BUREAU OF RECLAMATION

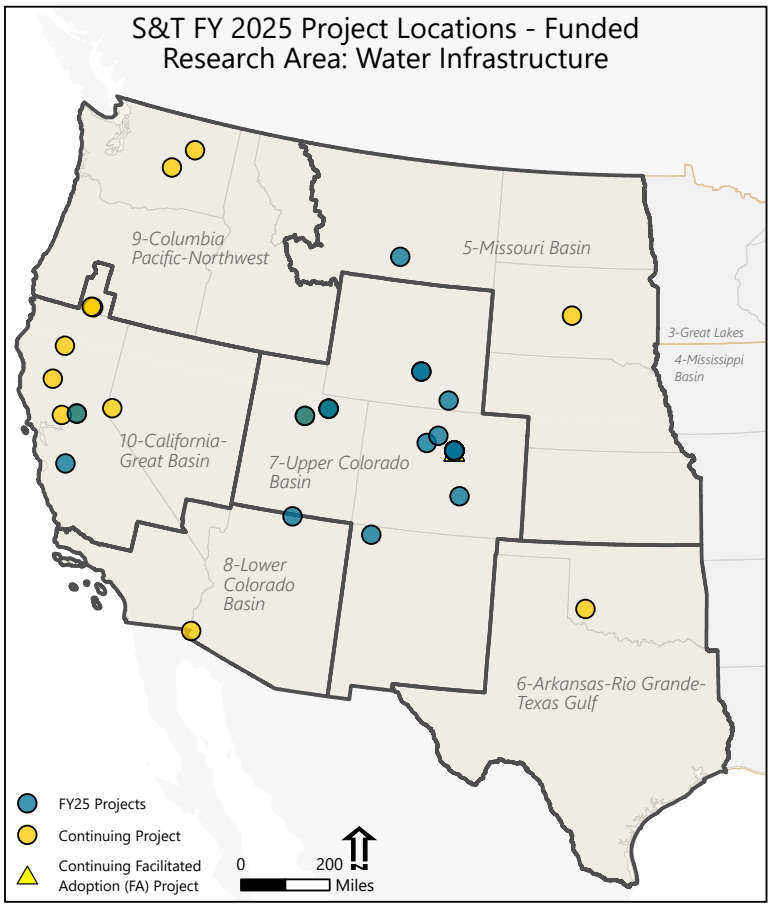
Research Area Summary
Water Infrastructure
Research and Development Office

U.S. Department of the Interior

June 2025

Executive Summary

The Water Infrastructure (WI) area of the Science and Technology Program (S&T) examines research in the following categories: Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure. In FY25, the S&T Research Program funded 19 projects in this area approximately totaling $2.6 M. Ten new projects received $1.0 M in FY25, and nine continuing projects received $1.6 M in FY25. Additionally, the S&T Facilitated Adoption Program continued to fund four projects totaling $1.1 M in FY25. S&T estimates a benefit-cost ratio (BCR) for WI projects each year to demonstrate the value of this research. The BCR was 1276 for Laboratory Evaluation of Field Repairable Materials and Techniques for Cavitation Damage: Phase II. This project evaluated two commercial polyurethane elastometers (polymers with rubber-like properties) for mitigating cavitation. These elastomers provide 30 times better cavitation resistance than polymeric coatings used in draft tubes under mild cavitation. The BCR is realized primarily due to reduced cavitation damage and potential reduced outage duration. As demonstrated, WI research is extremely valuable to Reclamation.



Reclamation's Research and Development Office (R&D) manages the Science and Technology Program (S&T) and is focused on providing innovative solutions for Reclamation water and power facility managers and its western customers and stakeholders, primarily through competitive funding opportunities to Reclamation employees.

