# FY 2024-25
# Mineral Lease Fund Report

## Utah Water Research Laboratory

for

Office of the Legislative Fiscal Analyst
State Capitol Complex
House Building, Suite W310
Salt Lake City, UT 84114

by

Bethany T. Neilson, Director

Utah Water Research Laboratory
Utah State University
Logan, UT 84322-8200

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Utah Water Research Laboratory
UtahStateUniversity

## Foreword

Water is a precious and scarce resource, essential for life, agriculture, industry, economic development and healthy ecosystems. Yet around the world as well as here in Utah, water challenges are intensifying. Climate variability and extreme weather events, population growth, rising demands for food and energy, and the need to protect valuable environmental resources place unprecedented pressures on our water systems. Meeting these challenges requires research, innovation, and collaboration. The Utah Water Research Laboratory (UWRL) serves as a diverse center of excellence, advancing knowledge, developing practical solutions, informing policy and management decisions, and training tomorrow's water leaders. Through its support of the UWRL, Utah is investing in the interdisciplinary expertise needed to manage water resources effectively in the years ahead.

This report highlights the projects funded by State of Utah Mineral Lease funds (MLF) during fiscal year 2024–25 (FY 25). UWRL researchers are addressing some of Utah's most pressing water and environmetnal challenges, from improving water use measurement and monitoring to assessing water and air quality and identifying emerging threats such as cyanotoxins, microplastics, PFAS, and invasive species. UWRL researchers play a key role in the Great Salt Lake Strike Team, a partnership with the University of Utah and State agencies, focused on recommending policies and strategies to address historically low lake levels that threaten Utah's economy and environment. UWRL research also informs hydrology scenarios for Colorado River basin planning and adapts operations to accommodate low flows and storage. The Logan River Observatory provides insights into watershed processes that shape runoff across western watersheds, including the Great Salt Lake basin. These and other ongoing research endeavors reflect UWRL commitment to supporting sustainable economic and environmental development across the state.

To support our mission, the UWRL receives 2¼% of deposits made to the Mineral Lease (ML) Account, "to be used for activities… having as a purpose the development… of water resources in the State of Utah." With this basic support, the UWRL is able to leverage significant funding from other public and private sources to enhance the scope and impact of our projects. In FY 25 alone, over $6.9 million in external funding expanded opportunities to address state water issues, expand collaborations and partnerships, and contribute to economic growth. As one of the nation's first and most respected university-based water research facilities, the UWRL remains committed to providing the data, tools, and solutions to safeguard Utah's water future.

In compliance with House Bill 103 passed during the 1993 Legislature General Session, this report details the UWRL's FY 25 MLF-supported research, training, and service projects, along with an accounting of the ML funds for FY 25, budgeted expenditures for FY 26, and planned expenditures for FY 27. The projects are organized into broad areas of activity that address a spectrum of high-priority water resources needs and issues in the state. Each project includes a statement of the project purpose, the specific benefits to the citizens of Utah, and areas benefited.

As the UWRL looks forward to another year of service to Utah, we are proud to acknowledge the dedicated people, past and present, who have contributed to the UWRL's achievements and its outstanding reputation for water research and education. We are pleased to submit this report to the Legislature through the Office of the Legislative Fiscal Analyst, and we welcome any comments or questions.

Bethany Neilson, UWRL Director

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Section 1

# Introduction

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## History of the Utah Water Research Laboratory

The Utah legislature authorized the establishment of the UWRL at Utah State University in 1959 as an important component of the State of Utah's commitment to water resources research, assuring cutting-edge solutions to the State's water problems. Today, the UWRL continues its service as one of the first and most respected university-based facilities performing research, training the next generation of leaders, and providing practical solutions to the most pressing problems facing Utah, and indeed our nation and the world.

Water is often referred to as the lifeblood of Utah. As we work toward a sustainable water future, it is essential to recognize how important water resources have always been to the prosperity and quality of life of Utah's citizens. This was evident in the vision of our state leaders when USU was established as the State's Land Grant University in 1888, and water, irrigation science and the engineering of water works were of foremost importance as curricular and research components. During the following several decades, water resources education and research were mainly carried out by faculty and students in the relevant academic departments and by the Engineering and Ag Experiment stations. In 1957, George Dewey Clyde, former Dean of Engineering at USU, was elected the 10th Governor of Utah, serving two terms until 1965. During his tenure, he strongly supported research on best practices for using and protecting Utah's precious water resources, including funding and breaking ground for construction of the Utah Water Research Laboratory in 1963. The following year, 1964, Congress approved the Water Resources Research Act that created a water resources research institute in every state. The Utah institute, known as the Utah Center for Water Resources Research (UCWRR), was established at the UWRL as part of a national network of water resources research institutes.

With USU already acknowledged as a world leader in water engineering, the opening of the new Utah Water Research Laboratory building in 1965 provided the State and the university with a world-class research facility to support the work of faculty, students, and water professionals from across the state and around the world. The Laboratory's facilities include one of the largest and most well-equipped hydraulics laboratories in the United States and a unique erosion testing facility with a large rainfall simulator. In 1981, an extensive remodeling project added an environmental quality laboratory wing, significantly upgrading facilities and equipment needed for water quality testing and research. In 2009, the UWRL completed a hydraulics modeling and testing laboratory in a new building on the north side of Logan River to support expanded hydraulics research activities associated with releases from dams (and related hydraulic phenomena, such as venting) and the design of hydraulic structures in Utah, such as the irrigation lift stations on Utah Lake. Today, the UWRL has a total of more than 113,000 square feet of state-of-the-art laboratory, computer, and office space. This continued growth and productivity over the past 60 years has allowed the UWRL to have a significant state, national, and worldwide impact in water resources research and applications.

## Productivity

UWRL faculty leverage their expertise by collaborating with colleagues from various USU departments as well as faculty from other institutions and professionals from the private sector and government agencies in Utah and elsewhere. Several of our faculty members, including a former UWRL Director, have been awarded the Utah Governor's Medal for Science and Technology. In addition, our faculty have received many national honors and recognitions and have served on numerous state, national, and international engineering and science panels and committees.

In addition to our research role, the UWRL is involved in university graduate and undergraduate education through the inclusion of students in hands-on projects, as part-time employees, and as research assistants. Graduate student involvement in research leading to masters and doctoral degrees prepares them to enter the workforce as trained water professionals. Undergraduate students involved in UWRL research projects gain skills and experience for their future careers.

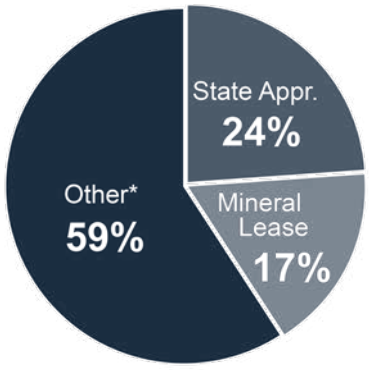
As students graduate and are hired by Utah employers, they carry the knowledge learned at the UWRL into their professional appointments and careers, often serving Utah's water and environmental agencies and organizations. Technology and information are also transferred through collaboration and partnerships with engineers, scientists, and managers of the Utah departments of Agriculture and Food, Environmental Quality, Natural Resources, and Transportation, the thirteen Utah local health departments, and several large water user districts and associations.

The table below summarizes the productivity of the Lab in terms of research, education, outreach, and training. The total research funding through the UWRL in FY 25 of over $13.3 million makes it one of the largest university-based water research institutes in the nation.

| UWRL Financial/Academic Summary FY 24 | |
|---|---|
| Number of Active Projects | 219 |
| Total Expenditures | $13,308,850 |
| Scholarly Publications in Peer-Reviewed Journals | 62 |
| Scholarly Presentations at Professional Conferences | 80 |
| **Outreach Activities FY 24** | |
| Short Courses and Field Training | 39 |
| **UWRL Student Support FY 24** | |
| Graduate Students Supported | 70 |
| Undergraduate Students Supported | 67 |
| **Degrees Granted FY 24** | |
| Doctor of Philosophy (PhD) | 4 |
| Master of Science (MS) | 14 |
| Master of Engineering (ME) | 2 |

## Research Program Structure and Organization

The research programs of the Utah Water Research Laboratory (UWRL) directly address current and future water resources needs of the state, and most are relevant to national and worldwide issues as well. The State of Utah provides state-appropriated funds (SAF) and Mineral Lease funds (MLF) for research support at the UWRL. These funds directly target problems facing the State of Utah. In FY 25, MLF funding accounted for 17% of total UWRL expenditures. With additional funding from federal, private, and other state sources (as shown in the pie chart), the total UWRL expenditures for FY 25 were over $13.3 million.




**UWRL Expenditures FY 25**
*Other sources include: other state awards; local, federal, and private sources

The MLF projects at the UWRL are organized into four major research program areas:

- Water Resources
- Environmental
- Hydraulics
- Education, Outreach, and Technology Transfer

The individual projects are under the direction of UWRL researchers and involve collaboration with other departments at Utah State University and other universities including:

### Utah State University:

- Applied Economics (College of Agriculture & Natural Resources)
- Aviation Technology (College of Agriculture & Natural Resources)
- Biological Engineering (College of Engineering)
- Biology (College of Arts & Sciences)
- Chemistry and Biochemistry (College of Arts & Sciences)
- Civil and Environmental Engineering (College of Engineering)
- Computer Science (College of Arts & Sciences)
- Electrical and Computer Engineering (College of Engineering)
- Environment and Society (College of College of Agriculture & Natural Resources)
- Extension (College of College of Agriculture & Natural Resources)
- Geosciences (College of Arts & Sciences)
- Horticulture and Agronomy Janet Quinney Lawson Institute for Land, Water and Air
- Mechanical and Aerospace Engineering (College of Engineering)
- Plants Soils and Climate (College of College of Agriculture & Natural Resources)
- Space Dynamics Laboratory
- Utah Agricultural Experiment Station
- Watershed Sciences (College of Natural Resources)
- Wildland Resources (College of College of Agriculture & Natural Resources)

### Other Universities

- Aachen University, Germany
- Arizona State University
- Boise State University (Idaho)
- Brigham Young University
- Imperial College, London
- Michigan State University
- Norwegian University of Science and Technology
- Ohio State University
- Shandong University of Technology, Zibo China
- University of Alabama
- University of California
- University of Oklahoma
- University of Liege, Belgium
- University of South Carolina
- University of Utah
- University of Vermont
- University of Washington in St. Louis
- University of Zurich

The project summaries in this report demonstrate the diverse overall UWRL research, education, and training activities related to Mineral Lease funding. However, the totality of the UWRL's programs, taking into account state funds and our external contracts and grants, is even broader. We continue to be involved in advancing hydrologic information systems for data management in support of transparent and reproducible research. Our hydraulics, erosion control, and environmental quality laboratories are involved with a range of experimental work and service projects that utilize our unique facilities. Computer models, remote sensing, geographic information systems, digital terrain models, expert systems, and many other modern technologies are developed and applied in the research projects and are used to develop tools for use by water and environmental managers and professionals in Utah. The UWRL also prepares guidance materials for use by practitioners. Some projects are relatively small in scope while others involve interdisciplinary teams and collaboration with multiple agencies and with the private sector. Most of our projects also include an outreach component, engaging our staff in public and professional service, technology and information transfer, and public education.

In one example of addressing state water needs, UWRL faculty led an ongoing initiative on water measurement and informatics needs for the Utah Division of Water Rights (DWRi). The recent report "Evaluating Surface Water Movement and Measurement near Great Salt Lake" facilitates a better understanding of current surface water hydrology and informs future measurement infrastructure needs throughout the Great Salt Lake's ecoststem. This information is needed to support diverse objectives, including managing lake level, habitat, and salinity, while ensuring deliver of water dedicated to Great Salt Lake. As an example of national collaborative work, UWRL faculty are also part of the National Oceanic and Atmospheric Administration (NOAA) Cooperative Institute for Research to Operations in Hydrology (CIROH), a large national consortium committed to translating research on the forecasting of floods, droughts, and water quality into actionable operational products supporting the use of water predictions in decision making. Twenty projects, with 19 to UWRL faculty, have so far been funded through this cooperative institute, for a funding total of over $6 million.

## Management of USGS 104 Program for State Benefit

The Water Resources Research Act of 1964 established a national network of Water Resources Research Institutes (WRRIs) in the United States and an allotment program, Section 104, providing funds for the institutes. In Utah, this program is administered by the Utah Center for Water Resources Research

(UCWRR), located at the Utah Water Research Laboratory. UCWRR oversees two U.S. Geological Survey (USGS)-funded programs that benefit the state: the 104b Annual Base Grant and the 104g Competitive Grants.

The 104b Annual Base Grant provides $146,895 in federal funds, which must be matched 1:1 with non-federal funds, much of which comes from Mineral Lease (ML) funds. In FY25, the USGS 104b base grant, in combination with ML funds, directly benefited the State of Utah in the following areas:

1. Identifying "second-dip" La Niña events—two consecutive La Niña years—as a strong indicators of severe drought. These events consistently lead to warmer, drier winters, earlier snowmelt, and reduced streamflow, followed by summer drought. With climate warming amplifying these impacts, improved forecasting is critical, particularly in Utah and the Intermountain West, which face increasing drought risks that threaten agriculture and water supplies. The project shared findings with water managers and regional agencies and will provide updated tools and resources through the Utah Climate Center to support proactive water planning.
2. Examining microbial and geochemical processes that influence nutrient cycling, carbonate precipitation, and color changes in the water at Bear Lake in Utah and Idaho. Water and sediment samples from multiple sites and depths were analyzed for nutrients, organic carbon, alkalinity, and microbial DNA to identify harmful algal bloom species and pathogens. Early results show seasonal nutrient declines from July to September likely from reduced agricultural returns in dry conditions, but also localized nutrient level hotspots from human impact, as well as shifts in carbonate chemistry. Findings will help pinpoint high-risk areas and guide management strategies to protect Bear Lake's ecological integrity and recreational value.
3. Quantifying the Great Salt Lake river basin's consumption-based water footprint, including virtual water trade embedded in agricultural and industrial products, in the face of severe water deficits as demand outpaces supply, driving unsustainable declines in lake volume. Using data from 2000–2024, the study integrates river flows, water depletion, and virtual water imports and exports to build an accounting framework and scenario models. These models illustrate trade-offs among population growth, water use, and lake levels, highlighting how virtual water strategies could help address Utah's structural water deficit. Results will support informed policy and long-term water management for the GSL watershed.
4. Improving groundwater representation in water management models for the Great Salt Lake basin, focusing on Cache Valley in the Bear River watershed, which is the lake's largest tributary. The PI is developing an integrated model combining surface water and groundwater systems, incorporating water use and future climate scenarios. This approach provides a more complete picture of available resources, supports long-term planning in the face of reduced streamflows to the lake and could help policymakers adapt to climate variability, protect water supplies, and mitigate risks to Great Salt Lake and surrounding communities.

Utah institutions of higher education are also eligible to propose, through the UCWRR, to the nationwide competitive USGS 104g program. A USU team led by Wei Zhang in the department of Plants, Soils and Climate, received a $249,536 grant from this program, administered through the UCWRR, for a three-year project ending 12/31/26 titled, "Quantification and Projection of the CONUS Water Budget using a Hierarchical Modeling System." This project is improving water budget quantification across the Contiguous United States using a hierarchical modeling system developed through collaboration between Utah State University and USGS. The study evaluates water budget components and uncertainties caused by hydroclimate variability, providing insights into future changes in water availability. These results will inform

water managers and policymakers, supporting better resource planning and adaptation strategies under changing climate conditions.

## Relevancy and Benefits of the Mineral Lease Fund

Utah is one of the driest states in the nation. With an average annual precipitation of only 13 inches, mostly in the form of winter snowfall, Utah must meet economic, social, and environmental water needs through hot, dry summers. As state leaders have emphasized for decades, water is the essential resource that sustains Utah's prosperity and quality of life. The State's investment through ML funds is vital to developing technologies and methods to protect, manage, and use limited water resources wisely for the benefit of all Utah citizens.

