Ferguson, Andrew Tiffenbach, Evan Lindenbach, & Jennifer Bountry

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### Snowcast Showdown Challenge

The [Snowcast Showdown](#) prize competition seeks new and improved methods to estimate the amount of water stored in snowpack – referred to as the snow water equivalent (SWE) – at a high spatial and temporal resolution over the Western United States using near real-time data sources, including satellite remote sensing data.

Mountain snowpack is a critical water resource throughout the Western United States. Snowpack acts as a natural reservoir by storing precipitation during the winter months and releasing it as snowmelt in spring and summer. Snowmelt from mountain headwaters is a major source of runoff to streams and rivers across the West. Water resource managers use measurements and estimates of the SWE as inputs to streamflow and water supply forecasts, which then inform a wide range of management decisions, including managing reservoir storage levels, setting seasonal water allocations, and planning for extreme weather events such as floods and droughts.

Streamflow and water supply forecasts currently rely primarily on ground-based and aerial methods to estimate the SWE, which are limited in areas covered and times measured. High-resolution satellite imagery offers promising opportunities to improve snow monitoring—using satellite imagery to estimate the SWE remains an active research area. This competition focuses on using machine



*The Snowcast Showdown competition seeks improved estimates of spatially-distributed snow water equivalent (SWE) over the Western United States.*

learning methods and satellite imagery to improve real-time estimation of the SWE across the West.

The Snowcast Showdown competition includes two tracks. In the “Prediction Challenge” track, solvers develop and use machine learning models to estimate the spatial distribution of the SWE over the Western United States at a 1-kilometer spatial resolution. Models are developed and tested between December 7, 2021, and February 15, 2022. From February 15 through July 1, the models will undergo real-time evaluation and will be run on a weekly basis to generate near real-time estimates of the SWE; these estimates will then be evaluated against ground truth data, and prizes will be awarded based on model performance. In the “[Model Report Competition](#)” track, solvers will submit detailed documentation of their solution methodology and its performance against historical data. All solvers who submitted a solution to the “Prediction Challenge” track are eligible to participate in the “Model Report Challenge” track.

### More Water Less Concentrate Challenge

The [More Water Less Concentrate](#) prize competition is focused on discovering innovative, affordable, and environmentally sound solutions to reduce the volume of concentrate and generate more usable water from inland desalination plants.

—continued



*Reclamation's Water Quality Improvement Center in Yuma, Arizona.*

—continued from *More Water Less Concentrate Challenge*

This multiphase competition was launched in October 2020, and solvers were first asked to develop a white paper submission describing their proposed solution and how it improves on existing concentrate management approaches. Solvers were also required to provide a plan for developing a prototype system to demonstrate the capabilities of their technology and a vision of how the technology could eventually be scaled up for full-scale implementation. From these initial submissions, [five finalists were selected](#) in July 2021, and each received an award to support

prototype development efforts along with additional interim awards as development milestones were met.

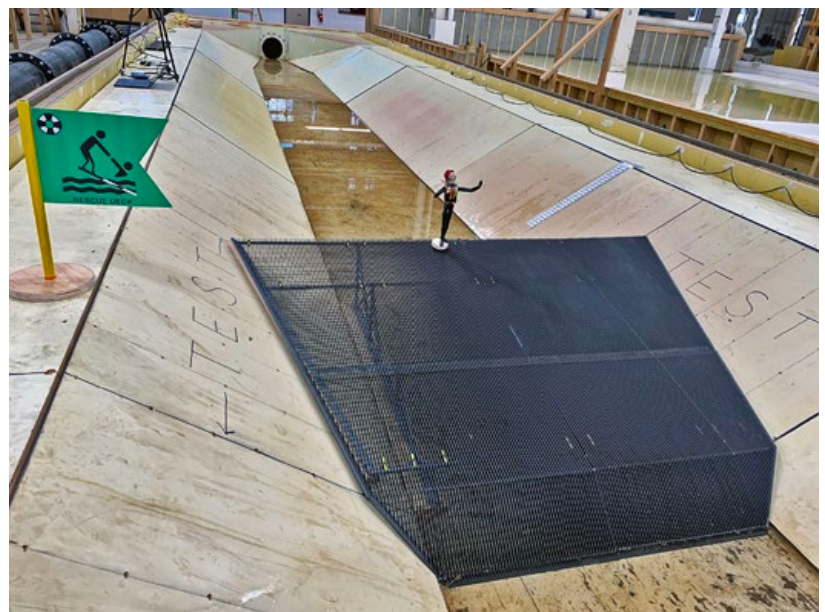
The prize competition will culminate in summer 2022 with demonstrations of the prototype technologies at Reclamation’s Water Quality Improvement Center in Yuma, Arizona. During demonstration testing, each team will operate their prototype system for seven continuous days using a feed source of reverse osmosis concentrate. Prizes totaling \$250,000 will be available for the highest performing teams.