The S&T Program has five research areas (listed below) directly related to Reclamation's mission.
For more information, visit: https://www.usbr.gov/research/st/index.html

S&T Research Areas and Categories

Water Infrastructure (WI)
Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure

Power and Energy (PE)
Hydro Powerplants and Pumping Plants

Developing Water Supplies (WS)
Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses

Environmental Issues for Water Delivery and Management (EN)
Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration

Water Operations (WP)
Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Hydrologic Variability

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Water Infrastructure

FY24 Completed Projects

19227: Polysiloxane and Vinyl Coatings Comparison and Field Trial – Carter Gulsvig

Historical coatings used on Bureau of Reclamation infrastructure provided a minimum 50-year service life. Modern coatings have been shown to provide reduced service lives. Within the past five years, researchers identified several promising epoxy polysiloxane coatings. However, these were designed for atmospheric service environments and required evaluation of their suitability and performance in water immersion. The study performed three phases of laboratory investigation: 1) evaluation of corrosion performance of 32 systems; 2) a reproducibility study using different batch numbers, applicators, and number of coats; and 3) evaluation of return-to-service time. The investigation recommended primer systems for a total of 32 coating systems and found that polysiloxane from multiple manufacturers performed well in water immersion service when epoxy primers are utilized. The study recommends that field applications of polysiloxanes should be monitored for corrosion protection and durability performance. The study also included a field investigation of an epoxy polysiloxane coated structure at Tennessee Valley Authority's Fontana Dam. Findings showed that the gates were in excellent condition with adequate barrier properties.

Radial gates coated with polysiloxane at Fontana Dam, North Carolina.

19317: Field Implementation of Burrowing Animal Deterrents for Earthen Canal Embankments – Richard Bearce

Reclamation oversees extensive canal systems where animal burrows near earthen embankments can lead to increased risk, including seepage, settlement, and internal erosion. Traditional deterrent methods are costly, highlighting the need for innovative, sustainable, and cost-effective solutions. In 2016, the Research & Development Office's Prize Competition Program solicited ideas, awarding five approaches. This research evaluates three selected approaches: a wind-powered acoustic emitter, noxious plants, and a concrete canvas liner. Effectiveness of the approaches varied, and researchers made improvements and provided recommendations on implementation. Future research will expand field testing in collaboration with additional Reclamation regions and the U.S. Army Corps of Engineers. The results and lessons learned from this study will be used to develop and prototype an embankment armoring strategy tailored to target species, as well as explore an innovative AI-based detection and response deterrent system.

Surveilance footage of rockchuck activity at canal test site near Boise, Idaho. Red dashed boxes show the location of rockchucks.

20081: Identifying End States in Internally Unstable Soils – Carolyne Bocovich

Internal instability, or the migration of finer soil particles out of a coarser soil matrix, can result in substantial damage and potential failure of embankments. Most research on internal instability focuses on predicting if and when internal instability initiates. This research focuses on the end state of internal instability if allowed to continue to equilibrium. The study used a rigid wall permeameter to run internal instability tests on four internally unstable soils to an equilibrium state, and then applied vertical consolidation stresses to the top of the specimens. Test outcomes were used to refine the test procedure and to demonstrate that equilibration conditions of internal instability do exist. Results indicated that the equilibrium state is dependent on stress conditions. Further research is needed to better understand and define the equilibrium state of internal instability in soils representing Reclamation embankments.

Soil specimen and setup for internal erosion analyses in a rigid cell permeameter.

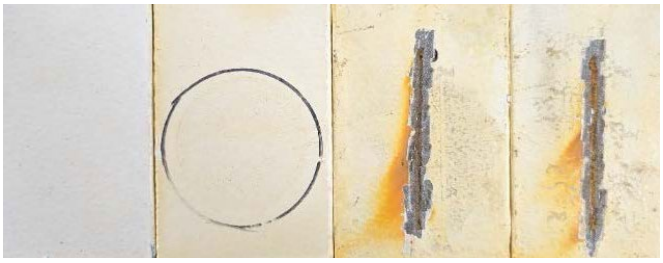
21049: Improving Reclamation's Geologic and Geotechnical Investigations with Drill Parameter Recorder Technology – Evan Lindenbach

The goal of a geotechnical drilling program is a cogent package of qualitative and quantitative information describing what's under our feet. An experienced team will not only characterize material using traditional methods, but also observe subtleties in drill rig response (i.e. changes in vibration of the drill rig), often as valuable to characterization as the core logs, laboratory results, or the samples themselves. A "Monitoring While Drilling" (MWD) system is equipped with sensors to continuously record parameters such as penetration rate, torque, down pressure, rotational speed, and fluid injection pressure. Because drilling is typically expensive and can require extensive permitting and site access coordination, the value proposition for each drill hole increases as more data can be obtained using a MWD system. This research produced an invited peer-reviewed publication, two invited presentations, and a proposal to further this research with additional data collection and analysis. These products are discussed within the final report and provided in more detail as appendices.