## Research Program Planning and Project Selection

The goal of the UWRL research programs is to identify and develop projects that will help to ensure a sustainable water and environmental future for Utah's citizens and economy. This requires a broad and deep understanding of surface and groundwater resources in the context of climate and environmental variability, the complex physical and biological processes that affect water quantity and quality, and the dynamic interaction of human activity in land and water use in our arid environment.

In order to focus research on problems and needs that are both relevant and current, UWRL engineers and scientists work closely with state and local government agencies and are actively involved with and serve on many state and local organizations, committees, and boards, as well as a wide range of local, state, national and international professional organizations. These associations give UWRL researchers influence in and a greater understanding of critical water-related research efforts around the nation and the world that are applicable to Utah. Participation in various professional water and environmental organizations helps to bring recognition and external project funding to the state and provides exposure to worldwide research and best practices.

The UWRL director, associate directors and faculty members meet regularly with state and federal agency managers and personnel from local water organizations to discuss research needs and identify opportunities for the UWRL to respond to these needs. The UWRL has worked with many State agencies and other local, state, regional, and national organizations over the past few years. Below are a few key examples:

### State of Utah Agencies

- **Department of Agriculture and Food**
- **Department of Environmental Quality,** Harmful Algal Blooms Team, Division of Air Quality, Division of Water Quality, Long-Term Storm Water Management Work Group, Division of Drinking Water, Onsite Wastewater Recertification Revision Working Group, Wastewater/Water Treatment Operator's Certification Commissions
- **Department of Natural Resources,** Division of Water Resources, Division of Water Rights, Division of Forestry, Fire, and State Lands, Division of Wildlife Resources
- **Department of Transportation**, Aeronautics

## Local Agencies and Organizations

- Cache Clean Air Consortium
- Cache County - Solid Waste Management Advisory Board, Cache County State Implementation Plan Team
- Cache Water District
- Folsom Corridor City Creek Daylighting Project
- Great Salt Lake Basin Integrated Plan Steering Committee
- Great Salt Lake Strike Team
- Jordan River TMDL Advisory Committee
- Logan City (Air Quality, Renewable Energy and Sustainability Advisory, and Water & Wastewater/Sewer boards)
- Logan River Task Force
- Mountain West Unmanned Systems Alliance

## Other State, National, and International Agencies and Organizations

- California Water Quality Monitoring Council, Environmental Flows Strategic Workgroup
- National Dam Safety Review Board
- NOAA Cooperative Institute for Research to Operations in Hydrology
- Texas Integrated Flood Framework Technical Advisory Team
- United States Geological Survey, Water Mission Area and Utah Water Science Center

## Professional Organizations

- Accreditation Board for Engineering and Technology (ABET)
- Air and Waste Management Association
- American Geophysical Union (AGU)
  American Institute for Medical and Biomedical Engineering
- American Society of Agricultural and Biological Engineering (ASABE)
- American Society of Civil Engineers (ASCE)
- American Society for Testing and Materials
  American Water Resources Association (AWRA), Utah and Intermountain West chapters
- American Water Works Association, Customer Metering Practices, Water Loss and Water Meter Standards committees
- Association for the Advancement of Artificial Intelligence, AI for Agriculture and Food Systems
- Consortium of Institutes for Decentralized Wastewater Treatment
- Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI)
- Institute of Biological Engineering, Steering Council
- International Association for Hydro-environment Engineering and Research
- Mountain West Association for Uncrewed Systems International
- National Institutes for Water Resources (NIWR)
- National Inventory of Low-Head Dams, Joint Task Committee
- Northeast Biotechnology Center and Consortium
- Soil Science Society of Utah
- Sustainable Nanotechnology Organization
- United States Society on Dams, Hydraulics of Dams, Spillways, Valve and Gate committees
- Utah Onsite Wastewater Association
- Water Environment Association of Utah - Residual and Biosolids committee
- Water Research Foundation

## Mineral Lease Fund Expenditures

The table below summarizes the actual, budgeted, and planned expenditures of ML funds allocated to the UWRL for FY 2025 through FY 2027 for research projects in the five major Program Areas.

| Mineral Lease Fund Expenditures: Research Program Area | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|
| Administration | $302,909 | $311,996 | $321,356 |
| Environmental | $726,060 | $538,999 | $537,564 |
| Hydraulics | $216,366 | $159,029 | $155,499 |
| Education, Outreach and Technology Transfer | $167,666 | $170,528 | $167,340 |
| Water Resources | $840,658 | $631,648 | $630,441 |
| **TOTALS** | **$2,253,659** | **$1,812,200** | **$1,812,200** |

Expenditures differ from budgeted amounts due to fluctuations in the actual amount of ML funds received and due to the time required to properly plan and spend funds received. Funds received are, as noted above, 2.25% of deposits made to the Utah ML account. Expenditures last year exceeded the budgeted amount from last year due to fluctuations in actual state deposits from year to year. Additional funds were invested as reported herein. The budgeted $1,812,000 for FY 26 and FY 27 reflect the MLF amount budgeted for the UWRL in the Utah State Legislature higher education base budget. Recognizing that the state deposits received will differ from this budgeted amount, the project budget planning for each program area may include amounts for undesignated research projects, which will only be initiated if actual ML deposits are sufficient.

A detailed breakdown of the expenditures for each project within these Research Program Areas is presented in the Research Project Summaries section of this report.

## Benefits to the State of Utah

ML funding is often used as leverage to acquire additional support from other sources, which allows us to perform even more research in the State. Every one of Utah's counties have benefited from one or more of the UWRL projects conducted during the past year.

The following gives a general overview of some of the recent and current benefits produced by ML funded projects by Program Research Area. The Research Project Summaries section of the report describes specific State benefits from each research project.

### Water Resources

This diverse program has strengths in both the theoretical and the applied aspects of hydrology and water resources. Hydrologic research includes hydrology-related data collection and modeling that focuses on rainfall and evapotranspiration processes, snow hydrology, floods, droughts, terminal lakes, erosion and sediment transport, surface water quality and temperature, groundwater/surface water connectivity, and groundwater.


Research areas in water resources management include water conservation, river basin planning, reservoir operating policies, habitat monitoring and restoration, urban water management, and land use change. This program area also addresses various institutional and legal aspects of water, such as water rights transfers, water banking, distributed water demand and supply modeling, and cost allocation and user fee determination. To be effective, water and environmental managers must have access to relevant and sometimes real-time data to support decision-making. The UWRL is a leader in the development of advanced monitoring and sensing systems for collecting environmental and water-related data along with cyberinfrastructure for managing the resulting data and interfacing with user-driven decision support systems. Another significant area of research focuses on remote sensing technology and data to improve water, agricultural, and environmental resources management. This includes the UWRL's development of a unique unmanned aerial remote sensing system (AggieAir™). These small aircraft are programmed to fly over research sites, such as farm fields, wetlands, rivers, and riparian environments collecting multispectral high-resolution imagery. The data are then analyzed using innovative image processing techniques and used to enable more efficient irrigation of crops, identify and manage invasive vegetation, and improve water and environmental management.

## Environmental

This program emphasizes an integrated engineering and science approach to managing and improving the quality of our land, water, and air resources. The program includes engineering approaches for the treatment, reclamation, recycling, and reuse of municipal and industrial wastewater and biosolids and the sustainable management of stormwater for its capture and reuse using green infrastructure approaches. The fate of emerging contaminants in water bodies, wastewater, biosolids, soils and crops, and the risks that these emerging contaminants pose to human health and the environment are also topics of active research. Faculty with expertise in nano particles, microplastics, and cyanotoxins are addressing topics of emerging interest in environmental water quality, treatment, and use. In addition to the research on water and land processes, this area also includes work on contaminant uptake into plants and indoor and outdoor air quality problems in the state, including $PM_{2.5}$, ozone, and ammonia associated with the Great Salt Lake, winter inversions, animal production, and vehicle emissions. This research encompasses diverse areas of specialization, including environmental engineering, environmental chemistry, environmental microbiology, chemical engineering, soil science, photochemistry, aerosol chemistry, plant science, and modeling.

## Hydraulics

The UWRL uses numerical and scaled physical models to evaluate and optimize hydraulic structure design and performance. Hydraulic structure modeling projects include, but are not limited to, dams, reservoirs, spillways, canals, pipelines, tanks, power stations, pump stations, tunnels, and diversion structures. The hydraulics group also performs calibrations and tests on valves, pumps, flow meters and other hydraulic

equipment to assist worldwide manufacturers and users. Research in the hydraulics area includes many other topics such as sediment dynamics in river channels to quantify how rivers respond in form and quality and changing sediment inputs associated with wildfires and other disturbances.

### Education, Outreach, and Technology Transfer

The UWRL mission also involves outreach activities related to public service, information dissemination, technology transfer, and short courses. These activities provide benefit to Utah's state and local agencies, elected officials, citizens, and the MLF, have substantial education, outreach, and training components. Resources provided by ML money are sometimes used to enhance the development of technologies, training modules, or educational materials and are often used to provide technical support to Utah's state and local agencies on water-related issues. For example, the Utah On-Site Wastewater Treatment Training Program at the UWRL offers on-site wastewater training in support of the State of Utah certification program for on-site wastewater treatment professionals. Additional information can be found at https://uwrl.usu.edu/research/owt. Undergraduate and graduate students also participate in projects that involve hands-on, real-world activities.

## Information Dissemination

UWRL information dissemination activities include the publication of research results in professional journals, distribution of information on various UWRL and UCWRR web pages and newsletters, presentations before various professional societies at organization and association meetings both in the state and around the country, and sponsorship and participation in numerous short courses and training programs.

The UWRL web page (http://uwrl.usu.edu) provides general information about the UWRL and its personnel and, from time-to-time, a feature article on different research projects, faculty, and students at the UWRL.

## Professional Service

UWRL Faculty are active professionally and serve on state and local advisory panels to provide technical expertise, input, and review of water-related issues. Faculty also participate in and organize conferences, sessions, and workshops with professional societies. Many serve as journal peer reviewers and editors and assist funding agencies with proposal reviews. UWRL personnel are frequently invited to provide technical and informational presentations before state and national professional groups. Through this work they serve the profession and remain current on emerging research. The following represent a few key UWRL faculty service activities:

| Utah Boards/Committees | Other State/Local Boards/Committees |
|---|---|
| Utah Department of Environmental Quality<br>– Harmful Algal Blooms Team<br>– Utah Air Quality Board<br>– Utah Drinking Water Board<br>– Wastewater Operator certification Council<br>Utah Division of Water Resources, Utah Agricultural Water Optimization Task Force (UDWR)<br>Great Salt Lake Basin Integrated Plan Steering Committee<br>Great Salt Lake Strike Team | Cache County Solid Waste Advisory Board<br>Cache County Implementation Plan Team<br>Crocket Avenue Project Technical Advisory Board<br>Logan City Air Quality Taskforce<br>Logan City Renewable Energy and Conservation Advisory Board, Air Quality Task Force<br>Logan City Water & Wastewater Board<br>Logan River Task Force<br>Logan River Water Users<br>Water Environment Association of Utah – Biosolids Committee |
| **Editorial Boards for Professional Journals** | **Professional Leadership and Service** |
| Environmental Modelling & Software Journal, editorial board<br>Frontiers in Control Engineering, editor<br>Hydrological Processes, associate editor<br>International Conference for Unmanned Aircraft Systems, associate editor<br>Journal of the American Water Resources Association<br>Journal of Coastal and Hydraulic Structures, editor<br>Journal of Biological Engineering, editorial board<br>Journal of Bioremediation and Biodegradation, editorial board<br>Journal of Hydraulic Engineering, associat editor<br>Journal Sustainability Speciial Issue, editor<br>Journal of Water Resources Planning and Management, ASCE, associate and reproducibility editor | American Geophysical Union Committees<br>American Society of Agricultural and Biological Engineers Committees<br>American Society of Civil Engineering Committees<br>Association for the Advancement of Artificial Intelligence<br>Chinese-American Professors in Environmental Engineering and Science<br>European Working Group on Overflowing and Overtopping Erosion<br>International Association for Hydro-Environment Engineering and Research<br>Mountain West Association for Uncrewed Systems International<br>National Inventory of Low-Head Dams<br>North American Plant Phenotyping Network<br>United States Society on Dams Committees |

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Section 2

# Administration, Advisory Support and Special Equipment

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## ACTUAL, BUDGETED, AND PLANNED EXPENDITURES OF MINERAL LEASE FUNDS

| ADMINISTRATION: Area | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|
| Administration of the MLF Program | $38,863 | $40,029 | $41,230 |
| Communications and Outreach | $71,977 | $74,136 | $76,360 |
| Business Services | $192,069 | $197,831 | $203,766 |
| **TOTALS** | **$302,909** | **$311,996** | **$321,356** |

### Administration and Advisory Support and Special Equipment

The Administrative Officers of the UWRL are responsible for managing the facilities and budget of the lab and overseeing the diverse projects conducted by faculty and their students. The director and associate directors of the UWRL also work to maintain liaison with water planning and management officials across the state. Frequently, faculty from the UWRL are invited to serve on committees or provide technical or advisory support on water problems by various state or local agencies and, to the extent that it lies within the mission of the UWRL to provide such input, ML funds are sometimes used to cover expenses required to support these activities. Additionally, when research needs arise that require specialized equipment that cannot be made available through other means, MLF resources are sometimes used to acquire these equipment items critical for Utah-based research. Any such investments are detailed in the respective reports.

### Administration of the MLF Program

MLF money spent on administration at the UWRL provides some salary support for the UWRL director and associate directors and supports the administration of the USGS 104(b) program funding that comes to the state. FY24 administrative costs represented approximately 1.7% of total UWRL MLF expenditures.

### Communication and Outreach

The UWRL Communications and Outreach Office provides support for outreach activities (such as the production of presentations, maintenance of the UWRL and UCWRR web pages, etc.). MLF expenditures in FY24 on these support activities accounted for 3.2% of total MLF funding.

### Business Services

Overall, annual research expenditures for the UWRL have generally fluctuated between $8 and $13 million, and at any point in time, around 200 active research contracts are administered at the UWRL. These projects require significant support from the UWRL Business Services Office in the form of accounting and financial oversight. MLF expenditures in FY25 on these support activities accounted for 8.5% of total MLF funding.