## Canal Safety Challenge

The [Canal Safety Prize](#) Demonstration was held in November 2021 at the Technical Service Center’s Hydraulics Laboratory in Denver, Colorado. Three finalists were selected to design and fabricate prototype devices to reduce drownings in canals. Finalists provided their laboratory prototypes to Reclamation’s engineers for a virtual demonstration event in a 1:6-scale laboratory flume. Devices were tested in a straight-channel section of the canal and upstream of a siphon entrance. Teams were awarded points based on how well each device saved nonvolitional dummies, limited impacts to operations, and managed a variety of debris. Teams participated virtually through Microsoft Teams app during the judging phase and worked with Reclamation engineers during a post-judging optimization period.

While all devices performed well, the gradual slope of Isotrope LLC’s Rescue Deck™ allowed human dummies to wash up gently in a safe manner, and they were awarded the grand prize of \$100,000! For more information about the finalists and the competition, [www.canalsafetychallenge.org/](http://www.canalsafetychallenge.org/).

Next steps include engaging with the winning team and other finalists to further optimize solutions and upscale the devices for use in an operating canal.



*Isotrope LLC’s Rescue Deck™ was selected as the winner of the Canal Safety Challenge.*



*Testing during the Canal Safety Challenge demonstration event.*

—continued from Prizes Recap

## Guardians of the Reservoir Challenge

The Bureau of Reclamation (Reclamation), in collaboration with the U.S. Army Corps of Engineers, is currently in phase 2 of the [Guardians of the Reservoir prize competition](#). Five teams were selected from phase 1 to represent innovation from across the globe, including the United States, Germany, Switzerland, and Australia. The teams have been working diligently to develop unique techniques to improve the efficiency of collecting and transporting sediment from reservoirs at a rate that sustains their current capacity. Reclamation’s primary interest in this technology is to reduce sediment accumulation at the average annual rate at which it would otherwise accumulate. With more wildfires and continued drought influencing risk of losing valuable reservoir storage, this

competition is increasingly vital to gaining the upper hand on managing sediment in a manner that is economical and efficient. Innovations being explored by the teams include improved nozzle heads, slurry pipelines, and autonomous road-accessible precision dredges. Many of the teams have been dealing with unique challenges due to the COVID-19 pandemic and natural disasters, which were accommodated by a shift in the overall schedule to allow more time for solution development. Authors of the three most compelling submissions in phase 2 will be announced at the end of April, and they will move into the final phase, Phase 3, which will include a final demonstration and virtual event to showcase the new innovations for the prize competition sponsors.

## Prizes Into Practice

By Sherri Pucherelli, Justin B. Rittgers, Ken Nowak, & Rick Bearce

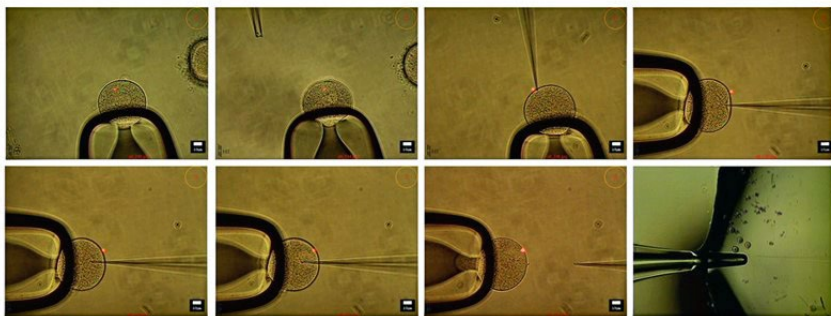
spucherelli@usbr.gov, jrittgers@usbr.gov, knowak@usbr.gov, rbearce@usbr.gov

