BUREAU OF RECLAMATION

R&D Office Research Updates

Developing Water Supplies

U.S. Department of the Interior

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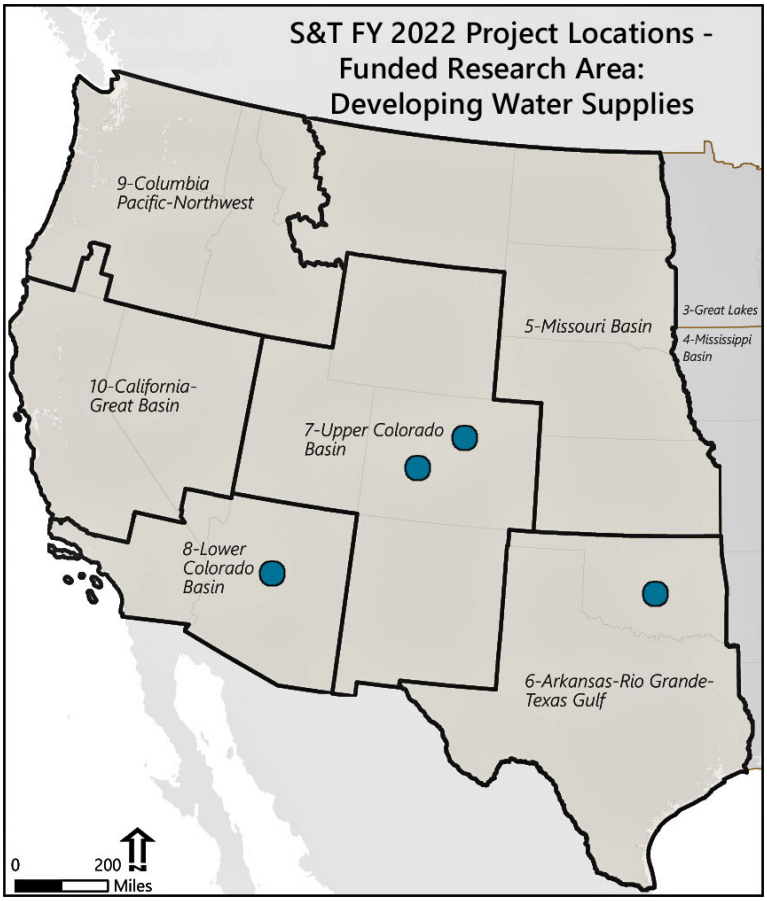
Executive Summary

The Developing Water Supplies (WS) Research Area of the Science and Technology Program (S&T) examines research in the following categories: Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses. This document provides a summary on projects in the advanced water treatment category only. In FY22, S&T funded 17 WS Projects approximately totaling $0.6M: four are new totaling $0.4M and 13 are continuing totaling $0.2M. Advanced water treatment is an enormous field of study spanning a wide range of technology types, a diverse group of water users, and a complex landscape of water types. This year the advanced water treatment roadmap will also be completed, and its findings used to guide research in this area for the upcoming FY23 call for proposals.



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: www.usbr.gov/research/st/needs_priorities/index.html.

S&T Research Areas and Categories

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

Power and Energy (PE)
Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non-Hydropower Renewable

Developing Water Supplies (WS)
Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System 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 (WP)
Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Climate Change and Variability

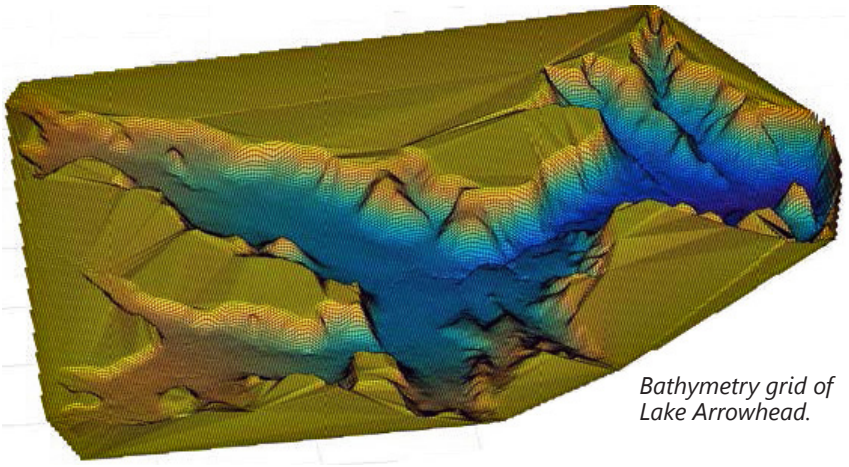
Front Cover: Electrodialysis membrane system at BGNDRF.
Back Cover: BGNDRF indoor test bays.

