



— BUREAU OF —  
RECLAMATION

# Research and Development Office FY 2023 Highlights



# Reclamation's Research and Development Office

The Research and Development Office (R&D) administers innovation programs to advance the agency's mission to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. R&D's two appropriated programs, Desalination and Water Purification Research and Science and Technology, address the technical obstacles related to our mission. R&D also administers the Open Water Data program to provide bureau-wide water data publishing and enhance science and product dissemination from R&D programs. Learn more at: <https://www.usbr.gov/research>.

## Desalination and Water Purification Research (DWPR)

### DWPR Projects FY 2023 by the Numbers

- 18 Awarded Grants
- \$3.9M Federal Funding
- \$4.1M Non-Federal Match

Reclamation's DWPR Program seeks to reduce the cost, energy consumption, and environmental impacts of using desalination and other water purification technologies to develop water supplies from otherwise unusable sources (e.g., brackish groundwater, sea water, produced water from oil and gas extraction, municipal wastewater).

Topics addressed by FY 2023 funded projects include:

- novel desalination technology development
- membrane development and optimization
- inland concentrate management
- nutrient separation and recovery
- resource recovery from brine
- per-and polyfluoroalkyl substances (PFAS) separation and treatment



*BGNDRF evaporation ponds used to manage desalination concentrate.*

## Brackish Groundwater National Desalination Research Facility

The DWPR program funds the operation and maintenance of BGNDRF, located in Alamogordo, New Mexico, a focal point for developing technologies for the desalination of brackish and impaired groundwater found in the inland states. The facility supports piloting to full-scale testing of desalination and water purification technologies, concentrate management technologies, and projects utilizing renewable energy.

BGNDRF brings together researchers from federal, state, and local government agencies, universities, private sector, and research organizations to work collaboratively and in partnership. The facility hosted 11 projects in FY2023 and expects several new projects to begin in FY2024.

In October 2023, the facility hosted their sixth annual Water Innovations and Networking (WIN) Workshop with over 90 registrants and presentations over two days from recent clients. The keynote address by Dr. Megan Plumlee from Orange County Water District highlighted the challenges of PFAS mitigation water that utilities are facing. The next WIN Workshop is scheduled for October 2024.



*Indoor test bays at BGNDRF.*

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

The S&T program funds innovative development, applied and demonstration research addressing the full range of technical issues confronting Reclamation water and power managers, customers, and stakeholders. Program research is funded in five areas:



### Water Infrastructure (WI)

Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure



### Power and Energy (PE)

Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non-Hydropower Renewable Energy



### Developing Water Supplies (WS)

Water Treatment, Water Supply Augmentation, Groundwater Supplies, Agricultural and Municipal Water Supplies, and Water Losses



### Environmental Issues in Water Delivery and Management (EN)

Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration

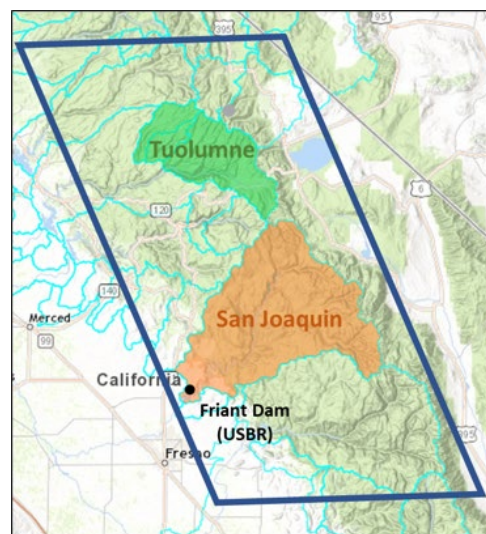
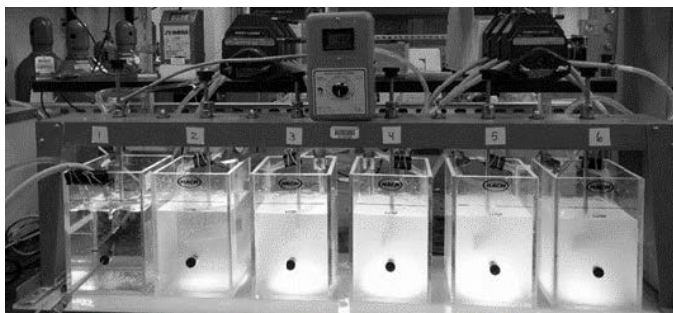


### Water Operations and Planning (WP)

Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Climate Change and Variability

### S&T Projects FY 2023 by the Numbers

- 213 Active Projects
- 38 Completed Projects
- \$4.66 M New Federal Funding
- \$3.81 M Non-Federal Match

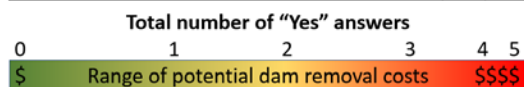


(Top) Six CSTRs-in-series running at steady state. Observe the increase in turbidity from left to right. (Left) Demonstration of a generalized merged Airborne Snow Observatory tool in the San Joaquin River Basin.