Monitoring while drilling system on Reclamation drill rig.

21067: Investigating Newly Formulated Polysiloxane Coating Systems with Improved Erosion and Impact Properties – Brian Baumgarten

Vinyl has long been considered the benchmark coating system for immersion service for the Bureau of Reclamation and the United States Army Corps of Engineers. However, more stringent environmental regulations are causing these historical systems such as vinyl to be phased out. Many modern replacement systems exhibit reduced longevity. Recent studies have highlighted epoxy polysiloxane coatings that exhibit comparable corrosion protection. The goal of this study was to improve impact and erosion resistance of epoxy polysiloxanes while maintaining corrosion protection. Manufacturers provided modified or new formulations for polysiloxane coatings. A total of twelve systems from three different manufacturers were evaluated and compared against vinyl Systems 4 and 5-E-Z. Results found one coating system that is a viable replacement for vinyl System 4 and none that were viable replacements for System 5-E-Z. Researchers recommend further investigation and field trials on this coating system.



New polysiloxane coating system evaluated during laboratory corrosion testing.

21100: Standardizing Methods for Disaggregation of Slakable Rock and Fat Clay –Richard Bearce

Reclamation has numerous facilities where the local geology contains slakable rocks, such as shale or claystone, and fine-grained soils. These can be notoriously difficult to sample and prepare for testing, and require disaggregation, which typically involves manually grinding with a mortar and pestle. Hand processing is time consuming, labor intensive, and can lead to inconsistencies in test results. Ball milling is an alternative with potential to improve the preparation process, leading to more accurate test results. This research sought to develop a standardized ball milling approach for processing slakeable rock and desiccated/indurated soil. This study presents the gradation and plasticity results of samples processed with various ball milling combinations on six natural materials and a concrete sand. Results indicate that ball milling is effective at disaggregating a wide variety of natural geomaterials, but additional testing is required before a standard can be developed. The manuscript, "Evaluating Methods for Ball Mill Disaggregation of Slakable Rock and Fine-Grained Soil," documents the research and is accepted for publication in ASTM's Geotechnical Testing Journal and will be presented at ASTM's 2025 Symposium on Shear Testing of Soils.

Ball mill device used to prepare samples for disaggregation analysis.

22039: Boundary Layer and Aerated Flow Effects on Hydraulic Jacking in Spillway Chutes – Tony Wahl

Hydraulic jacking failures have always been a concern for spillways and other high-speed waterways. Hydraulic jacking can occur when flow strikes an offset in the surface and is brought suddenly to rest, similar to a pedestrian tripping on a sidewalk crack. This report summarizes a series of research efforts funded by the Science & Technology Program and Dam Safety Technology Development Program. The work began in late 2016 with a small literature review and scoping study, building upon two earlier Reclamation research efforts related to hydraulic jacking. During this initial phase of the project, the failure at Oroville Dam occurred and the subsequent forensic investigation demonstrated that the fundamental fluid mechanics phenomena that drive the hydraulic jacking process were still poorly understood. The end result of these studies is a vastly improved understanding of hydraulic jacking. Designers and risk analysts will be well-equipped in the future to estimate uplift pressure heads, flow through joints and cracks, and the effects of different joint and crack remediation strategies. An end product of this study is a new engineering monograph titled The Fluid Mechanics of Hydraulic Jacking, which combines all of the results contained in the previously mentioned journal articles under a single Bureau of Reclamation cover.

Laboratory setup for the hydraulic jacking research.