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Section 3

# Project Summaries

## Research Project Summary Categories

This section of the report provides a summary of each project and its benefits to the state and areas benefited. The projects are organized into the previously noted program areas as follows:

- Water Resources
- Environmental
- Hydraulics
- Education, Outreach and Technology Transfer

# Water Resources

## Actual, Budgeted and Planned Expenditures of Mineral Lease Funds

| Water Resources: PI | Project Name | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|---|
| Rosenberg, D. | Adapting to Low Colorado River Flows and Storage | $7,516 | $7,741 | $7,973 |
| Young, S. | Advancing Camera-Based Monitoring for Operational Hydrologic Applications | $38,550 | --- | --- |
| Shuai, P. | Advancing the Representation of Groundwater in a Water Management System Model for the Bear River Watershed | $50,145 | $51,649 | $53,198 |
| Hotaling, S | Clarifying the Potential of Utah's Mountain Rock Glaciers to Buffer Streamflows and Support Biodiversity as Statewide Snowpack Declines | --- | --- | --- |
| Coopmans, C. | Development of Inexpensive UAS for Sensing Land Surface Hydro/Multispectral UAS Collaborative Remote Sensing System for Irrigation Water Management and Ecological Assessment | $34,736 | $35,778 | $36,851 |
| Young, S. | Drone Meteorology: Developing Accurate, Mobile Environmental Sensors to Accelerate Information Gain from Remote Sensing Missions | $49,105 | --- | --- |
| Coopmans, C. | Enabling the Use of Short-Wave Infrared (SWIR) for Aerial Drone-Based Water Use Studies such as Canal Leakage | $34,736 | $35,778 | $36,851 |
| Lane, B. | Establishing a Functional Flows Framework for the Great Salt Lake Basin | $8,370 | $8,621 | $8,879 |
| Neilson, B. | Evaluating Surface Water Movement and Measurement near Great Salt Lake | $15,265 | --- | --- |
| Barker, B. | Forage Crop Water Use under Subsurface Drip (SDI) Irrigation in Utah | $3,045 | $3,136 | $3,230 |
| Kulmatiski, A. | Forecasting Vegetation Water Use for the Western United States | --- | --- | --- |
| Tarboton, D. | Great Salt Lake Basin Hydrologic Modeling | $86,104 | $88,687 | $91,347 |
| Horsburgh, J. | Hydroinformatics Advancements: Advancing Utah Division of Water Rights Operational Measurement Data Systems | $35,723 | $36,794 | $37,897 |
| Barker, B. | Improving Profitability of Small and Medium Sized Farms Through Economic Optimization of Wheel-Line Irrigation | $3,045 | $3,136 | $3,230 |
| Torres-Rua, A. | Improving the Economic and Environmental Sustainability of Tart Cherry Production through Precision Management | $16,742 | $17,244 | $17,761 |
| Neilson, B. | Interconnectedness of Little Bear River and Canals | $50,123 | $51,626 | $53,174 |

| WATER RESOURCES (CONTINUED): PI | Project Name | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|---|
| Flint, C. | Local Water Management Organizations in the Great Salt Lake Basin of Utah, USA | $32,862 | $33,847 | $34,862 |
| Neilson, B. | Logan River Observatory (LRO) | $135,751 | $139,823 | $144,017 |
| Horsburgh, J. | Modernized Standards and Tools for Sharing and Integrating Real-Time Hydrologic Observations Data | $69,505 | --- | --- |
| Barker, B. | Pelican Lake Subsurface Drip Irrigation Pilot Program | $3045 | $3,136 | $3,230 |
| Phillips, C. | Predicting Physical Water Quality | $70,206 | $72,312 | $74,481 |
| Lane, B. | Post-Fire Runoff and Sediment Hazards: Predicting, Mitigating, and Planning for Direct and Downstream Impacts to Transportation Infrastructure | $8,370 | $8,621 | $8,879 |
| Neilson, B. | Quantifying Dynamic River Gains and Losses Using Inverse Water Temperature Modeling | $28,475 | --- | --- |
| Wang, S | Quantifying the Rate of Future Decline of the Great Salt Lake's Water Level | $10,977 | --- | --- |
| Neilson, B. | Sevier River Gap Analysis | $28,475 | --- | --- |
| Barker, B. | Subsurface Drip Irrigation Evapotranspiration | $3,045 | $3,136 | $3,230 |
| Torres-Rua, A. | Water Use Assessment in Golf Courses and Urban Green Areas | $16,742 | --- | --- |
| | *Undesignated projects in program area* | | *$30,583* | *$11,351* |
| | **TOTALS** | **$840,658** | **$631,648** | **$630,441** |

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# Adapting to Low Colorado River Flows and Storage

## Research Summary:

As Colorado River flows and reservoir levels decline, we face a new era of aridity where we must live with what the river offers. This project explores ways to manage the river based on flow and storage rather than storage alone. More adaptive management can also increase program sustainability and water user autonomy to manage conflicting climate vulnerability while leveraging prior negotiations and decreasing conflicts.

### Why this research?

Drawdown of Colorado River reservoirs and an increasingly uncertain water supply put users and ecosystems at growing risk of water shortages. Communities that depend on the river face unequal vulnerability due to disparities in access to water infrastructure, information, and adaptive capacity. Meanwhile, system-level objectives, such as maintaining critical reservoir elevations, often conflict with the goals of water users, Tribal nations, and ecosystems to sustain reliable deliveries and protect cultural and ecological values. A pressing need exists to (1) identify management paradigms that allow users to more autonomously manage climate vulnerability and (2) better understand the motivations and decision processes that shape how different actors manage water-supply risk.

### Utah impact

Utah water conservancy districts, agricultural users, and state agencies can strengthen their ability to manage climate-related vulnerabilities without relying as heavily on basin-wide negotiations. At the same time, Lower Basin states and contractors can adopt similar approaches to reduce their own climate risks, easing pressure on Utah water managers and improving coordination across the basin both now and in the future. These approaches can also be adapted to other statewide water challenges such as efforts to shepherd water to the Great Salt Lake.

### What we did

We built online collaborative model environments using shared web spreadsheets in video conference sessions where basin partners immersed themselves in user roles within a basin-scale reservoir water balance model. Participants adapted their strategies to manage vulnerability in response to simulated water availability, others' decisions, and real-time discussion. We also developed an optimization model for Glen Canyon Dam to quantify win-lose tradeoffs between hydropeaking value and number of steady low flow days that allow downstream aquatic invertebrates to lay and hatch eggs and increase productivity. Results guided design of a financial instrument to provide an annual budget for ecosystem managers to

### Principal Investigator:

David E. Rosenberg (PI)

### Student Researchers:

Mozzam Rind (MS)
Anabelle Myers (BS)

### Research Collaborators:

Federal: Clayton Palmer, Brent Oseik (Western Area Power Admin.); Theodore Kennedy (USGS); Carly Jerla, Jim Prairie, Rebecca Smith, Sarah Baker (US Bureau of Reclamation)

University: Erik Porse, U. of California, Agricultural and Natural Resources: Lindsey Bruckerhoff, Ohio State U.

Federal/State/Local: Upper Colorado River Commission managers and experts, agencies of the Colorado River basin states, water districts, consulting firms, universities, a non-governmental organization, a foundation, a First Nation.

### Geographic Areas:

Study Areas: Portions of 10 Utah counties within the Colorado River basin; portions of Wyoming, Colorado, New Mexico, Arizona, California, Nevada, and northern Mexico

Areas Benefited: Municipal and agricultural water providers throughout Utah

### Contact:

**David E. Rosenberg**
435.797.8689
david.rosenberg@usu.edu

choose days of steady low releases and compensate hydropower producers for lost value and reduce hydropeaking-ecosystem conflict. Finally, we identified more adaptive Lake Powell releases operations responsive to inflow and evaporation and analyzed the Lake Mead water conservation programs to identify successes, challenges, and insights to increase sustainability and user autonomy post 2026.

## What we found

We identified a need to include reservoir inflow in decisions to release and conserve water; synthesized 10 lessons to improve model process, build trust, increase operational flexibility, and generate more actionable suggestions for reservoir management and identified sequences of extreme low natural flows above Lake Powell.

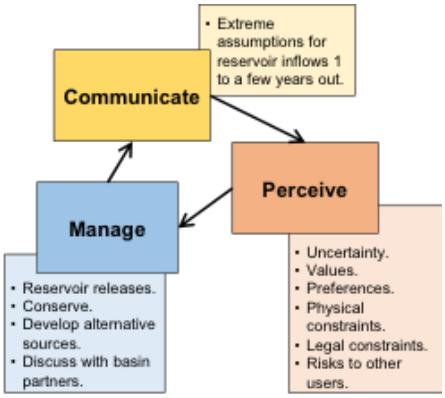



**Figure 1:** *Project risk communication, perception, and management where management decisions affect future risk.*

## Work plan FY 25–26

Future Lake Mead immersive model sessions will focus on: (1) understanding why people make decisions to manage their risk of water shortages, (2) improving NOAA Colorado River Basin Forecasting Center products, and (3) exploring ways to more effectively integrate forecasting products into immersive models. We will work with basin partners to more adaptively manage and reduce conflicting system, user, Tribal, and ecosystem vulnerabilities.

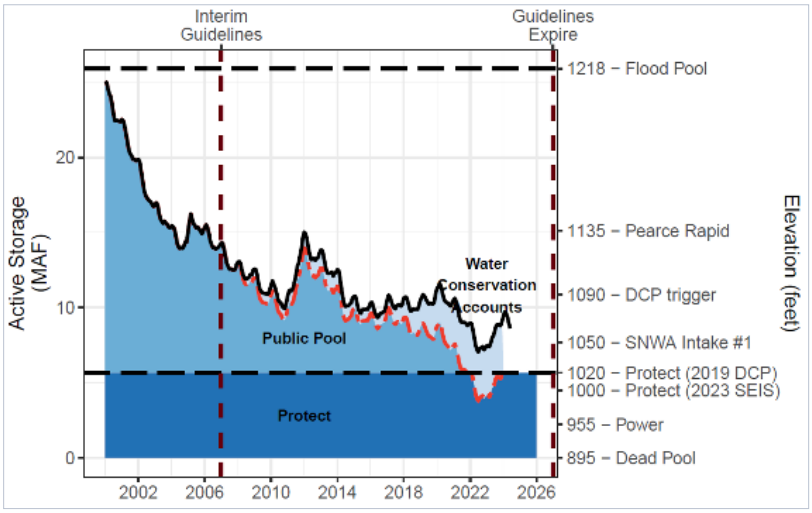



**Figure 2:** *Lake Mead Storage (solid black line), Water Conservation Account Balances (light blue fill), and anticipated lake volume absent the water conservation program (dashed red line). The conservation program kept Lake Mead level above elevation 1020 feet (5.9 million acre-feet) during low lake levels in 2022 and prevented larger releases from Glen Canyon Dam to balance storage in Lake Powell and Lake Mead.*

### Datasets:

D.E. Rosenberg, (2024), *Lake Mead Water Conservation Program Analysis.*" Utah State University. Logan, Utah. https://github.com/dzeke/ColoradoRiverCollaborate/tree/main/LakeMeadWaterConservationProgramAnalysis

### Publications:

- D.E. Rosenberg, A. Myers, R. Morovati, C. Stephenson, H. Akbar, and E. Porse. (2026). *Reasons We Have Hope for Consensus on Colorado River Management*. Journal of Water Resources Planning and Management, 152(1), 01825001. https://doi.org/10.1061/JWRMD5.WRENG-7194.
- Multiple related HydroShare Resources. https://www.hydroshare.org/user/1157/

### Media Coverage:

- Utah State Today article: https://www.usu.edu/today/story/new-collaborative-research-generates-lessons-for-more-adaptive-lake-management. July 30, 2024
- California Water Blog: *10* Lessons from a collaborative modeling approach to discussing more adaptive Lake Powell and Lake Mead operations. July 21, 2024

# Advancing Camera-Based Monitoring for Operational Hydrologic Applications


## Research Summary:

This project developed and field-tested an AI-enabled camera system that measures river water levels and discharge without in-stream sensors. Using deep learning segmentation, machine-learning stage prediction, and edge computing, the system provides low-cost, real-time hydrologic data. The results show strong accuracy and scalability for expanding Utah's water-monitoring capacity.


### Why this research?

Traditional streamflow monitoring systems rely on in-stream sensors that are costly to install, labor-intensive to maintain, and vulnerable to damage from debris, ice, and high-flow events. As Utah and the Intermountain West face more variable hydrologic conditions due to climate change, factors such as budget constraints and difficult site access contribute to large gaps in monitoring coverage.
This project addresses the central problem of how to expand high-resolution hydrologic monitoring at low cost and without relying on physical instruments inside the water. It explores whether fixed cameras paired with artificial intelligence can provide accurate, continuous, and autonomous measurements of river stage and discharge.

### Utah impact

The technology developed in this research benefits Utah by offering a scalable, low-cost method for expanding hydrologic observation networks across the state. Many creeks, tributaries, and headwater systems in Utah are ungauged due to high installation costs and the logistical difficulty of maintaining conventional sensors. Camera-based, non-contact monitoring removes the need for in-stream infrastructure, making it feasible to instrument hazardous, remote, or environmentally sensitive locations.

### What we did

Using imagery from fixed cameras at two active Utah field sites (Logan River/First Dam and Blacksmith Fork River) the project developed an operational pipeline for image-based hydrologic monitoring. First, deep learning image-segmentation models, including the Segment Anything Model (SAM), MobileSAM, and SegFormer, were used to automatically identify the water surface in each image. Next, machine-learning regression models translated segmentation-derived pixel features into estimates of water level (stage).


### Principal Investigators:

Sierra Young (PI)
Jeffery Horsburgh (Co-PI)

### Student:

Razin Bin Issa (MS)

### Research Collaborator:

Erfan Goharian (Co-PI, University of South Carolina)



### Funding Source:

United States Geological Survey (USGS)


### Geographic Areas:

Study Areas: Logan and Blacksmith Fork rivers in Utah

Areas Benefited: The technology developed as part of this project would have the potential to impact hydrologic streamflow monitoring across the state (focus on rivers)


### Contacts:

**Sierra Young**
435.797.1519
sierra.young@usu.edu

**Jeffery Horsburgh**
435.797.2946
jeff.horsburgh@usu.edu

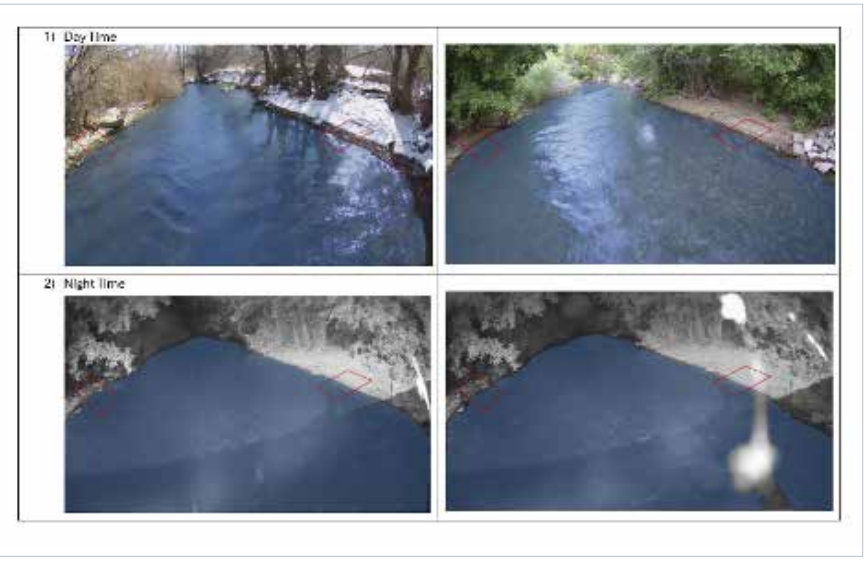
Those stage estimates were then converted to river discharge using site-specific hydraulic rating curves that relate water level to flow. Finally, the full pipeline was deployed on low-power edge-computing devices to enable on-site, real-time processing without relying on continuous high-bandwidth internet. Models were trained and validated using paired image and stage data collected across seasons and a range of lighting and flow conditions, allowing the system to be evaluated for both accuracy and operational robustness in realistic Utah environments.

## What we found

The AI-enabled system produced accurate water-level and discharge estimates across the two field sites, even under changing environmental conditions. At the Blacksmith Fork site, the best ensemble model achieved a coefficient of determination ($R^2$) of 0.92 with a root mean square error (RMSE) of 3.39 centimeters for stage prediction. At the First Dam site, ensemble performance reached an $R^2$ of 0.67 with an RMSE of 1.47 centimeters. When these stage predictions were converted to discharge using rating curves, the resulting flow estimates compared well with in-situ observations, with $R^2$ values up to 0.88, demonstrating that camera-based monitoring can provide practical discharge information. Overall, the findings show that camera-based, AI-driven monitoring can complement or, in some cases, replace traditional in-stream sensors, lowering costs and enabling expanded, real-time hydrologic monitoring in Utah's remote or under-instrumented watersheds.

## Work plan FY 25–26

This project is complete.




*Camera and radar overlooking the Logan River.*

### Publications:

- R. Bin Issa. (2025). *Operationalizing Camera-Based Hydrologic Monitoring with AI and Edge Computing: Towards Real-Time Water Level and Discharge Measurements*. All Graduate Theses and Dissertations, Fall 2023 to Present. https://doi.org/10.26076/ec60-598c
- R.B. Issa, S. Neupane, S. Khan, J.S. Horsburgh, & S. Young. (2025). *Towards Real-Time Water Level and Discharge Measurements using Imagery, Machine Learning, and Edge Computing* (SSRN Scholarly Paper No. 5531964). Social Science Research Network. https://doi.org/10.2139/ssrn.5531964

### Presentations:

- R.B. Issa, S. Young, J.S. Horsburgh, S. Khan, S. Neupane. *Operationalizing Camera-Based Hydrologic Monitoring with AI and Edge Computing*. ASABE Annual International Meeting. July 2025
- E. Goharian, S. Young, J.S. Horsburgh, R.B. Issa, S. Khan, S. Neupane, M. Hatami. *Advancing camera-based monitoring for operational hydrologic applications*. American Geophysical Union Fall Meeting. December 2024.