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

### (EN) Cost Estimating Guidelines for Dam Decommissioning Alternatives

Major Cost Drivers (surrogate indicators)	Yes	No
Will more advanced construction methods be required? (e.g. coffer dam for dewatering, cranes for tall dams, helicopters for remote access)		
Is sediment volume large relative to the river's sediment load? (e.g. many years average annual sediment load, reservoir width >> river width, phased removal)		
Will the reservoir or dam be missed? (e.g. infrastructure replacement, navigation use, lake recreation, expected litigation, stakeholder outreach, societal value, historical landmark)		
Will there be extensive remedial actions? (e.g. revegetation, restoration, grade control,...)		
Is there "reason to believe" complexities will increase cost? (e.g. sediment quality, archeological sites, buried infrastructure,...)		



Example matrix for planning-level cost estimating too for cost estimating dam decommissioning.

**Problem:** Dam safety, river restoration, and asset management programs require cost estimating methods that factor in dam decommissioning when appropriate. Traditional approaches often overlook complexities that significantly impact total costs. With an increase in dam removal case studies (Duda et al. 2023a; Tullos and Bountry 2023; American Rivers 2022), cost data has become available, but total costs can vary widely for similar dams.

**Solution:** This project developed planning-level cost estimating tools for dam removal alternatives, including: (1) new case study databases; (2) scoping questions to identify complexity cost drivers; (3) machine learning regression trees for estimating cost ranges; and (4) a Computation Guide for Cost Estimating to facilitate discussions on cost items, quantities, and unit costs.

**Impact:** The project offers cost savings through reduced labor and improved fish survival rates.

**Total Federal Cost:** \$0.15M

**Benefit Cost Ratio:** 11

## (PE) Optimizing Hydraulic Turbine Operation and Maintenance Through Reducing Cavitation

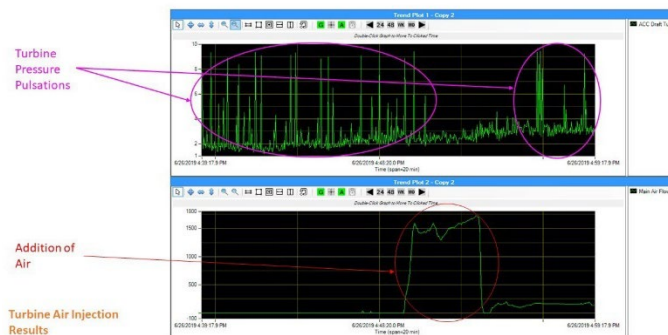
**Problem:** Hydropower turbines operating in off-design conditions may face issues such as cavitation-erosion, excessive vibrations, and unit fatigue. Repairs can worsen these issues by adding stress and altering turbine blade designs, ultimately reducing turbine lifespan. This research focuses on improving techniques for detecting and mapping turbine cavitation erosion and its intensity.

**Solution:** *Cavitation Detection:* Monitoring equipment enables real-time detection of cavitation, allowing staff to adjust unit loading to minimize damage while meeting water delivery requirements. Validated data from the detection system supports informed, data-driven decisions on repair outages. *ROV Inspection:* Remote-operated vehicles (ROVs) facilitate visual inspections without the need for clearance, significant outages, or the setup time associated with draft tube platforms. This approach reduces labor, minimizes confined space entries, and improves personnel safety.

**Impact:** Effective cavitation detection can reduce damage and outages and enhance decision-making, and ROV inspections can lower labor costs while improving safety.

**Total Federal Cost:** \$0.5M

**Benefit Cost Ratio:** 598



Example output from monitoring equipment to enable real-time cavitation detection.



Flooding conditions at the Blanco River stream gage, Colorado.