23011: Concrete Cavitation- Low-Cost Lining Materials – Allen Skaja

The intent of this project was to evaluate commercially available cavitation-resistant coating products for concrete infrastructure that were cost effective, could be applied to larger structures, and could resist cavitation damage. However, researchers were unable to identify products that warranted investigating in laboratory testing. The lack of commercially available products for mitigating concrete cavitation is a known issue to TSC researchers. To address this technology gap, there is ongoing research through other Science & Technology funded projects to develop products with superior cavitation performance, including S&T projects 23009 and 24005. The new materials are showing excellent cavitation resistance in laboratory testing and are currently in field trials. However, the current formulations are not UV stable, and would require additional formulating to obtain UV stability.

Bare concrete and a cavitation resistant coating after cavitation testing.

24002: Investigating the Need for Corrosion Protection of Steel Reinforcements in Concrete at Reclamation – Grace Weber

This scoping study sought to investigate whether concrete corrosion is a significant issue at Bureau of Reclamation facilities and determine if further implementation of corrosion protection methods is warranted for Reclamation structures. This was accomplished through review of Reclamation Asset Management resources and outreach to field contacts. Findings from the data collection indicated that, at this time, there is not sufficient need or benefit to begin widespread implementation of additional corrosion protection techniques for Reclamation's reinforced concrete infrastructure other than those already utilized (e.g., adequate cover). However, targeted implementation may still be useful if corrosion of the reinforcing steel can be definitively shown to be the primary factor in concrete deterioration, or a significant secondary effect due to adverse exposure conditions. This could be further investigated or verified through future work, as listed in the final report.

Spalling pedestal with exposed reinforcing steel.

FY25 New S&T Research Projects

25002: The Laboratory Investigation of Utilizing Recycled Rubber Fills in the Infrastructure - Phase I – Belay Nerea

The U.S. generates about 300 million scrap tires annually, with approximately 60 million scrap tires ending up in landfills each year. The proposed research aims to utilize scrap tires as a fill material in infrastructure applications. Tire-derived aggregates (TDA), processed from the waste rubber tires, possess unique engineering properties of being durable, lightweight, allowing drainage, and having cohesive abilities. A comprehensive literature review and a series of experiments will be conducted to better understand and quantify the engineering properties of TDA.

25006: Evaluation of Permanent and Laboratory Reference Electrode Performance – Grace Weber

Past Reclamation experience has shown that reference electrodes (REs) do not always meet manufacturer lifetime claims. REs are used to monitor the performance of cathodic protection systems for corrosion protection, either via permanent installation for continuous monitoring or during discrete inspections. This project will investigate this finding and include new RE technology, to determine if it is superior to typical REs. Testing will include a variety of types of REs in conditions common to Reclamation facilities.

25008: Establishing Risk-Informed Coating Maintenance for Steel Penstocks – Bobbi Jo Merten

This project will establish a risk-informed coating maintenance approach for Reclamation steel penstocks that includes ultrasonic thickness testing, coating visual assessment, and coating impedance spectroscopy testing. Reclamation repair costs to address corrosion pitting and corrosion-caused metal loss due to poorly maintained coatings are growing. The risk-informed approach will prioritize coating maintenance across different facilities. This will minimize penstock corrosion risk and consequences while maximizing coating investments. The findings will also inform ongoing condition-based maintenance initiatives using permanent sensors.

25009: Evaluating Rock Material Properties from In-situ Flexible Membrane Dilatometer Tests Using an Inverse Modeling Approach – John Foran

Effective engineering design of our infrastructure depends on the proper characterization of the material it is founded on. Laboratory testing of earth materials is the industry standard for determining material properties; however, it falls short in that we are limited by the size of samples we can test. In-situ tests allow us to test larger volumes of material, but in the case of the flexible membrane dilatometer test, there is considerable uncertainty in the direct applicability to engineering design. This proposal aims to reduce uncertainty by developing a numerical model to evaluate the engineering properties of in-situ materials from flexible membrane dilatometer tests.