# Advancing the Representation of Groundwater in a Water Management System Model for the Bear River Watershed


## Research Summary:

Human actions have altered stream flows leading to the Great Salt Lake (GSL), impacting the lake's water levels. This project improves groundwater representation in GSL basin water management models, particularly focusing on the Bear River watershed, the lake's largest tributary. We developed two models: one integrating water management and hydrology, and another linking groundwater flow under future climate scenarios. The research supports joint management of both surface and groundwater, improving water use strategies. The results will guide long-term planning, helping policymakers adapt to and mitigate climate change impacts.


### Why this research?

Groundwater aquifers and their interactions with surface water have been inadequately represented in water management models, yet groundwater sources are major contributors to the streamflow entering the Great Salt Lake.

### Utah impact

This work is developing a comprehensive water usage database for the Bear River watershed (BRW) that incorporates both surface and groundwater data to be integrated into a water management model that will centralize information, improve understanding of groundwater utilization in the watershed, and highlight areas where state agencies can enhance data collection. Secondly, the integrated hydrologic and water management model, under development for catchments within the BRW, WEAP-MODFLOW, will facilitate the evaluation of management strategies for the GSL by viewing groundwater and surface water as elements of a single hydrological entity. The model will also

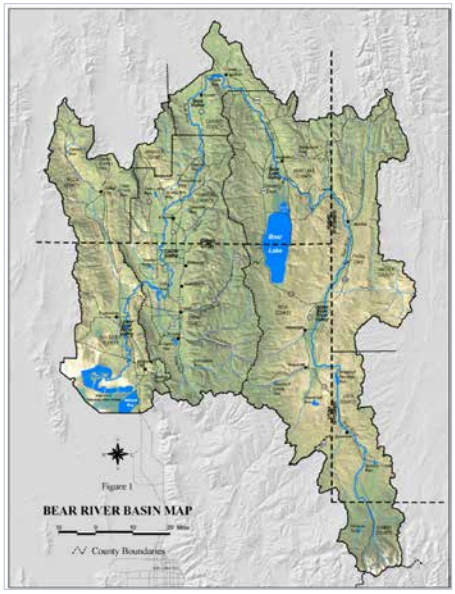



Figure 1: *Bear River watershed.*


### Principal Investigator:

Pin Shuai (PI)

### Student:

Pamela Clare (PhD)

### Research Collaborator:

National: Eric Humphrey, Utah Water Science Center (USGS)


### Geographic Areas:

Study Areas: Bear River watershed

Areas Benefited: Bear River watershed and Great Salt Lake

Contact:

**Pin Shuai**
435.797.1531
pin.shuai@usu.edu

Datasets / Model Code:

- P. Claure, P. Shuai (2025). *Lower Bear River Groundwater* Use Database, HydroShare, http://www.hydroshare.org/resource/c1e0f438b4064a43a4f5984f4cf2dd76
- P. Claure, P. Shuai (2025). *Bear River Watershed Water Evaluation and Planning Hydrologic Mode*l, HydroShare, http://www.hydroshare.org/resource/d9754de48b48432da06895d1e0c29727

be instrumental in assessing the water system's resilience to climate variability and various water usage scenarios. The outcomes will guide policymakers in adapting to future climate conditions and in mitigating potential adverse effects.

## What we did

We have developed a comprehensive water-use database for the Cache Valley area within the Bear River Watershed and created a hydrologic model in WEAP for the entire watershed. Since then, we have refined our scope to focus more specifically on Cache Valley, developing a water management model in RiverWare to better align with the work being done by DWRe at the state level. Our current efforts focus on representing major water users and incorporating groundwater inflows in Cache Valley to evaluate various water management scenarios.

## What we found

This project is ongoing.

## Work plan FY 25–26

- Objective 1 (09/2025–02/2026): Develop a detailed water management model in RiverWare considering groundwater-surface water interactions for Cache Valley, Utah.
- Objective 2 (03/2026–08/2026): Develop a one-way coupled RiverWare and MODFLOW model for Cache Valley, Utah to aid operational planning under low flow conditions.

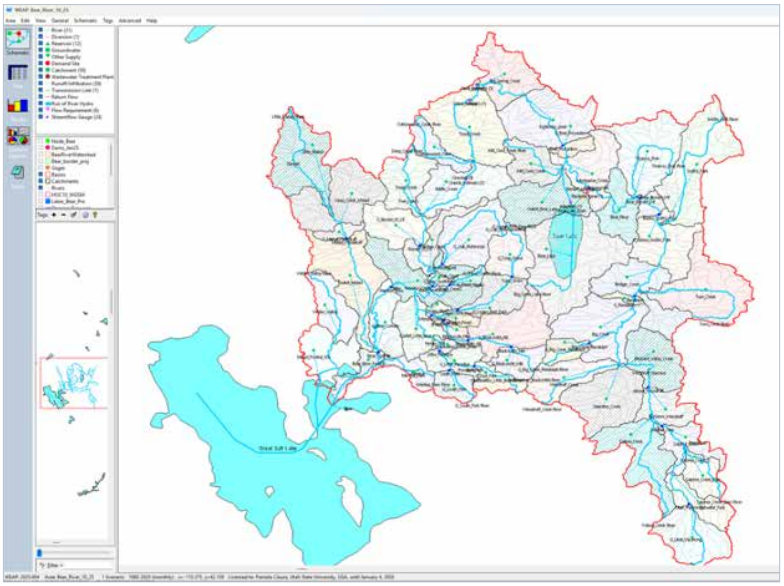


**Figure 1:** *Snapshot of the WEAP model for the Bear River watershed.*

# Clarifying the Potential of Utah's Mountain Rock Glaciers to Buffer Streamflows and Support Biodiversity as Statewide Snowpack Declines

## Research Summary:

Utah is a dry state that relies heavily on seasonal snowpack for its water supply, yet that snowpack is in decline. Our research examines how rock glaciers—large masses of debris-covered ice—influence Utah's mountain water supply and aquatic biodiversity, specifically their contribution to downstream flows and their potential of rock glaciers to serve as climate refugia for cold-adapted aquatic species.

### Why this research?

Global-scale atmospheric warming presents significant threats to Utah's water supply and ecosystems. Seasonal snowpack is the largest natural "reservoir" of water in the state, yet it has been steadily declining since high-resolution monitoring began in ~1980. To date, peak annual snowpack has decline by about 16% statewide. However, the more than 800 rock glaciers in Utah appear to be resistant to climate warming due to their insulating debris cover. By understanding the influence of rock glaciers on Utah's water supply and aquatic ecosystem, we can better understand the future of Utah's natural resources and improve risk management.

### Utah impact

Water is critical to the well-being of all Utahns, and as one of the driest states in the nation, Utah faces persistent water scarcity. Rock glaciers appear to hold substantial volumes of climate-resilient ice, making them an important but under-studied component of the state's mountain water supply. By determining how rock glaciers contributing streamflow and support ecosystem integrity, we are developing a more accurate—and potentially optimistic—picture of Utah's water future as snowpack declines. For example, our measurements show that the single rock glacier feeding Twin Lakes Reservoir near Brighton in late summer contributes roughly 2-3% of the late-summer canyon flow measured by Salt Lake County at the mouth of Big Cottonwood Canyon. Dozens more rock glaciers are located in Big Cottonwood Canyon alone.

*A Brighton study area rock glacier: the sole inflow water source into Twin Lakes Reservoir in late summer.*

### What we did

Hydrology. We studied streams emanating from 7 rock glaciers in Utah: 4 in the Wasatch and 3 in the La Sal mountains. To understand the degree to

### Principal Investigators:

Scott Hotaling (PI, Watershed Sciences)

Matthew Morriss, (Co-PI, Utah Geological Survey)

### Students:

Anna Shampain (PhD)
Josh Vollmer (MS)
Jace Kjar (BS)

### Research Collaborator:

State: Greg Carling, Brigham Young University

### Geographic Areas:

Study Areas: Wasatch Mountains

Areas Benefited: Wasatch Front, Uinta and La Sal Mountains and surrounding regions, and any other areas near the ~800 rock glacier features in Utah

### Contact:

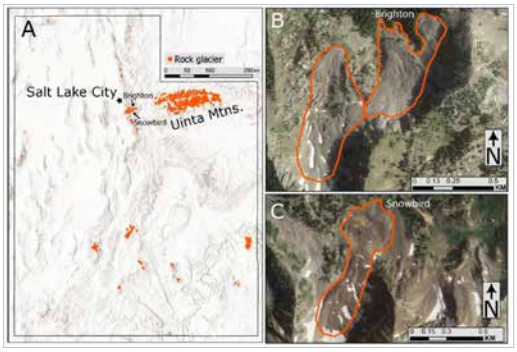
**Scott Hotaling**
828.507.9950
scott.hotaling@usu.edu

### Publication:

S. Hotaling, K. Becker, M. Morriss (2024). *Rock Glaciers in Utah.* Utah State University Extension [downloaded 820 times since publication on June 4, 2024]. https://digitalcommons.usu.edu/extension_curall/2417/

### Work plan FY 25–26

This project is complete. We will continue to analyze data and publish findings using other avenues of related support.




*The 800+ rock glaciers in Utah (A) and our primary study sites in the Wasatch (B,C).*

which water flowed year-round from rock glaciers in Utah's mountains, we deployed two types of sensors at each stream: (1) temperature loggers to continuously record hourly in-stream temperature and (2) automatic water samplers to collect stream samples at 12-hour intervals. We analyzed these samples for stable isotopes (oxygen and hydrogen), which enabled us to assess how source contributions changed in the stream over time (i.e., we expected snowmelt to dominate in early season and rock glacier contributions to be the primary inflow in late summer). We also collected high-quality water chemistry data for the same samples, which allow us to assess how inputs of interest (e.g., sulfur) change through the season and to detect any potential risks to water quality.

Ecology. We sampled stream invertebrates, with a particular focus on the federally protected stonefly, *Zapada glacier*, which has been linked to rock glaciers in other regions of the Intermountain West but has not been confirmed in Utah (despite a few putative records from the 2000s). Because *Z. glacier* can only be identified in its aquatic life stage through genetic "barcoding"—where a certain sequence of the mitochondrial gene cytochrome oxidase I (COI) is sequenced and compared against reference databases—we barcoded any specimens from the genus *Zapada*.

*Matthew Morriss handing gloves to Scott Hotaling as they install a flow monitoring logger in a rock glacier outflow stream.*

### What we found

All streams in the study flowed continuously during the summer and appear to contribute significant amounts of water to downstream habitats. The rock-glacier-fed streams were marked by cold temperatures, rarely exceeding 2° C in summer, with several streams maintaining less than 1° C the entire summer season. During the same observational period, enrichment of oxygen isotopes indicated a change in seasonal snowmelt source to rock glacier ice melt. From an ecological perspective, we collected *Zapada* from several sites but are still in the process of barcoding those specimens.

*A pressure transducer installed in a rock glacier-fed stream in the Wasatch Mountains.*

# Development of Inexpensive UAS for Sensing Land Surface Hydro/ Multispectral UAS Collaborative Remote Sensing System for Irrigation Water Management and Ecological Assessment

## Research Summary:

Scientific-quality data is essential to managing water and other environmental resources well. In this project, AggieAir, a highly capable aerial remote sensing group at USU's Utah Water Research Laboratory, provides high-quality information for hydrological and other natural resources management tasks and other applications, along with development of specific aerospace and drone technology to collect this data.

### Why this research?

Many current sources of remote sensing (crewed aircraft and satellite platforms) are too expensive, have low spatial resolution, or are not activated frequently enough to be practical for many applications. A low-cost, small uncrewed aerial system (sUAS) called AggieAir fills this need for actionable aerial information by providing low-cost, multispectral imagery and other scientific data quickly and frequently. The AggieAir platform design does not require a runway, enabling launch almost anywhere. In contrast to other 'drone' platforms available on the market, AggieAir is more capable and delivers for more accurate, higher-quality data. Some applications include agriculture, riparian habitat mapping, road and highway surface monitoring, wetland mapping, and fish and wildlife tracking.

### Utah impact

AggieAir data have the potential to help save water in Utah by offering a low-cost solution to mapping crop soil moisture to help farmers and scientists to irrigate and manage natural resources more efficiently, canal operators to manage water more effectively, or wetland managers to manage invasive plant species. Left unchecked, invasive species can take over native vegetation, destroy bird habitat, and use excessive amounts of water. AggieAir can also provide new jobs and economic growth in the state of Utah. A long-term goal of the AggieAir program is to establish a Utah-based spinoff company that can commercialize the technology and advance Utah State University's outreach mission AggieAir's technology also highlights Utah's expertise in aerospace, unmanned systems, and civil uses for technologies like remote sensing for agriculture. For more than a decade, the AggieAir lab has provided a home for STEM undergraduate recruiting, senior design projects, and a range of student-driven research. Through the lab's resources (students, employees, capabilities, etc.) AggieAir has supported STEM outreach and education programs such as NSF GearUP, Engineering State, drone education at EAA AirVenture, National Intercollegiate Flying Association, Civil Air Patrol training, Women in Aviation, etc.

### Principal Investigators:

Calvin Coopmans (PI)
Alfonso Torres-Rua (Co-PI)

### Students:

Sadikul Alim Toki (PhD), Richard Snyder (MS), Zeb Astle (BS), George Blue (BS), Brandon Curdy (BS), Bryce Lyon (BS), Htoo Poe Sar (BS), Austin Washke (BS)

### Research Collaborators:

Local/USU: Scott Budge (USU Electrical and Computer Engineering), Baron Wesemann (USU Aviation Technology), Steve Petruzza (USU Computer Science), USU Space Dynamics Laboratory, Janet Quinney Lawson Institute for Land, Water and Air

Commercial/National: 47G (DeseretUAS/UADA/ UAMMI), Dunlevy Consulting, ElectraFly, Fortem Inc., Northrop Grumman, Almond Board of California, E & J Gallo Winery, GRAPE-X, NASA, USDA

### Geographic Areas:

Study Areas: Test site flights near Cache Junction, UT under FAA FAA COA 2023-WSA-12075-COA. Sites across Utah inluding Great Salt Lake and Utah Lake

Areas Benefited: All counties in the state and region could benefit

Contact:

**Calvin Coopmans**
435.764.4579
cal.coopmans@usu.edu

Website:

https://aggieair.usu.edu/

Publications/Proceedings:


- A. Sewell, E. Payne, C. Coopmans, A. Torres-Rua, and S. Petruzza, *Towards Real-Time SLAM-Based Orthomosaic Generation for High-Resolution Scientific Multi-Band sUAS Imagery*, in 2025 International Conference on Unmanned Aircraft Systems (ICUAS), May 2025, pp. 264–271. https://ieeexplore.ieee.org/document/11007794
- S. Toki, A. Kafi, R.I. Antara, and C. Coopmans, *A Shallow Convolutional Neural Network for Onboard CubeSat Image Classification*, Small Satellite Conference, Aug. 2024, [Online]. Available: https://digitalcommons.usu.edu/smallsat/2024/all2024/267
- S.A. Toki, S.G. Slack, and C. Coopmans, *Image Quality Assessment of UAV Simulator Imagery Based on Different Orthomosaic Maps*, in 2024 International Conference on Unmanned Aircraft Systems (ICUAS), Chania - Crete, Greece: IEEE, June 2024, pp. 923–928. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10556972
- UDOT report - Moving Utah Forward: The Economic Impact and Community Benefits of Advanced Air Mobility. February 2025 (p16): https://site.utah.gov/connect/wp-content/uploads/sites/50/2025/03/Utah-AAM-EIA-FINAL.pdf (p16)


## What we did

AggieAir has continued to develop its aerial platform and has accomplished many small projects and missions. In the 2024 Utah Summer Ozone Study (USOS)AggieAir collaborated with the National Oceanic and Atmospheric Administration (NOAA), the Utah Division of Air Quality (UDAQ), Utah State University, and other third-party agencies and universities to measure the spatial distribution of ozone, characterize the distribution of ozone precursor concentrations, and examine the structure of the planetary boundary layer as represented in the NOAA's weather forecasting models. These measurements support a better understand of the factors that contribute to ozone levels exceeding the US EPA standard (Fig. 1). An environmental sensing mission over Promontory Point, UT, was also executed successfully (Fig. 2).