After a solver is awarded a prize for their solution, there are several possible next steps that could advance the technology into practice. A Science and Technology research project or a partnership agreement between the Bureau of Reclamation (Reclamation) and the solver are common ways the solution is developed further. There are many partnership agreements available that enable continued research and development of the initial prize solution. [www.usbr.gov/research/technology\\_transfer/partnerships.html](http://www.usbr.gov/research/technology_transfer/partnerships.html)

## Mussel Control Solution Pursued Through Cooperative Agreement

Reclamation conducted a prize competition in 2018 to identify theoretical solutions for the control of invasive dreissenid (quagga and zebra) mussels in large reservoirs. The winning solvers proposed a genetic biocontrol solution that seeks to engineer a quagga and zebra mussel specific disseminated neoplasia. The goal is to replicate the naturally occurring and self-spreading cancer that has decimated some marine bivalve populations.

Reclamation chose to establish a cooperative agreement with the winning solvers from Biomilab, LLC, because they had the technical expertise to pursue the solution. Reclamation has now been working with Biomilab on the project for 3 years, with an additional 2 years planned. The cooperative agreement allows Reclamation to remain engaged and to guide the work. Genetic biocontrol of invasive species is a new area of study, and Biomilab has made significant technical advancements for its use with invasive mussels. This project has also spurred Reclamation to start a working group focused on dreissenid mussel genetic biocontrol to connect Biomilab and other researchers working on similar projects.