25021: Using Monitoring While Drilling Technology to Improve Subsurface Characterization – Evan Lindenbach

This research project will continue a previous effort focused on improving subsurface characterization with monitoring while drilling (MWD) technology. MWD incorporates a number of state-of-the-art sensors onto a drill rig to capture significantly more information about the subsurface and facilitate a data-driven approach. The use of MWD is rapidly evolving for geotechnical exploration programs; Reclamation is at the state of the art and is partnered with the Federal Highway Administration, U.S. Army Corps of Engineers, and a number of universities to forward the technology. As geotechnical explorations are occurring across Reclamation during all parts of the year, with costs well in the millions of dollars, any improvements to the data collection, analysis, and end use represent a significant value proposition.

25002: Using Machine Learning to Automate Crack Mapping and Structural Health Monitoring – Evan Lindenbach

Machine learning (ML), and the broader umbrella of artificial intelligence (AI), are tools where a user can utilize iterative algorithms to find hidden patterns in a data set. The use of ML is rapidly growing across all industries, with many applications for dams, water conveyance systems, and power generation. This proposal seeks to fund the development of ML tools for two immediate areas of need: 1) automating the detection and mapping of cracks in concrete, and 2) improving structural health monitoring and anomaly detection. The research will be performed by a cross-disciplinary team of engineers and scientists and will have impacts across Reclamation.

25035: Uncrewed Autonomous Systems Solutions Scoping – Robert Allen

There has been significant progress made over the last twenty years in the autonomous systems space, from divers to uncrewed aerial systems (UAS), to humanoid or canine-like robots being developed. This research investigates opportunities for Reclamation to adopt the use of uncrewed, autonomous systems to improve personnel safety, efficiency, and expand its capabilities. This scoping study will assess the various systems and weigh capabilities and other parameters to see if there is potential for use of these systems in Reclamation facilities.

25037: Developing a Standard Method for Ball Mill Disaggregation of Slakable Rock and Desiccated Fine-grained Soil – Richard Bearce

Reclamation's facilities have complex geology. Often, soil and rock contain materials that are difficult to sample and test due to their fine-grained composition and bonded/cemented nature. Breaking down slakable fine-grained rock and soil by hand for laboratory testing is time consuming, labor intensive, and inconsistent depending on operator. Preparing samples via ball mill provides more accurate and consistent laboratory results and is also less labor intensive than hand processing. This project builds on previous research evaluating the variables associated with ball milling geomaterials to develop a standardized approach.

25038: Informing Best Practices During Permeability Testing – Carolyne Bocovich

Permeability, the rate that water flows through a soil medium, is essential data for seepage analysis and modeling, as well as for evaluating dam performance and the risk of potential failure modes. It is also a critical design criterion for seepage cutoff walls. Permeability testing is conducted as part of nearly every

Reclamation project; accurate test results are critical to the project and Reclamation's mission. This research will refine the state of the current practice by informing best practices outlined in ASTM D5084. Further, this research will investigate methods to validate laboratory testing equipment used across the industry.

25039: Developing Guidance for Hydrokinetic Technologies in Open Waterways - Culmination of Field and Laboratory Testing – Joshua Mortenson

Hydrokinetics (HK) use the energy from flowing water in open channels to generate power. Although HK is marketed as a low-cost system that utilizes existing infrastructure and has widespread implementation potential, important considerations for impacts to canal operational and safety must be addressed. Canal systems were designed to convey water at low speeds for effective operation and minimal energy dissipation. HK field demonstrations from past research have produced increased water levels, which can increase risk for overtopping, canal leakage, and disruptions to operations. This project continues work to combine findings from field and laboratory testing and develop guidance for safe and effective application of HK technologies.

FY25 Continuing Facilitated Adoption Project

FA25053: Demonstration and Use of Advanced 3D Measuring Techniques Using Portable Laser and Arm Technology – Chad Paulson

Laser metrology has untapped potential across Reclamation in applications of reverse engineering, component alignment, verification of contractor work, and in quality control for laboratory tests. The goal of this project is to implement the use of laser metrology at hydropower facilities and demonstrate the diverse benefits this technology has to offer in accomplishing Reclamation's Hydropower objectives. Over the course of this facilitated adoption, metrology measurements will be collected for unit placement, reverse engineering components for FEA analysis, and weld repair scanning for distortion estimation.