**Figure 1:** *Graduate student Donald Olsen preparing the AggieAir GreatBlue UAS drone at Unicorn Point (8/6/2024). Credit: Mike Anderson, KSL TV*

**Figure 2:** *AggieAir's GreatBlue aircraft flying an environmental data collection mission over the Great Salt Lake at Promontory Point UT*

## What we found

AggieAir produces scientifically validated results and is recognized as a leader in remote sensing, unmanned aerial operations, and advanced data delivery

Other Outreach:

- 2025 presentations at IEEE ICAUS, IEEE Big Sky Aero, AUVSI Xponential, UDOT Aeronautics

Media Coverage:

- News article: https://ksltv.com/local-news/researchers-use-drone-to-track-ozone-pollution-in-the-state/668413/
- Project video: https://www.youtube.com/watch?v=igVwumGEba0
- Project video: https://www.govtech.com/transportation/north-dakota-research-project-takes-drones-to-rural-america

## Work Plan FY 25–26

AggieAir will continue supplying remote sensing, data processing, and aerial information to the scientific community and stakeholders in Utah and beyond, In addition to existing campaigns, AggieAir will continue development of drone systems that comply with new airspace and trade requirements, while maintaining the cutting-edge performance and scientific accuracy that define the AggieAir mission.

# Drone Meteorology: Developing Accurate, Mobile Environmental Sensors to Accelerate Information Gain from Remote Sensing Missions


## Research Summary:

This project developed a mobile drone-based meteorological sensing system ("metDrone") that collects high-resolution atmospheric data needed to improve environmental modeling in Utah. By integrating advanced sensors, custom open-source drone software, and field-tested flight operations, the system enables precise measurements of wind, temperature, humidity, and other variables that ground stations cannot capture.


### Why this research?

Environmental models used for water management, crop water use estimation, evapotranspiration analysis, and air quality forecasting rely heavily on accurate local meteorological data. However, most available weather information comes from stationary ground-based instruments, which cannot capture the highly variable conditions that occur across landscapes or within the lower atmosphere. As AggieAir and similar drone remote-sensing platforms continue to extend their range and capabilities, the lack of mobile, co-located atmospheric measurements limits the accuracy of environmental models and the usefulness of remote-sensing missions. This project addresses that gap by building a drone-based sensing system capable of collecting atmospheric data directly where it is needed.

### Utah impact

Utah depends on accurate environmental data to manage scarce water resources, support agriculture, and address challenges related to drought, air quality, and land-use pressures. A drone-based meteorological sensing platform expands the state's ability to gather information in locations where installing weather stations is impractical or impossible, such as agricultural fields, canyons, wetlands, and high-elevation terrain. By providing high-resolution measurements of wind, humidity, temperature, radiation, and pressure, the system directly improves evapotranspiration modeling, crop-water-use estimation, and pollutant-dispersion analysis, thereby supporting better decision-making for farmers, water managers, and environmental researchers.

### What we did

We developed and integrated a full meteorological sensing payload for a drone platform, including a 3D sonic anemometer, an iMet-XQ2 temperature/humidity/pressure sensor, and an Apogee SI-111-SS infrared


## Principal Investigators:

Sierra Young (PI)
Alfonso Torres-Rua (Co-PI)
Calvin Coopmans (Co-PI)

## Student:

Htoo Poe Sar (BS)


## Geographic Areas:

Study Areas: Northern Utah

Areas Benefited: The UAS sensing system developed as part of this project has the potential to improve meteorological sensing in any geographic area of Utah; targeted applications include improved evapotranspiration modeling for agriculture


## Contacts:

**Sierra Young**
435.797.1519
sierra.young@usu.edu

Video:

- USU research highlight video. https://www.youtube.com/watch?v=eUfSaAzhh9M

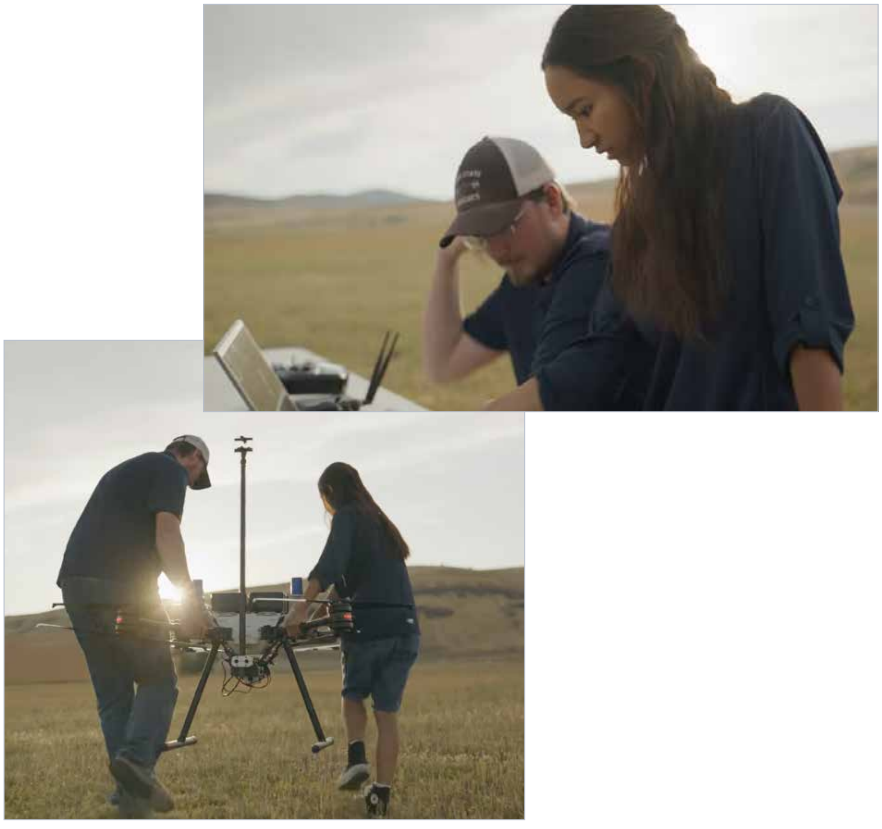
radiometer, all connected to an onboard computer for real-time data logging and processing. We built open-source drone software enabling seamless communication between the UAS and a variety of off-the-shelf environmental sensors. This software allows the drone to record data onboard, transmit environmental readings to the ground control station in real time, and synchronize sensor and flight data for research applications. The drone-sensor system was successfully tested across several flights, demonstrating reliable data collection, communication, and field operability.

## What we found

The project validated that drone-based atmospheric sensing provides critical environmental information that cannot be obtained from ground stations alone. The open-source communication software performed reliably, enabling real-time sensor data streaming and synchronized logging during flight operations. Together, these findings demonstrate that a drone-based meteorological sensing platform can enhance environmental modeling, strengthen remote-sensing missions, and provide Utah researchers and decision-makers with a flexible, high-resolution tool for monitoring atmospheric conditions across diverse landscapes.

## Work plan FY 25–26

This project is complete.



# Enabling the Use of Short-Wave Infrared (SWIR) for Aerial Drone-Based Water Use Studies such as Canal Leakage

## Research Summary:

New water resources applications increasingly use shortwave infrared (SWIR) data to detect moisture in, for example, surface soil. Leveraging drones, SWIR can also be used to evaluate conditions in agriculture lands and water infrastructure such as canals. This project aims to develop a system for collecting and processing SWIR data to identify canal leaks, thereby supporting water conservation efforts.

### Why this research?

As canals and other water infrastructure age, leaks often develop, resulting in significant water loss. Yet practical and efficient inspection methods remain limited. Water is a finite resource and conserving it for downstream users is critical.

### Utah impact

Utah contains hundreds of miles of canal infrastructure, and many exposed sections of these aging systems can be inspected from the air to detect leaks.

### What we did

AggieAir has used and extended our software platform, the 'Scientific Timely Actionable Robotic Data Operating System' (STARDOS),

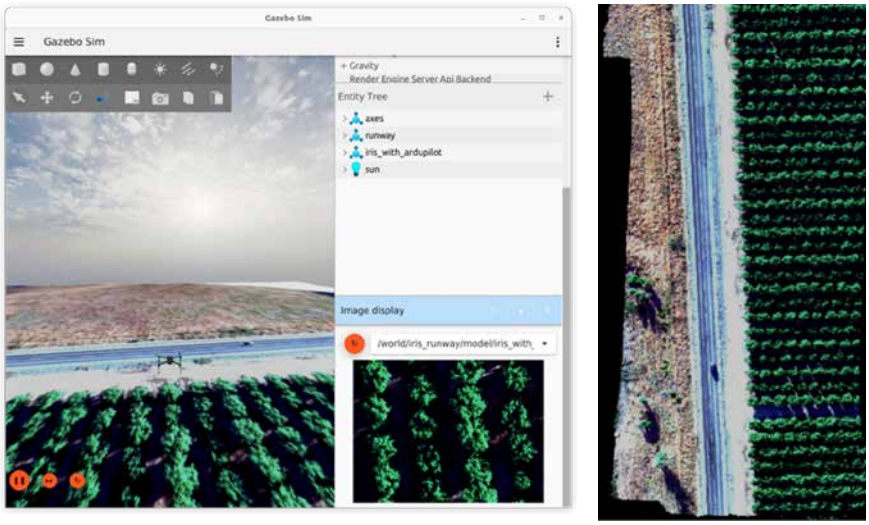



Figure 1: (a) *STARDOS RASIC simulator for real-time testing; (b) Results of visual (RGB) imagery simulated real-time data from a simulated test flight*


## Principal Investigators:

Calvin Coopmans (PI)
Alfonso Torres-Rua (Co-PI)
Steve Petruzza (Co-PI)

## Research Collaborator:

Sierra Young (USU/UWRL)

## Students:

Sadikul Alim Toki (PhD),
Richard Snider (MS)
Htoo Poe Sar (BS),

## Geographic Areas:

Study Areas: Cache County, UT

Areas Benefited: All counties in the state could benefit

## Contact:

**Calvin Coopmans**
435.764.4579
cal.coopmans@usu.edu

## Website:

https://aggieair.usu.edu/

and 'Real-time Actionable Intelligence for Crops' (RASIC), to target agriculture applications in addition to water distribution-related topics. By integrating a real-time platform developed by Co-PI Steve Petruzza and creating a simulator to allow the code to be tested in field-like conditions, the team can make the code robust without flying and speed the process of integration. These results are positive and have been published under peer-review. We are starting with thermal imagery (TIR) before we move to shortwave imagery (SWIR) due to the ease of development.

## What we found

We have developed a robust simulation platform that demonstrates the effectiveness of the STARDOS RASIC system and its applicability to addressing the problem (see Figure 1 a,b). The simulator closely reflects real flight conditions, providing a reliable environment for testing the RASIC code prior to flight deployment.

## Work plan FY 25–26

We plan to further integrate the STARDOS RASIC system with additional sensors, including TIR and SWIR, and conduct testing in the simulator and on the ground before deploying the sensors on the AggieAir aircraft. Once airborne, our goal is to generate high-quality maps capable of producing actionable insights, such as identifying canal leaks from aerial imagery.

### Publications/Proceedings:


- A. Sewell, E. Payne, C. Coopmans, A. Torres-Rua, and S. Petruzza, *Towards Real-Time SLAM-Based Orthomosaic Generation for High-Resolution Scientific Multi-Band sUAS Imagery*, in 2025 International Conference on Unmanned Aircraft Systems (ICUAS), May 2025, pp. 264–271. https://doi.org/10.1109/ICUAS65942.2025.11007794
- C. Coopmans, R. Snider, S.A. Toki, A. Sewell, S. Petruzza, and E. Montgomery, *A Real-Time Aerial Imagery Collection, Mapping, and Remote Sensing Testbench for Uncrewed Missions*, in 2025 International Conference on Unmanned Aircraft Systems (ICUAS), May 2025, pp. 378–384. https://doi.org/10.1109/ICUAS65942.2025.11007796

# Establishing a Functional Flows Framework for the Great Salt Lake Basin

## Research Summary:

A functional flows water management approach, focusing on seasonal elements of the natural flow regime known to sustain important ecosystem processes, offers a pathway for linking understanding of ecosystem processes with discrete, quantifiable measures of the flow regime for a broad range of species. Functional flows will be integral to the Great Salt Lake Basin Integrated Plan by quantifying when, where, and how much water is needed to maximize ecosystem and water quality benefits to upstream rivers and wetlands as well as the Great Salt Lake itself.

### Why this research?

Utah is making historic investments in the Great Salt Lake (GSL) ecosystem. The Functional Flows Framework (FFF) will provide a tool to help managers maximize the benefits of these investments.

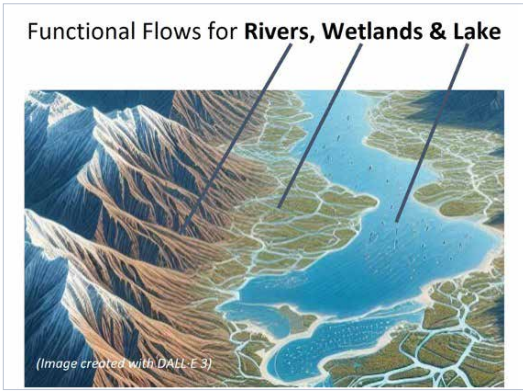



**Figure 1:** *Seasonal components of the natural streamflow regime provide distinct ecological, geomorphic and/or biogeochemical functions quantitatively described by a set of flow metrics (magnitude, frequency, timing, duration, rate of change).*

### Utah impact

This project will help decision makers balance ecological and societal needs and meet goals for water quality, fish, and aquatic life by developing a common understanding of ecologically important hydrograph components of GSL basin streams. It will also foster interagency collaboration and communication by emphasizing the linkages between water quality, water quantity, and wildlife.

### What we did

We used stakeholder input to characterize key functional flows and ecological goals for GSL basin rivers and wetlands. We also identified reference streamflow gages representative of natural hydrologic conditions and developed an automated calculator that quantifies functional flow metrics in terms of magnitude, timing, duration, frequency, and rate of change.

### Principal Investigators:

Belize Lane (PI)
Bethany Neilson (Co-PI)
Sarah Null (Watershed Sciences, Co-PI)
Michelle Baker (Biology, Co-PI)

### Research Technician:

Melissa Stamp (UWRL)

### Post-Doctoral Fellow:

Farah Nusrat (Biology)

### Research Collaborators:

State: Jeff Ostermiller, Utah Division of Water Quality

Paul Thompson, Utah Division of Wildlife Resources

### Geographic Areas:

Study Areas: Great Salt Lake Basin

Areas Benefited: State of Utah

### Contacts:

**Belize Lane**
435.797.4145
belize.lane@usu.edu

**Melissa Stamp**
m.stamp@usu.edu

### Website:

https://uwrl.usu.edu/research-projects/project-details?w0KCQ7oqTSTsw3jQCWgB

### Publication:

Fact sheet: https://water.utah.gov/wp-content/uploads/2023/11/GSLBIP-Work-Plan-Appendix-J-FINAL.pdf

### Media Coverage:

UDWR video: https://www.youtube.com/watch?v=g--K3ImuLTY

### Presentation:

F. Nusrat, B. Lane, J. Ostermiller, S. Null, B. Neilson, P. Thompson, N. Patterson, M. Stamp, M. Baker. *Establishing a Functional Flows Framework for the Great Salt Lake Basin*. Salt Lake County Watershed Symposium, West Valley City, UT. Nov. 20, 2024.