## (WP) Software Tool Development to Generate Stochastic Hydraulic Simulations using HEC-RAS

**Problem:** This investigation targeted a project aiming to define discharge for effective and appropriate sluicing. With limited data for model calibration and validation, initial results were interpreted as relative values and changes rather than definitive baselines. The goal was to identify threshold conditions that increase the likelihood of undesirable effects, such as a reduction in mean bed sediment size to fine sand and excessive sediment deposition and accretion in the modeled reach.

**Solution:** Researchers developed Monte-Carlo Simulation and Analysis (MCSA) software that helps end users set up and implement Monte-Carlo simulations for Unsteady Flow and Sediment Transport modeling using HEC-RAS. This gives probabilistic results for various outputs so that users can examine the sensitivities of model results to parameters and boundary conditions.

**Impact:** This iterative analysis examines variability that isn't usually explored, which could allow for better design than would occur with a deterministic model and reduce labor costs that would be required to do this analysis.

**Total Federal Cost:** \$0.03M

**Benefit Cost Ratio:** 27

## (WI) Laboratory Evaluation of Field Repairable Materials and Techniques for Cavitation

### Damage: Phase II

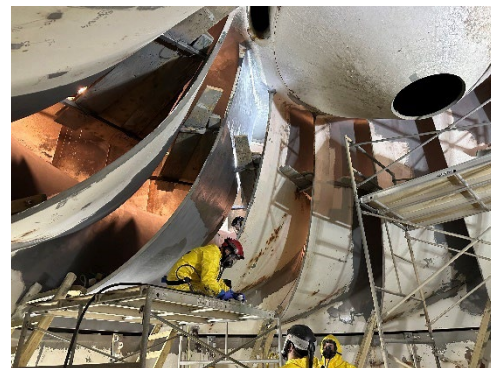
**Problem:** The Bureau of Reclamation uses structures like pipelines and hydro-turbines to manage water and generate power, but these are prone to cavitation damage from high flow rates and pressure changes. Currently, Reclamation mitigates cavitation with time-consuming Type 308/309 stainless steel weld overlays, which require outages of up to six months and repairs every three years at costs of \$100,000 to \$250,000 per unit. This makes cavitation one of Reclamation's most significant maintenance expenses.

**Solution:** Polymeric cavitation-resistant coatings have had mixed results in mild conditions, often needing repairs within a few years. This research evaluated 22 coatings and two metal repair methods against Type 316 stainless steel, A36 mild steel, and Type 308/309 stainless steel weld overlays. The cold spray method showed promise but requires further development, while the Cavitec weld method developed cracks and is unsuitable as an alternative. Two commercial polyurethane elastomers exhibited 30 times better cavitation resistance than previous coatings and may perform well in moderate to severe conditions, comparable to Type 308/309 overlays. Ongoing field trials will validate their performance, with severity levels based on damage observed in lab tests.

**Impact:** Addressing cavitation damage using polyurethane coatings could reduce the area of damage, reduce the amount of weld repair material, reduce labor performing cavitation repairs, reduce outage duration, and possibly eliminate a scheduled maintenance outage.

**Total Federal Cost:** \$0.7M

**Benefit Cost Ratio:** 1276



Field trial of polyurethane coatings on a turbine.

## **(WS) Occurrence of Organic Micropollutants in the San Juan River in Northwest New Mexico and their Removal During Drinking Water Treatment**



Rapid small-scale column test experimental setup.

**Problem:** Bureau of Reclamation (Reclamation) is overseeing the design of two drinking water treatment plants (DWTPs) for the Navajo-Gallup Water Supply Project, sourcing raw water from the San Juan River (SJR) in northwest New Mexico for Navajo Nation communities and the City of Gallup. In 2012, sampling revealed low levels of unregulated organic micropollutants (OMPs) in the SJR, including artificial sweeteners, pesticides, and pharmaceuticals, which may increase during droughts. The health effects of these OMPs are largely unknown, potentially affecting consumer confidence. Many are on the EPA's Candidate Contaminant Lists for future regulation. This research will conduct seasonal sampling to characterize OMPs in the SJR and Cutter Reservoir and evaluate their removal using simulated bench-scale DWTP processes, including granular activated carbon (GAC) adsorption.

**Solution:** This research found that powdered ash-treated pine biochar can remove readily adsorbable organic micropollutants (carbamazepine, cotinine, DEET, and theobromine) from water in a comparable manner to powdered activated carbon for a much lower cost.