FA25057: Demonstration of Robotic Vehicles for Inaccessible Metallic Pipe – David Tordonato

Traditionally, inspection of penstocks and outlet works at Reclamation has been completed by humans using rope access techniques where necessary. Robotic crawlers and submersibles offer the ability to physically collect information in these structures remotely without putting humans at risk. This project demonstrates robotic inspection vehicle solutions for visual and quantitative condition assessment of the lining of steel structures. A secondary objective is to develop the capability for Reclamation to perform these inspections in-house at other facilities.

FA25059 Refurbishment of Small Diameter Embedded Pipes in Powerplants and Dams – Avery Schilt

As Reclamation infrastructure ages, options for refurbishment of embedded small diameter piping are being explored. The Pipe Packer is a viable option to structurally repair a variety of damage in hard to access small diameter pipe. For this facilitated adoption, an 8-to-12-inch diameter Pipe Packer repair tool will be purchased and used to demonstrate the repair procedure in a discharge tube drain line, and concurrently train facility staff in this technique and troubleshoot any problems that arise. Successful demonstration and implementation will reduce facility downtime.

FY25 New and Continuing* Research Projects

ID	Final Year	Title	Lead
19119	2025	Comparison of traditional and new testing methods for riprap material quality	Robert Rinehart
19182	2025	Facility Management of Reclamation's Dams- O&M Integration of the Unified Intelligent Model	David Winslow
19206	2025	Improved Prediction of Seismically Induced Hydrodynamic Loads on Dams and Spillway Gates	Josh Mortensen
20096	2025	UAS Demonstration and Development for Inaccessible Features Inspections	Carter Gulsvig
21045	2025	Voids Behind Spillways, Conduits, Canals, Tunnels, and Siphons: Causes, Detection Techniques, and Repair Options	Evan Lindenbach
21076	2025	Concrete Cloth for Seepage Reduction – Field Demonstration	Caleb Nickel
21096	2025	Evaluation of Fiber Optic Technology for Use on Reclamation Critical Infrastructure	Justin Rittgers
22004	2025	Evaluation of Plunger Valves as a New Technology for Improved Water Delivery at Reclamation Dams and Hydropower Facilities	Josh Mortensen
22017	2025	Evaluate and model economical, safe and effective methods to mitigate and remove debris from dam intake structures	Juan Luna
22081	2025	Utilization of Trained Canines to Detect Leaks in Water Pipelines	Grace Weber
22086	2025	Evaluation of Acoustic Emission Sensing Technologies for Pressurized Buried Water Pipeline Leak Detection	Atousa Plaseied
22096	2025	Alternative methods for collecting data for photogrammetric crack mapping of interior cavities of buttress dams: Development of methodology and demonstration at Stony Gorge Dam	Matthew Klein
23009	2025	Investigating Rubberized Polysiloxane Coating Formulations to Improve Durability and Long-Term Performance	Allen Skaja
23010	2025	Advancement of CP Monitoring and Control for Water Storage Tanks Phase II	Avery Schilt
23012	2025	Investigation of Innovative Exposed Lining Systems	Brian Baumgarten
23014	2025	Long-Term Coatings Lab Testing Data Analysis for Service Life Correlations and Evaluation of New Testing Methods	Bobbi Jo Merten
23016	2025	Evaluation of Infrastructure Coated with Polysiloxane Coatings	Allen Skaja
23020	2025	Ground Modification using Microbially Induced Desaturation (MID) for Liquefaction Interim Risk Reduction	Angel Gutierrez
23024	2025	The effect of large earthquake loading on fine-grained foundation materials: determining residual undrained strengths at large strains and corresponding embankment deformations	Carolyne Bocovich
23028	2025	Determination of Long-Term Durability of Concrete Containing Calcined Shale in Reclamation Structures	Catherine Lucero
23036	2025	System Commissioning for Topical Concrete Coatings used for Algae Resistant Linings for Canals	Jeffery Keim
23042	2025	Hydraulic friction factors and energy dissipation of stepped chutes	Tony Wahl
23043	2025	Laboratory testing to inform risk estimation of internal erosion event progression - self-healing from upstream material	Carolyne Bocovich