### Other Presentations:

- Wetlands stakeholder workshop. September 5, 2024. Farmington, UT.
- Weber River Watershed Council Meeting. November 4, 2024. Layton, UT.
- Bear River Watershed Council meeting. January 23, 2025. Virtual meeting.
- Jordan River Watershed Council meeting. February 6, 2025. West Jordan, UT.
- to ~100 attendees including Utah and Great Salt Lake Basin researchers, agency staff, NGO staff and stakeholders.

## Work plan FY 25–26

Utah's Functional Flows Framework will include:

1. Refinement of machine learning models to predict functional flow metrics for GSL Basin streams for dry, moderate, and wet water years.
2. Assessment of current hydromodification of functional flows and linkages between functional flows, water quality, and other ecological indicators.

Figure 2: *Summer low flow conditions on Salt Creek, a GSL Basin stream*

3. Preparation of a map-based tool for viewing predicted functional flows and recommendations for using the framework to inform water management practices in the basin.

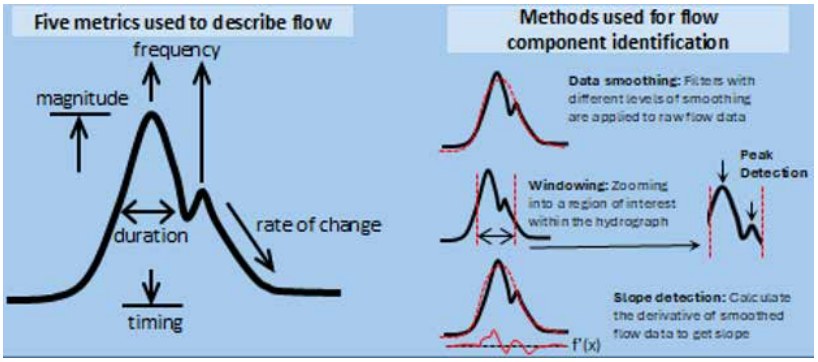



Figure 3: *Functional flows calculator methods*

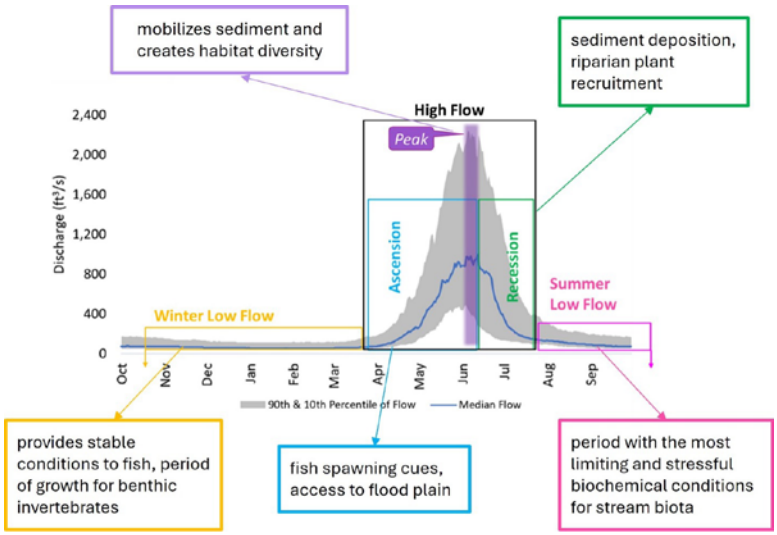



Figure 4: *Functional flows for Great Salt Lake Basin streams.*

# Evaluating Surface Water Movement and Measurement near Great Salt Lake

## Research Summary:

This work identified water movement and measurement infrastructure around Great Salt Lake to facilitate a better understanding of current surface water hydrology and inform future measurement infrastructure needs. This information is necessary to support lake-oriented objectives such as lake level, salinity, and habitat.

### Why this research?

Providing water to sovereign lands has not been considered a beneficial use of water until recently, so understanding of surface water hydrology near GSL is limited. As a result, no standardized method exists for estimating surface inflow to GSL. The most common method relies on the four gages located between five and thirteen river miles upstream of GSL's surrounding wetland complexes. However, with little surface or groundwater flow data downstream of these gages, the fraction of inflow that actually reaches playa and/or open water remains unknown due to potential groundwater exchange, evaporation, and transpiration. Despite these uncertainties, Utah's legislature passed House Bill 130 in 2020 and House Bill 33 in 2022 to address the ecological and economic impacts of declining GSL surface elevation. These bills established a water leasing program that allows water right holders to dedicate all or part of their water rights to GSL. For this dedicated water to reach GSL, the boundaries of its open water, playa, and wetlands must be explicitly defined, and the timing and magnitude of surface water pathways to better quantified. This information is essential for identifying where additional surface water measurement sites should be installed to improve hydrologic understanding and ensure delivery of dedicated water to GSL's ecosystem.

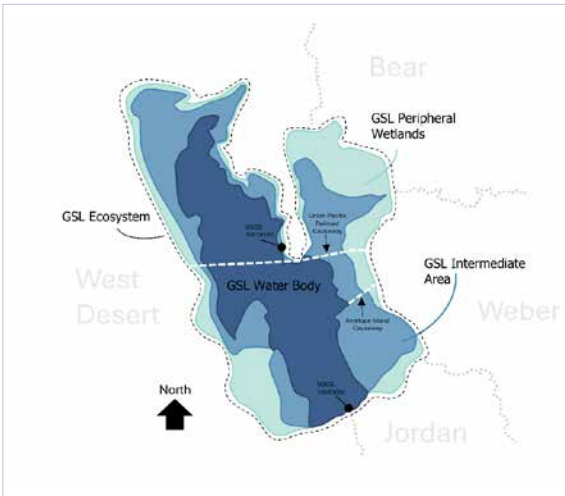



**Figure 1:** *Great Salt Lake's ecosystem includes the lake itself as well as the surrounding playa and wetlands.*

### Principal Investigators:

Bethany Neilson (PI)
Sarah Null (Watershed Sciences, Co-PI)

### Research Engineers:

Eryn Turney (Watershed Sciences)
Eileen Lukens (UWRL)

### Research Collaborators:

State: Utah Division of Water Rights and Great Salt Lake stakeholders

### Funding Source:

Utah Division of Water Rights

### Geographic Areas:

Study Areas: The Great Salt Lake, Utah

Areas Benefited: Great Salt Lake, Utah

### Contacts:

**Bethany Neilson**
435.797.7369
bethany.neilson@usu.edu

**Sarah Null**
435.881.9985
sarah.null@usu.edu

### Publication:

E.K. Turney, E. Lukens, S. Null, B. Neilson (2025). *Evaluating Surface Water Movement and Measurement near Great Salt Lake*, HydroShare online repository,

https://doi.org/10.4211/hs.4dff7b44bc574fb29beaa6ee56adbddd

### Media Coverage:

Article: Utah State Today, September 18, 2025. https://www.usu.edu/today/story/joint-study-details-surface-water-movement-measurement-need-across-great-salt-lake-ecosystem/

### Other Outreach:

Turney, E, E Lukens, S Null, B Neilson. *Evaluating Surface Water Movement and Measurement near Great Salt Lake*. Public meeting with GSL stakeholders. 9/25/2025

### Work plan FY 25–26

This project is complete.

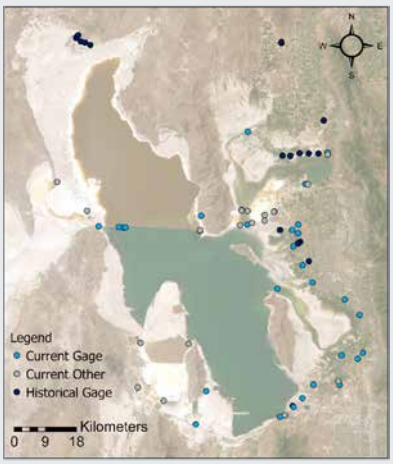



Figure 2: *Locations of current and historical measurement devices throughout GSL's ecosystem*

## Utah impact

GSL is a terminal lake in the Great Basin that offers considerable ecological and economic benefits to Utah and the surrounding region. GSL provides critical habitat for migratory birds, supports Utah's brine shrimp harvest and mineral extraction industries, and indirectly contributes to Utah's water supply and recreation via lake-effect snow. These ecological and economic benefits are closely tied to GSL's surface water elevation, which has declined in recent decades due to upstream consumptive water uses. Foundational information on water movement is needed to support both modeling and water leasing efforts aimed at achieving lake level objectives as well as other management goals such as salinity control and habitat protection.

## What we did

- In this study, we comprehensively documented surface water movement and measurement infrastructure throughout GSL's ecosystem via diagrams and geospatial datasets.
- With this information in a centralized location, we were able to qualitatively and quantitatively characterize the timing and magnitude of unmeasured points of inflow to GSL's Intermediate Area, a portion of GSL's ecosystem that was previously data-poor.
- Using this dataset and others, we evaluated different methods for estimating surface inflow to GSL's Peripheral Wetlands, Intermediate Area, and Water Body. This work fills a gap in understanding how different methods for estimating surface water inflow to these regions vary.
- Finally, we used study information to identify potential pathways for delivering dedicated water to specific locations within GSL's ecosystem where no designated pathway previously existed due to ambiguity surrounding surface water movement.

## What we found

Collectively, this study improves understanding of GSL's surface hydrology by mapping surface flows and consolidating measurement infrastructure information into a single resource. We created 46 flow balance diagrams documenting surface flow pathways and measurement infrastructure throughout GSL's ecosystem, including 199 inflows to GSL's Intermediate Area and 76 active or historical measurement devices. Qualitative and quantitative data on inflow timing and magnitude highlight locations in GSL's Intermediate Area that could be monitored to assess wetland management impacts on inflows to GSL's Water Body. Evaluating methods of estimating surface inflow to different ecosystem boundaries underscores the need to further quantify water movement and the factors that influence surface hydrology near GSL.

# Forage Crop Water Use under Subsurface Drip (SDI) Irrigation in Utah

## Research Summary:

This project is estimating crop water use for subsurface-drip-irrigated alfalfa and barley in northern Utah using soil moisture sensors. We are comparing results to nearby fields irrigated using other methods (wheel-line sprinklers, center pivots, and surface/flood irrigation). This is the first data for forage crop water use using SDI in Utah and is part of a larger effort we are making to understand water use and production of SDI in different regions of Utah.

### Why this research?

Converting agricultural irrigation systems to subsurface drip irrigation (SDI) has been identified as a possible means to reduce the consumptive water use of irrigated agriculture. Studies in California, Kansas, and elsewhere have provided evidence that this may be the case. However, no data are currently available data on consumptive water use for alfalfa or other forage crops irrigated with SDI in Utah and surrounding areas. We are seeking to fill this gap.

### Utah impact

The collected data is a first step towards helping the State of Utah, including the Department of Agriculture and Food's Agricultural Water Optimization Program, estimate the return on investment in funding SDI systems. The results will also help producers understand water use and production relative to sprinkler irrigation.

### What we did

We estimated crop water use (evapotranspiration), applied irrigation water, and yield for three SDI-irrigated fields (one each in Cove, Richmond, and Garland, UT) and three nearby fields irrigated with more conventional methods (sprinklers or surface irrigation). Evapotranspiration was estimated using a water balance. This method is less accurate than using the eddy covariance method, a weather-measurement based method, but it is much less costly, enabling more study sites. Data were collected during the 2023 and 2024 growing seasons.

### What we found

We are currently finalizing the results.

Principal Investigator:
Burdette Barker (PI)

Student:
Nishchal Tamang (MS)

Research Collaborators:
Local: Farmers in Cove, Richmond, and Garland, UT

Funding Sources:
USU Extension, USGS 104b, Utah Agricultural Experiment Station

Geographic Areas:
Study Areas: Cache Valley, UT
Areas Benefited: Utah and the Intermountain West

Contact:
**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

### Outreach Workshops:

We hosted five workshops on subsurface drip irrigation that indirectly relate to this project.

- B. Barker. *Chemigation Safety and Irrigation Research Updates*. Sevier County Winter Crop Workshop, Richfield, UT. January 16, 2025
- B. Barker. *Irrigation Research Updates*. Carbon County Winter Crop Workshop, Price, UT. February 19, 2025
- B. Barker. *Irrigation Research Updates and the AG-DRIP Program*. Daggett County Crop School, Manilla, UT. February 25, 2025
- B. Barker. *Irrigation Research Updates and the AG-DRIP Program*. Uintah Basin Crop School, Vernal, UT. February 26, 2025
- B. Barker. *Getting the Most from Your Water Use*. Weber County Crop School, Washington Terrace, UT. February 27, 2025

## Work plan FY 25–26

This work is nearing completion with an MS student expected to finish their thesis in December 2025 and to subsequently prepare for submission to a refereed journal.

**Figure 1:** *Soil moisture measurement site immediately after installation in one of the study fields*

# Forecasting Vegetation Water Use for the Western United States

## Research Summary:

Most water that falls in Utah is returned to the atmosphere by plants, yet we rarely know how different species remove water from the soil. This research fills this knowledge gap by defining water uptake by dominant species in Utah.

### Why this research?

Most water that enters the soil is returned to the atmosphere by plant roots. Plants with roots that can capture more water tend to be able to grow more but also prevent water from reaching underlying aquifers. Further, plants with different types of roots can coexist because they use water from different depths or different times. In short, rooting distributions can determine how much a species can grow, which species coexist, and how much water reaches the atmosphere or aquifer. Yet, because water uptake by tiny root hairs is difficult to measure, we rarely know how roots of different species remove water from the soil. This research addresses this fundamental knowledge gap by directly measuring water uptake by different plant root systems.

### Utah impact

Arid lands around the world, including Utah, have realized woody plant encroachment that can increase fire risks and decrease forage production for livestock. Woody encroachment can also decrease runoff and aquifer recharge. A better understanding of where different species place their roots will allow predictions of how woody and forage plant growth is likely to change in the future or in response to plant management. It will also allow the design of plant communities for target uses like forage production, aquifer recharge, and wildlife habitat.

Figure 1: *Students injecting a water tracer around target plants near Monticello, UT (left) and Canyonlands National Park (right).*


### Principal Investigator:

Andrew Kulmatiski
(Wildland Resources, PI)

### Students:

Ryan Sandfort (PhD)
Lillian Gordon (MS)
Faraz Rehman (MS)
Evie Reading (BS)
Nizhonii Begaye (BS)
Krishaunna Riggs (BS)
Isaac Hirschi (BS)

### Research Collaborators:

National: Canyonlands Research Center, USGS (Moab)

### Geographic Areas:

Study Areas: Monticello, UT

Areas Benefited: Utah and Western US

### Contact:

**Andrew Kulmatiski**
435.770.2582
andrew.kulmatiski@usu.edu

### Presentations:

- A. Kulmatiski. *Testing the role of root plasticity in determining woody abundance*. Ecological Society of America Meeting, Baltimore, MD, August 2025.
- A. Kulmatiski. *The 'percolation matching' hypothesis of water use niche partitioning explains herbaceous/woody distributions*. Ecological Society of America Meeting, Long Beach, CA, August 2024. Symposium Organizer.
- R.A. Sandfort, A. Kulmatiski, F. Rehman. *Root water uptake across an aridity/elevation gradient*. Ecological Society of America Meeting, Long Beach, CA, August 2024. Symposium Organizer.

## Work plan FY 25–26

This project is complete, but our lab will continue this line of research. We will continue to analyze our data, combine it with data from other sites around the western US, and develop a forecast map for shrub and woody plant growth in the western US in the coming century. This map will also indicate forage production expected from woody plant control.

## What we did

We injected tracers to different soil depths at three sites in southern Utah near Monticello. We repeated these injections six times over two years. We then measured how much tracer each species absorbed from each soil depth. This allowed us to describe the rooting 'behavior' of dominant species like sagebrush, saltbush, big galleta grass, Indian ricegrass, pinyon, and juniper. We are now using this data in soil water flow models to describe how water flows through these systems and how different species can be expected to respond to different climate conditions (e.g., low-elevation arid conditions or high-elevation semi-arid conditions).