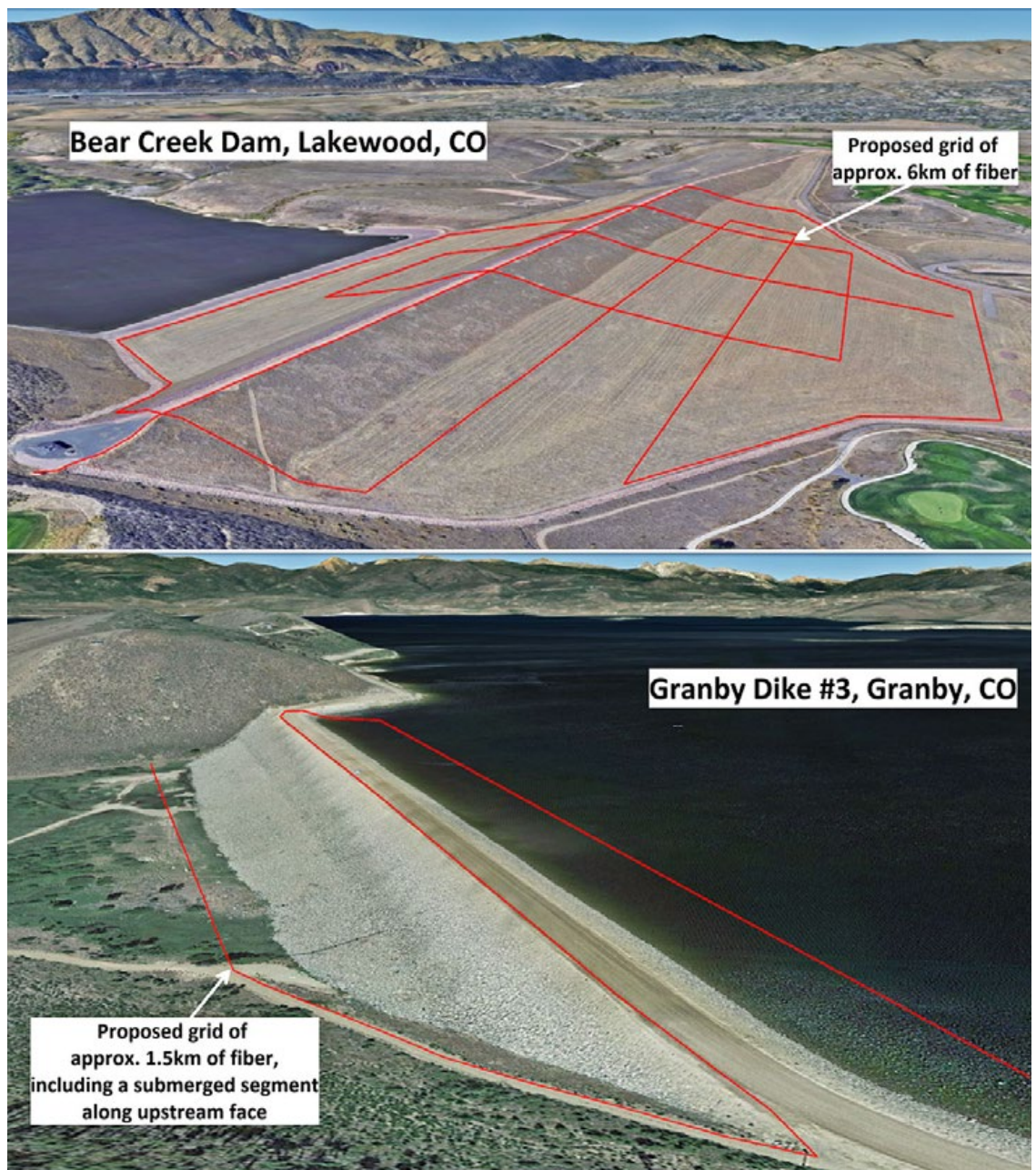


Microinjection of quagga mussel zygotes.

## Internal Erosion: Distributed Fiber Optic Sensing for Structural Health Monitoring

A 2016 Reclamation prize competition sought innovative solutions for detecting movement of soils (i.e., erosion) beneath earthen embankments. One winning solution proposed a permanently installed and automated monitoring approach for detecting seismic anomalies associated with development of internal erosion. Reclamation researchers have since been pursuing the use of distributed fiber optic sensing (DFOS) technologies for recording various types of seismic and temperature data with high spatiotemporal density. Monitoring for embankment erosion is just one of the many potential applications of this new sensing technology. Current DFOS research projects funded by Reclamation’s Science and Technology and Dam Safety Programs seek to collaborate with the U.S. Army Corps of Engineers (USACE) and academic partners to develop new approaches to structural health monitoring. One component of these

collaborations will involve two proposed DFOS array installations in large earthen embankments managed by the USACE and Reclamation: a 6-kilometer grid array installation at USACE’s Bear Creek Dam in Lakewood, Colorado, and a 1.5-kilometer array installation at Reclamation’s Granby Dike #3 near Granby, Colorado.



*Schematics of planned DFOS fiber array installations at Bear Creek Dam in Lakewood, Colorado; and at Granby Dike #3 near Granby, Colorado.*

## Maturing Sub-Seasonal Climate Forecast Rodeo Solutions

Reclamation, in partnership with elements of the The National Oceanic and Atmospheric Administration ran a year-long subseasonal (3–6 weeks into the future) forecasting competition titled the [Subseasonal Climate Forecast Rodeo](#). In this competition, teams were asked to submit subseasonal forecasts of temperature and precipitation for the Western United States every 2 weeks for a year. Winning teams successfully outperformed benchmark subseasonal forecasts over the year of competition. The competition concluded in 2018, and winners were honored at a symposium in early 2019. Owing to the success of the competition, a second, similar competition was run (Rodeo II) that expanded the competitor pool to include international participants. Winners from Rodeo II were announced in early 2021. From these competitions, Reclamation has spurred the development of several promising subseasonal forecasting methods. To continue this work and to identify winning solutions that hold promise for informing improvement of operational



subseasonal forecasts, Reclamation has partnered with University of California San Diego’s Scripps Institution of Oceanography Center for Western Weather and Water Extremes. This work will further evaluate promising methods through hind-casting and running experiments in near real-time. The work will also explore opportunities to create skillful ensemble forecasts by blending these and other methods. The ultimate goal is to identify methods and sources of predictability that can increase the skill of operational subseasonal forecasts.

## Rodent Burrows

Burrowing animals are detrimental to earthen canal and dam embankments because their burrows create voids that can lead to internal erosion and, in serious cases, embankment breach. A 2016 prize competition identified several approaches for deterring burrowing animals in earthen embankments.

A research team at Reclamation is currently developing three of the finalist’s deterrent approaches



and will implement these solutions at three test sites. The first prototype deterrent approach uses remotely deployable acoustic wave propagation emitters with programmable frequency range. The second approach to be evaluated is the use of noxious plants or plant-based concentrates targeted at specific animal species. The third approach is to place metal mesh or concrete cloth liners over an area filled with burrows to prevent further expansion of the burrowing. It is likely that each field site will require a custom approach for the target species and environment. The research team is currently pursuing field testing sites near the Snake River Area Office, Truckee Canal, and Palo Verde Ecological Reserve.