Developing Water Supplies Coordinator:
Yuliana Porras-Mendoza
yporrasmendoza@usbr.gov

Developing Water Supplies

FY21 Completed Projects

7100: Evaluation of approaches to determine mixing and assimilation of reuse effluent - Meghan Thiemann

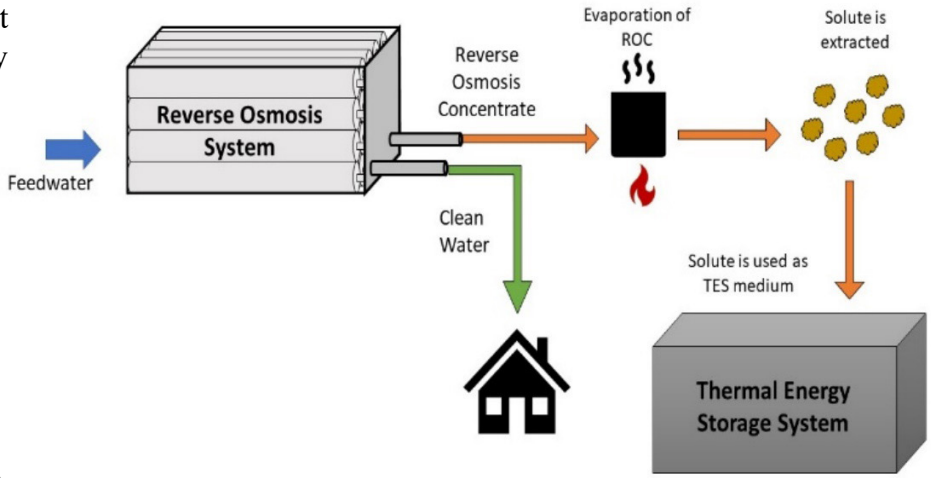


Bathymetry grid of Lake Arrowhead.

As reuse water becomes an ever-larger component of water resource planning, issues associated with measuring and modeling the mixing and dispersion of reuse water will become more prominent. Hydrodynamic modeling and tracer studies are required to evaluate and assess risks for indirect potable reuse (IPR) by surface water augmentation (SWA) projects, but technical approaches vary based on locality, reservoir configuration and available information, models used, and local and state regulations. This is increasingly important as drought continues in the western United States and more utilities pursue development of resilient local water supplies and augment drinking water sources with advanced treated recycled water. This project included a tracer case study and hydrodynamic modeling of Lake Arrowhead, which was used to develop a guidance manual. The guidance manual provides recommendations to help utilities plan and conduct hydrodynamic modeling and tracer studies for their reservoirs as part of the SWA-IPR evaluation process. It also includes information from other publicly available SWA-IPR tracer and hydrodynamic modeling studies, such as those completed for the City of San Diego's San Vicente and Miramar reservoirs.

8133: An ultra-low-cost thermal energy storage system using reverse osmosis concentrate - Saied Delagah

The reject of the reverse osmosis water treatment process (aka brine, concentrate) is a mixture of salts that are dissolved in high salinity water. The reverse osmosis concentrate (ROC) is classified as an industrial waste by the U.S. Environmental Protection Agency and can face regulatory limitations on disposal. State-of-the-art of ROC disposal includes deep-well injection, surface discharge to rivers, discharge to the ocean, and evaporation ponds. In this study, the feasibility of using ROC as a low-cost Thermal Energy Storage (TES) medium is explored by a techno-economic analysis. The normalized cost of TES (cost per unit volume of stored thermal energy) is estimated through a series of cost analyses and is compared to the cost targets of the U.S. Department of Energy for low-cost thermal energy storage. 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 (kWh) depending on ROC processing methods. Next steps for this research include utilizing ROC-based indirect two-tank TES systems. In addition, the effect of using the ROC-based TES on the levelized cost of energy of solar-thermal power should be investigated further.



Development of a reverse osmosis concentrate thermal energy storage system.

Atriplex plants at the Brackish Groundwater National Desalination Research Facility.

1780: Determining impacts of long term use of RO concentrate on atriplex species, soil characteristics and microbial habitats - Scott O'Meara

Drought in the Western U.S. has increased interest in non-traditional irrigation sources such as brackish groundwater. While reverse osmosis (RO) can be used to reduce salinity of brackish groundwater, RO concentrate management must be addressed. Concentrate may be used to irrigate halophytic native plants such as Atriplex canescens and A. lentiformis, two halophytic native plants which can then be cultivated for livestock feed. The objectives of the study were to (1) determine the impacts of ions from brackish water irrigation on the chemical properties of the soil, (2) evaluate how the addition of saline concentrate might impact the microbial community in the soil, and (3) assess halophyte germination, growth and vigor under highly saline irrigation. A salinity of up to 4,200 mg/L was permitted for irrigation at the Brackish Groundwater National Desalination Research Facility (BGNDRF). Since saline concentrate will have a greater electrical conductivity than what was permitted, a greenhouse experiment was set up to be able to double the salinity. The pattern of electrical conductivity did follow the expected bell shape of the wetting front. Germination of the plants was significant by species, soil type, and salinity in the water. Higher salinities of irrigation water did not affect plant height or soil plant analysis development. The testing was conducted for three years, and additional studies are needed to determine if nutrient content of the plants are affected at high salinity levels. The metabolism of the soil community should be further researched to ensure important soil processes are not disturbed by the ion accumulation. If long-term effects of high-saline irrigation water on soil chemistry and microbial communities are proven to be negligible, irrigation of Atriplex with concentrate could be possibility but more work is needed to obtain long-term data.