## What we found

We completed lab analyses of the over 3,000 collected tracer samples and are starting to summarize our results. Initial results indicate pinyon is surprisingly good at accessing soil water, but it is not as good at using that water, particularly in drier conditions. This result shows why pinyon has declined in the past 20 years while juniper has expanded. Our results suggest that pinyon is likely to continue to decline and juniper is likely to continue to expand in the coming century. This continuing juniper expansion is expected to increase fire risks and decrease forage production. However, our results also suggest that woody plant management is likely to result in greater forage production than was realized in the past, as long as cheatgrass can be suppressed.

**Figure 2:** *By injecting a tracer into the soil, we can learn how different species move water out of the soil—a central but poorly understood component of the water cycle.*

**Figure 3:** *Students collecting plant water samples near Monticello, UT.*

# Great Salt Lake Basin Hydrologic Modeling

## Research Summary:

This work integrates diverse modeling approaches to improve water balance understanding in the Great Salt Lake Basin. Studies address streamflow sensitivity to forest change, quantify evapotranspiration in peripheral wetland areas, and implement the basic model interface (BMI) for the Hydrologiska Byråns Vattenbalansavdelning (HBV) model within the Next Generation Modeling framework (NextGen) framework being adopted by NOAA's National Water Model, advancing interoperability and predictive capability for basin-scale hydrologic modeling.

### Why this research?

With declining Great Salt Lake (GSL) levels threatening the GSL ecosystem and the lake itself, a need exists for hydrologic modeling to better understand water availability and use. This extends from the forested mountain headwaters where most water originates as snow, to the peripheral wetland areas downstream from where streamflow is measured but where losses to evapotranspiration (ET) occur prior to streamflow entering the lake. Modeling is needed to quantify how forest change (e.g., disturbance due to fires or management) is related to streamflow. Modeling systems need to be advanced to be able to incorporate better process representations into models.

### Utah impact

Great Salt Lake (GSL) is an important resource for Utah where water is scarce, and consumption needs to be balanced with the need for water to sustain and restore GSL. By quantifying peripheral wetland losses and by modeling how runoff produced in headwaters may change with forest change, water managers and agencies have better information for decision making.

### What we did

The peripheral wetland work compared the GSL inflows, measured upstream from wetlands, the Bear River migratory bird refuge, and wildlife management areas on the shores of the GSL, with an estimate of water balance ET derived from precipitation, streamflow, lake evaporation and lake volume change, and with remotely sensed ET estimates based on Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat satellite data. Land cover within the GSL peripheral wetland area from NLCD (National Land Cover Database) was intersected with remotely sensed MODIS ET to determine ET from the land cover types present in this area and the changes from 2003 and 2021.

### Principal Investigator:

David Tarboton (PI)

### Student:

Motasem Abualqumboz (PhD)

### Research Collaborators:

National: Sara Goeking (US Forest Service)

Academic: Kieth Jennings (University of Vermont), Jan Siebert (University of Zurich)

### Geographic Areas:

Study Areas: Great Salt Lake

Areas Benefited: Great Salt Lake basin

### Contact:

**David Tarboton**
435.797.3127
david.tarboton@usu.edu

### Publication:

M.S. Abualqumboz and D.G. Tarboton. *Quantifying Evapotranspiration from the Peripheral Area between the Most Downstream Stream Gages and the Open Water Body of the Great Salt Lake*. Submitted to Journal of Hydrology Regional Studies. Preprint available at http://dx.doi.org/10.2139/ssrn.5356589

### Presentations:

- M. Abualqumboz and D.G. Tarboton, *Quantifying Evapotranspiration from the Peripheral Wetland Areas*

*near the shores of the Great Salt Lake*, American Geophysical Union, Fall Meeting, Washington, DC, December 13, 2024, https://agu.confex.com/agu/agu24/meetingapp.cgi/Paper/1543280

- M. Abualqumboz, D. Tarboton and S. Goeking, *Investigating streamflow response to forest changes in the Western United States using a modelling approach*, EGU General Assembly 2025, Vienna, Austria, 27 Apr–2 May 2025, EGU25-14020, https://doi.org/10.5194/egusphere-egu25-14020

## Work plan FY 25–26

A paper on the peripheral wetland work was submitted to the Journal of Hydrology Regional Studies and is currently under review. Once review comments are received they will be addressed to finalize publication. Two papers are in preparation on the work with HBV, one on modeling streamflow responses to forest changes and the other on implementing BMI interoperability for the HBV Hydrological Model. We plan to complete and submit these papers this year.

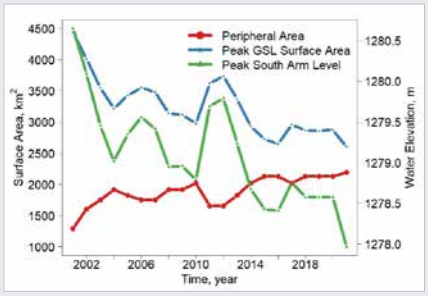



**Figure 3:** *Expansion of the peripheral area between the most downstream USGS stream gages and the open water body of the Great Salt Lake as lake level has declined from 2001 to present.*

Estimates of ET from the NLCD land cover types were reconciled with water balance estimates.

The forest change work used and calibrated the HBV model over watersheds that had experienced forest change and parameter differences to evaluate how forest changes altered watershed processes. Streamflow changes were evaluated by reconstructing runoff without forest change and then by comparing shifts in model parameters across time periods.

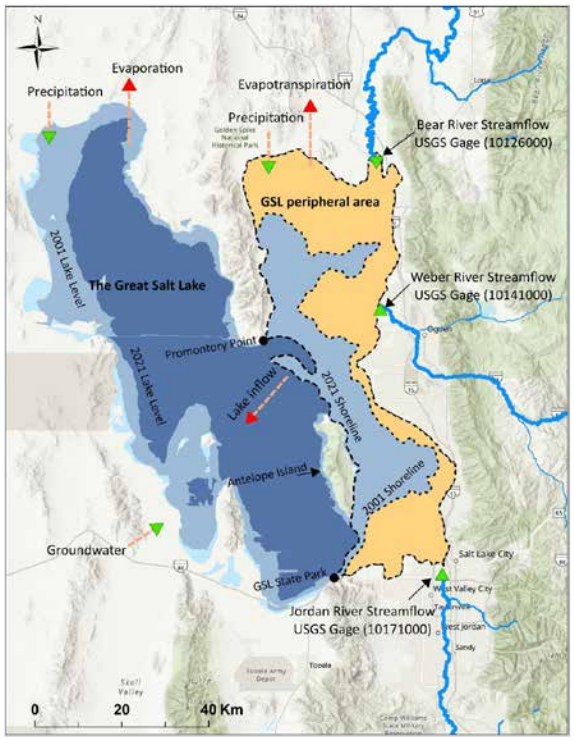



**Figure 1:** *The Great Salt Lake (GSL) and Peripheral Area between the most downstream USGS gages and the open water body of the GSL.*

## What we found

Peripheral wetland results showed that ET from the GSL peripheral area resulted in, on average, a 21% reduction streamflow measured at the upstream USGS gage prior to flowing into the lake. The MODIS ET product indicated that, within this peripheral area, Open Water and Wetlands had the highest and second-highest annual ET, respectively. These land cover types covered 49–57% of the area and contributed between 60–75% to the total ET volume.

The forest change results revealed that, while several watersheds exhibited the conventional inverse association between forest change and streamflow (i.e., streamflow increase due to vegetation loss), others showed neutral or nonconforming relationships (i.e., streamflow increase despite vegetation growth). Shifts in the distributions of HBV model parameters associated with snowpack accumulation, evapotranspiration, and snowmelt timing between the two periods provided insights into the hydrological processes affected by forest change. Work with the HBV model also showed how it could be successfully included in the NOAA NextGen modeling framework, which will facilitate its coupling with other models to refine process representations in future work.


**Figure 4:** *Evapotranspiration estimates for the land cover in the GSL peripheral area based on remote sensing evaporation product.*

# Hydroinformatics Advancements: Advancing Utah Division of Water Rights Operational Measurement Data Systems


## Research Summary:

UWRL researchers are assisting the Utah Division of Water Rights in advancing and deploying new software and database systems to modernize Water Rights' measurement data collection, storage, management, and sharing. These systems help Water Rights maintain Utah's water data management database and are the basis on which water allocation and decision making will be done moving into the future.


### Why this research?

The Utah Division of Water Rights (DWRi) operates the state's water management data collection and management infrastructure, which store and organize the measurement data used to make water allocation decisions under Utah water right law. Some of these systems have become dated and need upgrades to improve clarity, accessibility, and overall effectiveness so DWRi can meet its statutory mandates. Water in Utah is "the property of the public" (Utah Code 73-1-1), and the division is an office of public record (Utah Code 73-2-11). The director of DWRi is responsible for the general administrative supervision of the waters of the state and the measurement, appropriation, apportionment, and distribution of those waters (Utah Code 73-2-1(3)(a)). DWRi currently makes a variety of water data available online, but like all other infrastructure that ages and can become outdated with time, DWRi has recognized several opportunities for updating and improving their data infrastructure to ensure that Utah's water data management information is safely curated, well documented, consistent, and easily understandable. Given that DWRi's is also an office of public record, the data they create, store, and manage must be accessible not only for internal agency operations but also to agency partners and the public. Through this project, USU researchers are helping DWRi to identify opportunities for modernization and, together with the agency, develop and implement standards, technologies, software, and procedures that will improve the consistency, accessibility, and overall utility of DWRi's data systems and products.

### Utah impact

Utah DWRi is the state agency that regulates the appropriation and distribution of water in the state of Utah. It is an office of public record for information pertaining to water rights, including large volumes of data measured and recorded to assist DWRi in tracking and accounting for water use within Utah. The timeliness, accuracy, quality, and


### Principal Investigator:

Jeffery S. Horsburgh (PI)

### Software Engineers:

Ken Lippold
Daniel Slaugh
Maurier Ramirez

### Research Collaborators:

State: Utah Division of Water Rights

### Student:

Sabin Panta (MS)



### Funding Source:

Utah Division of Water Rights


### Geographic Areas:

Study Areas: State of Utah

Areas Benefited: Modernization of measurement data systems for the Utah Division of Water Rights. Statewide benefits through advanced systems for collecting, storing, managing, analyzing, and sharing measurements from monitoring sites on diversions, reservoirs, streamflow, and other sites throughout the state.


### Contact:

**Jeffery S. Horsburgh**
435.797.2946
jeff.horsburgh@usu.edu

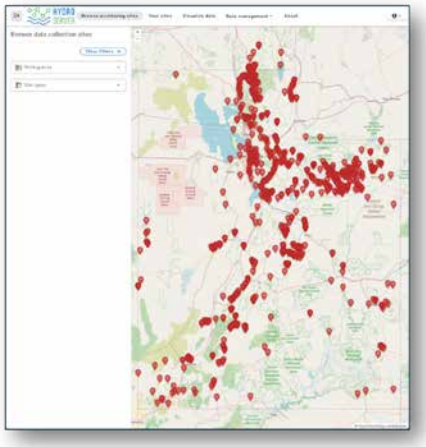
availability of DWRi's data, along with the reliability of DWRi's data systems, are critical to ensuring that Utah's valuable water resources are managed appropriately and in accordance with state law.

## What we did

We (1) performed a Hydroinformatics and Technology Gap Analysis that helped DWRi recognize gaps and deficiencies in their current data systems, along with opportunities for modernization and improvement; (2) developed a Technology Modernization Roadmap to assist DWRi in identifying priority needs and mapping those to a sequenced set of operational updates for modernizing and improving their data systems; (3) worked with DWRi to deploy an instance of the HydroServer software developed by the UWRL as a modernized system for storing and managing DWRi's operational measurement data; (4) developed a modernized job orchestration and data retrieval system to help DWRi modernize the way they are retrieving data from the dozens of parters who contribute datai; and (5) met regularly with DWRi to assist them in identifying and implementing new policies, data governance, and procedures to advance their internal data management.

## What we found

The Hydroinformatics and Technology Gap Analysis identified important opportunities for DWRi to modernize their data systems and enhance their data-management procedures. The Technology Modernization Roadmap outlines a prioritized plan for implementing these improvements. Our assessment showed that the HydroServer software stack, developed by UWRL researchers, is well-suited to DWRi's measurement data management needs. In collaboration with DWRi, we deployed HydroServer within the State of Utah's Google Cloud Platform account, ensuring that DWRi can operate and maintain the system within infrastructure they already fund and manage.



*HydroServer example*

## Work plan FY 25–26

Working with DWRi, we will (1) continue migrating DWRI's water measurement data from the existing database to the new HydroServer system, (2) deploy a new job-orchestration and data loading system that supports real-time updates from DWRi and partners, (3) provide ongoing training for DWRi staff on using HydroServer and integrating it with their other software applications. (4) develop a rules-based, data-quality-control application that automatically scans incoming measurements, flags potential errors, and improves data accuracy for water-use accounting.

### Publications:


- J.S. Horsburgh, D. Slaugh, K. Lippold (2024). *Utah Division of Water Rights: Hydroinformatics and Technology Gap Analysis Report*, 111 pp. Utah State University, Logan, UT, USA, HydroShare, https://doi.org/10.4211/hs.9d02ff3c946249fe9cbc39b2a16c829e
- J.S. Horsburgh, D. Slaugh, K. Lippold (2024). *Utah Division of Water Rights: Technology Modernization Roadmap*, 35 pp. Utah State University, Logan, UT, USA, HydroShare, https://doi.org/10.4211/hs.6bb192887d474555a75f1df86e9a9f66


### Presentation:


A. Abdallah, J.S. Horsburgh (2025). *Water Rights Hydroinformatics Update*, Utah Water Users Association Annual Meeting, Saint George, UT, 17-19 March.

# Improving Profitability of Small and Medium Sized Farms Through Economic Optimization of Wheel-Line Irrigation


## Research Summary:

We are studying the labor requirements, economics, water use, and crop production, of different modernization alternatives for wheel line irrigation systems at two USU research farms and seven cooperating production fields. We are measuring irrigation application effectiveness, crop water use (evapotranspiration), inefficiencies, and yield for three sprinkler technologies and testing technologies intended to reduce labor requirements, including remote-controlled wheel line movers, and remote shutoff. Preliminary results indicate a significant potential labor reduction is possible with some of the technologies. Experiments are ongoing.


### Why this research?

Wheel lines are used to irrigate hundreds of thousands of acres of land in Utah and neighboring states. These systems are important for small and medium-sized farms. However, the technology of the systems has seen little change over the last 60 years. Technologies now exist to potentially improve the economic and resource efficiency of these systems, but they need to be tested to determine the potential costs/benefits of these systems.

### Utah impact

Utah's small and medium farms frequently use wheel lines. This research will provide these farmers with options to optimize the water use and economics of their irrigation systems.

### What we did

We retrofitted two wheel lines on USU irrigation farms with remote-controlled movers and remote-controlled shutoff valves. We outfitted these wheel lines and two partner systems without the retrofits to include system operation logging systems that quantify differences in operational efficiency. We installed three types of sprinklers on 10 wheel-line systems around the state to compare water use and yield with these technologies. The experiment has been conducted in 2024 and 2025, with some of the retrofits occurring only in 2025.

### What we found

Preliminary results indicate that one of the more modern sprinkler technologies performs comparably with traditional sprinklers in uniformity


### Principal Investigators:

Burdette Barker (PI)
Ryan Larsen (Co-PI)
Matt Yost (Co-PI)

### Research Collaborators:

Farmers in Cache, Iron, Uintah, and Wayne counties, UT, and Hydroside, Inc.

### Students:

Maziyar Vaez (PhD), Saba Ardakani (MS, Applied Economics), Benedict Okorie (PhD, Plant Science), Chase Wilkinson (BS)



### Funding Sources:

USDA National Institute of Food and Agriculture, Hydroside, Inc., Utah Agricultural Experiment Station


### Geographic Areas:

Study Areas: Utah

Areas Benefited: Utah and western US


### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

and yield. However, it requires less pressure to operate, meaning a potential energy savings for farmers. The other tested modern sprinkler technology requires adjustments to the irrigation management that may not be practical for farmers (more moves of the system to complete an irrigation). Preliminary economic analyses indicate that producers may realize significant economic benefits with the retrofit options.