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ID	Final Year	Title	Lead
23050	2025	Reducing Reclamation's Carbon Footprint Through Modernizing Concrete Materials, Specifications and Construction Practices	Catherine Lucero
23062	2025	Improved Air Vent Sizing Methods for Emergency Gates	Joe Kubitschek
23065	2026	Demo On-line Cable Monitoring and 3-D Roof Panel Printing	David Tordonato
23066	2025	Comparing the Utility of LiDAR and Photogrammetry for Engineering and Scientific Analysis	Matthew Klein
23067	2026	Stilling Basin Design Downstream from Stepped Spillways	Tony Wahl
24006	2026	Instrumented Standard Penetration Testing (ISPT) to increase accuracy and reliability in penetration and delivered energy data for geotechnical analysis and liquefaction evaluation, continued	Christopher Haynes
24010	2026	Evaluating rust creep testing methods: Improving metal loss predictions for improved coating lifetimes	Meredith Heilig
24030	2026	Development of a Digital Twin: Coupling Building and Geologic Models for a Reclamation Dam	Evan Lindenbach
24033	2026	Determining optimal Mni Wiconi treated water quality to minimize impacts on distribution system materials.	Miguel Arias Paic
24034	2026	Reducing Canal Seepage with Innovative Materials	Katey O'Quinn
24046	2026	Innovative Use of the Hydraulic Profiling Tool (HPT), High- Resolution K (HRK), and Nuclear Magnetic Resonance (NMR) Logging for Optimizing Dewatering System Designs	Jong Kang
24057	2025	Laboratory Investigation of Commonly Used Geomembrane Liner Materials	Brian Baumgarten
24060	2026	Experimental and Numerical Modeling of Block Plucking with Applications to Spillway Erosion	Aaron Hurst
25002	2027	The laboratory investigation of utilizing recycled rubber fills in the infrastructure - Phase I	Belay Nerea
25006	2027	Evaluation of Permanent and Laboratory Reference Electrode Performance	Grace Weber
25008	2027	Establishing Risk-Informed Coating Maintenance for Steel Penstocks	Bobbi Jo Merten
25009	2027	Evaluating rock material properties from in-situ flexible membrane dilatometer tests using an inverse modeling approach	John Foran
25021	2027	Using Monitoring While Drilling Technology to Improve Subsurface Characterization	Evan Lindenbach
25028	2027	Using Machine Learning to Automate Crack Mapping and Structural Health Monitoring	Evan Lindenbach
25035	2027	Uncrewed Autonomous Systems Solutions Scoping	Robert Allen
25037	2027	Developing a Standard Method for Ball Mill Disaggregation of Slakable Rock and Desiccated Fine-Grained Soil	Richard Bearce
25038	2027	Informing best practices during permeability testing	Carolyne Bocovich
25039	2026	Developing Guidance for Hydrokinetic Technologies in Open Waterways - Culmination of Field and Laboratory Testing	Joshua Mortensen
FA24066	2026	Laboratory Information Management System for Reclamation Infrastructure	Catherine Lucero
FA24068	2025	Sky Mirror – Unmanned Aerial Systems (UAS) Data Collection	Matthew Klein
FA25053	2026	Demonstration and Use of Advanced 3D Measuring Techniques Using Portable Laser and Arm Technology	Chad Paulson
FA25057	2027	Demonstration of Robotic Vehicles for Inaccessible Metallic Pipe	David Tordonato
FA25059	2027	Refurbishment of Small Diameter Embedded Pipes in Powerplants and Dams	Avery Schilt

*Continuing projects include those that received no-cost extensions.

Front cover photo: Reclamation Columbia-Pacific Northwest Region drill rig instrumented with measurement while drilling (MWD) instrumentation at Anderson Ranch Dam, Idaho.

Back cover photo: Folsom Dam Auxiliary Spillway.