FY22 New Projects

22006: Integrating water reuse and stormwater management into constructed wetland designs to enhance water supply and multi-purpose project benefits - Nathan Kuhnert

This research aims to answer several important research questions about the implementation of wetlands to accomplish engineering goals to meet water supply needs while simultaneously achieving multiple ancillary benefits. The team is seeking to assess whether constructed wetlands can be optimized to achieve indirect potable reuse water supply augmentation benefits while also being able to treat stormwater. A hypothesis that constructed wetlands can reduce and potentially replace advanced water treatment processes for this purpose is another major question that this study will seek to answer.

22068: Investigating the potential of cloud seeding to enhance precipitation in the East River Basin of Colorado - Lindsay Bearup

The expected outcomes of this work are a model-based quantification of cloud seeding opportunities across the Colorado Headwaters region and the potential impacts of cloud seeding on precipitation in the East River Basin, as well as a demonstration of a model-based framework designed to be transferable to study the local impacts of cloud seeding in other river basins.

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FY22 New Projects -continued

22078: Increasing the effectiveness and simplicity of potable water reuse with a multi-benefit ferrate treatment process - Catherine Hoffman

One of the keystone treatment processes currently considered for potable reuse systems is called ozone/biologically active filtration (BAF). In the BAF process, the water flows through a granular media filter populated with microorganisms that consume the organic matter, an undesirable and regulated component of the water. Ozone is the oxidant typically used to accomplish pre-oxidation for the BAF process. This step breaks down the organic matter remaining in the treated wastewater effluent to make it more easily biodegradable by the microorganisms in the BAF. The objective of this study is to replace the ozone with ferrate and assess its viability in comparison to ozone. If successful it could provide several savings in cost, operation, and treatment benefits.

22102: Long-Term Arid Region Reservoir Usability Evaluation due to Salinity Induced Degradation of Water Quality - Neal Gallagher

This research will provide a comprehensive characterization of the sources of water quality degradation in Lake Meredith with respect to salinity and provide an outlook for water quality conditions in the reservoir to support water supply planning for the region. The team will gather data and develop an empirical model to understand sources of salinity, and long-term reservoir water quality implications of current and historical reservoir inflow water quality.

FY22 Active Projects

ID	Final Year	Title	Lead
1769	2022	Research to identify how to improve existing desalination approaches to reduce primary energy use	Yuliana Porras Mendoza
1855	2022	Scaling resistant RO/NF membrane	Saied Delagah
1877	2022	Cost modeling of membrane desalination processes using Reclamation's WaTER model	Leah Flint
7134	2022	Analysis of Microbial Communities in Constructed Wetlands	Yale Passamaneck
7138	2022	Oxnard Saline Demonstration Wetland	Catherine Hoffman
19093	2022	Pilot testing of renewable-energy powered desalination systems in the Navajo Nation for small and rural communities	John Rasmussen
19192	2022	Occurrence of Organic Micropollutants in the San Juan River in Northwest New Mexico and their Removal during Drinking Water Treatment	Miguel Arias-Paic
20008	2022	Navajo-Gallup Water Supply Project - San Juan Lateral Source Water Blending and Corrosion Studies	Caitlin Kodweis
20058	2022	Concentrate Minimization through Development of an innovative In-line Static Mixer	Saied Delagah
20083	2022	Evaluating Contaminates of Emerging Concern's Fate in Potable Reuse Membrane Treatment	Saied Delagah
20092	2022	Ion Exchange Pretreatment for Desalting Membrane Processes to Maximize Clean Water Production	Miguel Arias Paic
21011	2022	Investigating the use of green infrastructure to improve water quality and expand usable water supplies	Nathan Kuhnert
21026	2022	Cost and Performance Evaluation of Electrodialysis Reversal (EDR) Desalination of Brackish Agricultural Drainage Water and Groundwater	Luis Cruzado
22006	2024	"Integrating water reuse and stormwater management into constructed wetland designs to enhance water supply and multi-purpose project benefits	Nathan Kuhnert
22068	2024	Investigating the potential of cloud seeding to enhance precipitation in the East River Basin of Colorado	Lindsay Bearup
22078	2024	Increasing the effectiveness and simplicity of potable water reuse with a multi-benefit ferrate treatment process	Catherine Hoffman
22102	2024	Long-Term Arid Region Reservoir Usability Evaluation due to Salinity Induced Degradation of Water Quality	Neal Gallagher