**Impact:** The price of powdered activated carbon has gone up over time (sourced from coconut shell or bituminous coal), but ash-treated pine is often considered a waste product and can be procured for low cost. The carbon is activated through a thermal process, while lower heat is required to produce biochar, resulting in further cost savings.

**Total Federal Cost:** \$0.3M

**Benefit Cost Ratio:** 93

## **S&T Prize Competitions Program**

### **Prize Competitions Program FY 2023 by the Numbers**

- 2 On-going Competitions
- 2 Completed Competitions
- 7 Winning Solutions
- \$630,000 Cash Prizes Awarded
- 4 Technology Searches Initiated

Reclamation continued to utilize the innovative approach of crowdsourcing through Prize Competitions to identify alternative approaches to challenges encountered supporting Reclamation's mission and stakeholder interests.

In FY 2023, Reclamation continued supporting two on-going competitions. These competitions are reaching international communities of solvers.

*Veg Out Challenge: Managing Aquatic Vegetation in Canals*— Three teams shared the Phase 1 \$150,000 prize purse for successfully submitting a concept paper that described methods to reduce vegetation in canals. This challenge will conclude in FY 2024.

*Counting Every Drop Challenge*— Phase 1 was completed in December 2022 and awarded eight solvers \$10,000 each for their innovative precipitation prototype designs. This challenge will conclude in FY 2024.

In FY 2023, two competitions concluded with the following awards given out to solvers:

*Detect Me if You Can*— Team Permittivity was awarded the grand prize of \$25K for their entry "Utilizing Space Tech to Detect FRP Damage on Earth. While the submitted prototype did not meet all of the award requirements, its inventive approach has demonstrated significant promise as a viable, low-cost solution for the future.

*Divide and Conquer*— Four winners were awarded Prize purses totaling \$255,000 for innovation in improving execution speed of numerical models that simulate hydraulics, sediment erosion, transport, and deposition in rivers and reservoirs.

Prize competitions complement traditional research by providing another tool to help find breakthroughs or overcome technical obstacles and complexities. Reclamation continues to work internally and with prize winners to further develop solutions received from completed competitions.

Technology searches were identified as an additional tool to help define the problem and solution boundaries for prize competitions. In FY 2023, four technology searches were initiated:

1. Lateral Soil Stress at Rest
2. PFAS Sensing
3. Sealing Large Conduits
4. Subsurface Crack Detection

## S&T Snow Water Supply Forecast Program

### Snow Water Supply Forecast Projects FY 2023 by the Numbers

- 11 Awarded Cooperative Agreements
- \$11.1M Federal Funding
- \$6.2M Non-Federal Match

The Snow Water Supply Forecasting Program Authorization Act, 2020, established the Snow Water

Supply Forecasting Program within the Department of the Interior (DOI). The Research and Development office is implementing the Program to advance emerging technologies to enhance snow monitoring and improve water supply forecasts. In FY 2023 the Program:

- Selected projects totaling \$11.1 M that will enhance snow monitoring and water supply forecasting
- Collaborated with federal partners at NRCS and NOAA to support the advancement of water supply forecasting technologies



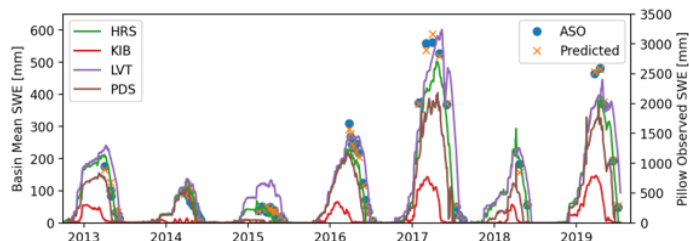
*Snowcapped Wyoming mountains.*

### S&T Facilitated Adoption Program

#### FA Activity Summary FY 2023 by the numbers

- 9 New Projects

In FY 2023, the R&D Office introduced the first offering of the S&T Facilitated Adoption Program to demonstrate the use of results or transferring knowledge from a completed project to enable the use of the results. Eligible projects are completed S&T Research projects or solutions from Prize Competitions. Nine projects were selected in FY 2023 for Facilitated Adoption.



*Demonstrating merged Airborne Snow Observatory tools, a follow on facilitated adoption project*

## S&T Technology Transfer Program

### TT Activity Summary FY 2023 by the numbers

- 2 CRADAs
- 5 MTAs

The S&T Program pursues a variety of joint venture research partnership agreements by leveraging Technology Transfer (TT) with the private sector.

This includes Cooperative Research and Development Agreements (CRADA), Materials Transfer Agreements (MTA), and Facility Use Service Agreements (FUSA), among others, where industry plays a role in maturing and transforming research results into usable, manufactured products that can be supplied to Reclamation and the broader water management community.



*Hydrokinetic unit, part of a Materials Transfer Agreement.*

## Geographic Information Systems

### (GIS)

#### GIS Program Activity FY 2023 By the Numbers

- 671 actively managed data layers are available to all Reclamation staff

The GIS Program promotes data management principles, a GIS community of practice, and the effective use of geospatial technology to support Reclamation's mission, our partners, and the public.

FY 2023 implementations for GIS platform:

- Refined enhancements to BORGIS GeoPlatform to support mobile data access and field data collection
- Developed and implemented workflows to host and maintain Asset Registry Project data
- Expanded GIS Data Managers Team to catalog, curate, and manage Reclamation geospatial data assets
- Nearly 190 Staff from all Regions and Denver attended 11 GIS training events

## Open Water Data

#### OWD Activity FY 2023 By the Numbers

- Datasets published in RISE: 683 available catalog records as of 9/30/2023
- RISE Releases: 6 deployments resulting in 93 changes
- Average Monthly RISE Users: 650

The Open Water Data Program focuses on making Reclamation's mission-related data available in open formats for broad public use and supports implementation of the OPEN Government Data Act. Program activities include developing, operating, and maintaining the Reclamation Information Sharing Environment (RISE) system for publishing open datasets, coordinating with regions and programs through the Open Data Team to develop open data policy and implement best practices, and interfacing with internal and external partners to enhance data access and use.

The RISE Reservoir Conditions page provides access to an interactive dashboard and a PDF map of current reservoir conditions. Users can see today's conditions or query past reservoir conditions.

In FY 2023, the Open Water Data Program continued to develop and add data to RISE (<https://data.usbr.gov>). RISE provides a platform for Reclamation programs and offices to publish water, hydropower, environmental, and related data for both internal and external data consumers. Enhancements introduced this year included a redesign of catalog details pages on the public-facing website to make data more intuitive to access, performance improvements for time series plotting, enhancements to Data Admin UI forms, enhancements to the CSV to JSON converter Catalog Record Data and Report from S&T Project 20081: Internal Erosion: Laboratory Testing to Identify End States in Internally Unstable Soils

The research discussed in this report investigated whether unique limit state conditions exist if internal erosion due to internal instability is allowed to continue to equilibrium, and the appropriateness of a rigid wall permeameter test to determine these limit state conditions. The research was conducted at the Geotechnical Laboratory and Field Support (GLFS) group of the Bureau of Reclamation Technical Service Center (TSC) in Denver, CO by modifying existing equipment and controlling software. Four tests were conducted on a gap graded, internally unstable soil. It was determined that internal erosion, if allowed to continue unimpeded, equilibrates to an end state condition resulting in the equilibration of hydraulic conductivity, height (or volume) change, and stress conditions throughout the specimen in a rigid wall permeameter. Further research is needed to better define and state conditions for soils representing dams in Reclamation's portfolio. The rigid cell permeameter is applicable for determining equilibrium states for hydraulic conductivity and final gradation. A flexible wall permeameter is required to determine the final volume change and mass loss at the end state of internal erosion and the effect of stress conditions on the end state parameters.

Generation Effort: S&T Project 20081: Internal Erosion: Laboratory Testing to Identify End States in Internally Unstable Soils  
 Location: Western US  
 Topics: Infrastructure and Assets  
 Tags: Internal Erosion, Internal Stability, SoilFusion, SoilFusion, Internal Instability  
 Reclamation Project: [none]  
 Reclamation Program: Science and Technology Program

ASSOCIATED ITEMS

Uploaded Files

- S&T Project 20081 Data: Internal Instability Test 2
- S&T Project 20081 Data: Internal Instability Test 4
- S&T Project 20081 Final Report: Internal Erosion: Laboratory Testing to Identify End States in Internally Unstable Soils

Also in FY 2023, the Open Data Team performed outreach to regions and directorates to gather information on current publishing methods, visualization tools, and open data needs and interests.

The updated RISE Catalog Record Details pages provide an overview of available data and easy access to individual datasets.



**Front cover photo:** Theodore Roosevelt Dam, part of Salt River Project, AZ  
**Back cover photo:** Hydropower generating units at Glen Canyon Dam, AZ