## Work plan FY 25–26

Field experiments will continue through 2025. Many of the full-field experiments will be completed in 2025. In 2026, the focus will be measuring sprinkler performance and efficiencies. The project is expected to generate about six peer-reviewed journal articles, several Extension fact sheets, and numerous Extension trainings.

**Figure 1:** *(top) Electric wheel line mover on a USU farm; (middle) Prototype automated shutoff and monitoring system on a wheel line at a USU farm; and (bottom) An example of a modern sprinkler technology being tested at a USU farm.*

### Publication:

S. Ardakani (2025). *The Economic Impact of Drought on Alfalfa Price Formation and Irrigation Modernization Feasibility in the Western U.S*. MS Thesis, Applied Economics Department, Utah State University. https://digitalcommons.usu.edu/etd2023/640/

### Media Coverage:

Radio Interview: Maziyar Vaez-Roudbari (student) *Wheel Line Irrigation Research in the Colorado River Basin*. Interview August 21, 2024. KUER, Salt Lake City, UT

### Presentations:

- M. Vaez-Roudbari, B. Barker, A. Torres-Rua, B. Tullis, R. Larsen, and M. Yost. *Optimizing Water Efficiency: Evaluating the Performance of Wheel Line Sprinkler Irrigation in Small and Medium-Sized Farms*. College of Engineering Research Week Poster Session, Utah State University, Logan, UT. April 2025
- M. Vaez-Roudbari, B. Barker, A. Torres-Rua, B. Tullis, R. Larsen, and M. Yost. *Optimizing Water Efficiency: Evaluating the Performance of Wheel Line Sprinkler Irrigation in Small and Medium-Sized Farms*. Northern Water Users and Spring Runoff Conference, Logan, UT. March 26, 2025.

# Improving the Economic and Environmental Sustainability of Tart Cherry Production through Precision Management

## Research Summary:

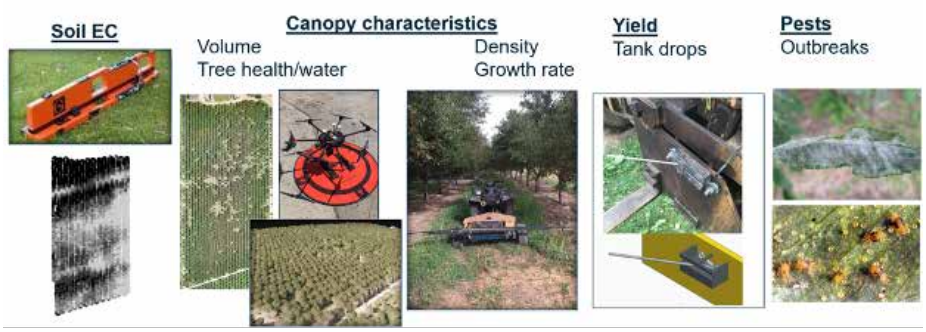
The "Digital Cherry" project is significant for its innovative approach to precision agriculture, utilizing affordable and accessible tools like Raspberry Pi, Arduino, drones, and spatial soil mapping. Through carefully designed experiments, the project aims to assess the effectiveness of these technologies. A primary objective of the "Digital Cherry" initiative is to develop a suite of precision agriculture technologies and practices that enhance productivity and cost-efficiency in tart cherry production.

### Why this research?

Fruit agriculture in Utah faces growing pressure from climate change, drought, urban growth, and competition form lower-priced imports. Although innovation and advances in precision agriculture tools have been developed, producers have not received clear, practical guidance on how to use them effectively. This project evaluating and demonstrating how precision agriculture practices and technologies can improve cherry production. For example, soil mapping can identify low fertility zones, and canopy monitoring with ground- and aerial-based sensors can identify zones of low to high production early in the season so growers can intervene sooner. Patters of insect infestation can also be better understood by looking at proximity to other fields, cherry tree canopy size and weather conditions. Also, the project is developing new low-cost technologies that can be used with agricultural machinery for harvesting or directly on trees for assessing water stress.

### Utah impact

Validating precision agriculture practices and developing new knowledge and technologies suitable for these operations will strengthen fruit and cherry (primarily) production in the Utah. Adopting these technologies can improve




### Principal Investigators:

Alfonso Torres-Rua (Co-PI) - CEE/UWRL
Brent Black (PI), Matt Yost (Co-PI), Marion Murray (Co-PI), Grant Cardon (Co-PI) - Plants, Soils, & Climate

### Students:

Anderson Safre (PhD)
Kurt Wedegaertner (PhD)
Christina Lilligreen (MS)

### Research Collaborators:

Local: Payson Fruit Growers, Payson, UT

National: Michigan State University

### Geographic Areas:

Study Areas: Santaquin, UT

Areas Benefited: Utah & Michigan

### Contacts:

**Brent Black**
435.797.2174
brent.black@usu.edu

**Alfonso Torres-Rua**
435.797.0397
alfonso.torres@usu.edu

### Publication:

A.L. Safre, A. Torres-Rua, B.L. Black, and S. Young. (2025). *Deep learning framework for fruit counting*

*and yield mapping in tart cherry using YOLOv8 and YOLO11*. Smart Agricultural Technology, 11, p.100948. https://www.sciencedirect.com/science/article/pii/S2772375525001819

PRESENTATIONS:

- A.L.S. Safre, A. Torres-Rua, B. Black. *Integrating UAV Multispectral and Thermal Imaging with Environmental Data for Stem Water Potential Estimation in Tart Cherry Orchards*. ASA, CSSA, SSSA International Annual Meeting, November 2024.
- A.L.S. Safre, A. Torres-Rua, B. Black. *Development of a Low-Cost Stem Dendrometer for Irrigation Scheduling in Fruit Trees*. ASA, CSSA, SSSA International Annual Meeting, November 2024.
- A.L.S. Safre, A. Torres-Rua, B. Black. *Computer Vision Based Fruit Counting Framework for Tart Cherry Yield Mapping*. ASA, CSSA, SSSA International Annual Meeting, November 2024.
- A.L.S. Safre, A. Torres-Rua, B. Black, K. Wedegaertner, G. Cardon. *Development of a Low-Cost Yield Monitor for Tart Cherries*. ASABE Annual Meeting, July 2025.

## Work plan FY 25-26

We will analyze and summarize findings across the different components of the project, with emphasis on outreach (USU Extension events and scientific publications).

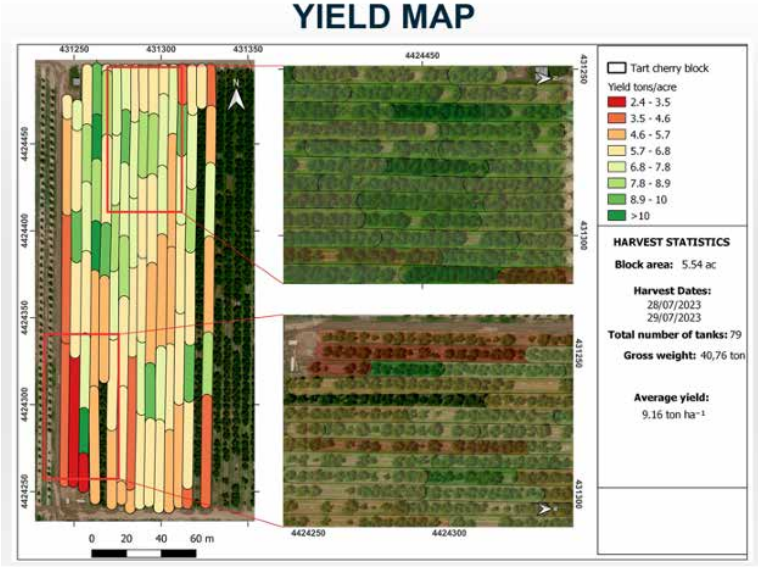
farm profitability of these activities in the state and help sustain the long-term viability of the state's farming communities.

## What we did

In 2023 we began field measurements in the Santaquin farming area and at the USU Kaysville Experimental Orchard site, conducting spatial soil mapping drone-based flights, insect infestation monitoring, and development of technologies tailored to harvesting machinery. In 2024 we expanded the work by involving undergraduate students in ongoing measurement efforts and by integrating new technologies to assess tree water stress conditions.

## What we found

Based on data collected from 2023 to the present, we have identified several opportunities to improve cherry production. A fertilization experiment informed by soil variability was implemented and is currently under analysis. We are also evaluating how well different technologies (ground LIDAR, drones, ground sensors) can map the effect of soil conditions and fertilization on tree canopy development and therefore yield. Our work using drone imagery and measurements of stem water potential shows promise for detecting water stress at the individual tree level. For our developed yield-monitoring technologies, we have demonstrated that the proposed system is adequate, after resolving early challenges with GPS signal loss and data collection processing issues, and Utah State University is pursuing intellectual-property protection for this work. Regarding insect infestation, results indicate that this is a complex issue influenced by insect life cycle, weather patterns, and tree development.



# Interconnectedness of Little Bear River and Canals

## Research Summary:

This study mapped how canals in the Little Bear River (LBR) watershed lose water through seepage that recharges groundwater and supports LBR flow. Understanding these hydrologic connections is vital before piping projects to ensure water efficiency improvements don't unintentionally lower groundwater levels or harm river ecosystems that depend on these hidden inflows.

### Why this research?

Irrigation canals in the Little Bear River (LBR) watershed are old, mostly unlined, and lose water through ground seepage. While this may seem wasteful, the canal seepage recharges groundwater and, in many cases, returns water to nearby rivers, helping maintain flow and keep temperatures cooler during the hot summer months. A major concern regarding canal companies' plans to replace open canals with enclosed pipelines to improve efficiency is the loss of this type of seepage and its benefits. Without them, groundwater levels could drop, causing river flow to decrease or cease for longer time periods and greater spatial extents. This study focuses on understanding these unmeasured connections between canals, groundwater, and rivers. By identifying where seepage occurs and how much it contributes, water managers can make informed decisions that balance irrigation efficiency with an understanding of the consequences of changes on the entire system.

### Utah impact

As agriculture modernizes, projects like canal pipelines aim to improve irrigation efficiency and conserve water. However, pipelines can unintentionally reduce canal seepage inflows that help maintain suitable river conditions and meet other water users' demands. This research helps water managers and local communities understand how canal piping affects groundwater, river flow, and potential impacts to instream temperature. Mapping these hydrologic connections helps to identify areas of canal seepage loss and provide insight regarding changes to a system that depends on hydrologic inefficiencies.

### What we did

We collected flow measurements at 73 locations over a combined 41 miles along the Highline, Paradise, and Hyrum Canals, and throughout a section of the LBR, using FlowTrackers and RS5 Acoustic Doppler Current Profilers (ADCPs). Key reaches were measured repeatedly to identify gaining

### Principal Investigator:

Bethany Neilson (PI)

### Students:

PhD: Michael Lasswell, Hyrum Tennant, Katy Osorio-Diaz

MS: Tarique Aziz, Preston Hodnett, Collins Stephenson, Shreya Vaidyanthan, Abby Johnson, Namuna Dhakal, Adrienne McKell, Michaela Shallue

Undergraduate: Brooke Bondley, Marie Foster

### Research Collaborators:

USU: Burdette Barker, USU Extension; Logan River Observatory

Local: Highline, Hyrum, and Paradise canal companies

### Geographic Areas:

Study Areas: Little Bear River watershed

Areas Benefited: Paradise and Logan cities, Cache Valley and other western US irrigated agricultural areas

### Contact:

**Bethany Neilson**
435.797.7369
bethany.neilson@usu.edu

### Outreach:

Significant time was spent with canal companies and different board members to complete these studies. Results were presented to Highline Canal Company in a follow up meeting

### Work plan FY 25–26

The insights gained from a nearby Logan River study that focused on understanding the impacts of canal inefficiencies on instream ecosystems can be directly applied to the LBR watershed. Like the LBR, the Logan River system is hydrologically connected to a network of nearby irrigation canals that influence groundwater recharge and distributed lateral inflows supporting larger and cooler summer baseflows in the river.

and losing segments, and to quantify and identifying areas of seepage. The resulting dataset provided a comprehensive view of groundwater–surface water interactions between these different waterbodies and enabled estimates of distributed seepage rates (both gaining and losing).

### What we found

Results showed that, while canals in the LBR watershed lose a significant amount of water, most of that lost water returns to the LBR. The study recommends that any future piping projects include additional detailed assessments of canal seepage and groundwater connections before construction. Overall, canal seepage protects river ecosystems and meets other surface and groundwater water users' needs that must be considered when increasing canal distribution efficiency through piping.

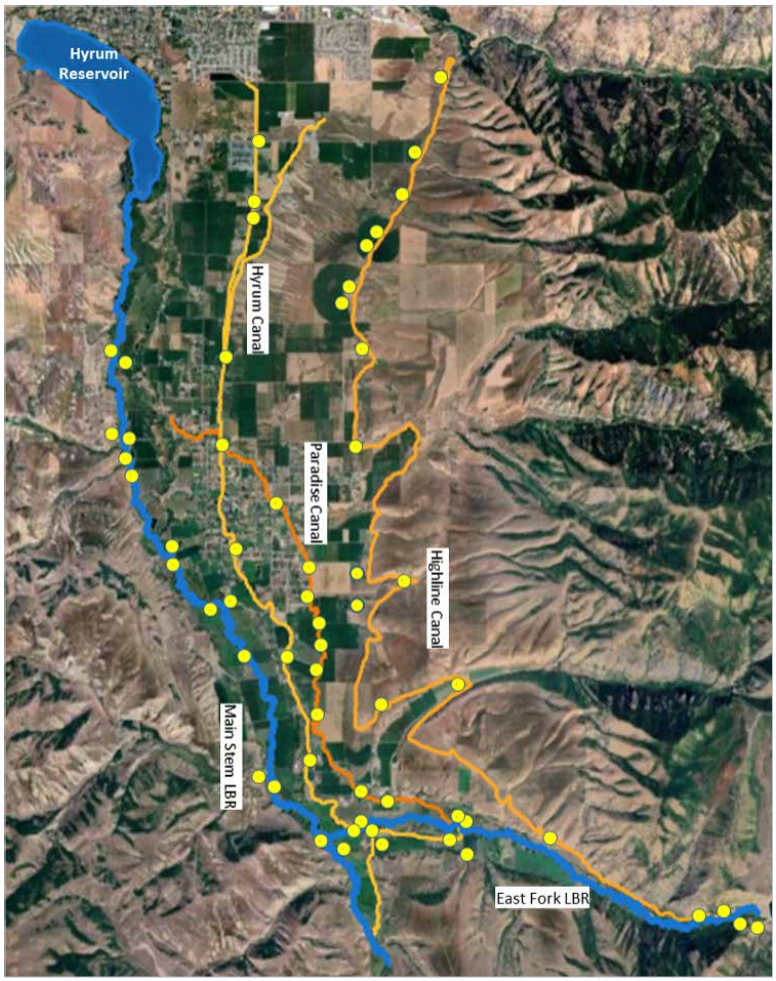



**Figure 1:** *Map of the Little Bear River (LBR) watershed from the East Fork LBR to the Hyrum Reservoir. Highline Canal, Paradise, and Hyrum Canals are labeled. Yellow dots show locations. of flow measurements. Image from Google Earth.*

# Local Water Management Organizations in the Great Salt Lake Basin of Utah, USA

## Research Summary:

This work aims to understand the practices, risk perceptions, and decision-making of local water management organizations. In Utah, where water concerns are at the top of many minds, understanding the role of these on-the-ground entities is critical for basin-wide water management efforts. This work can also help support state policy around water resources to help ensure that water management is better aligned to the work these entities do.

### Why this research?

This research aims to understand the role played by local water management organizations in managing water within the Great Salt Lake basin. Local water management organizations comprise irrigation companies, municipal water managers, public water suppliers, and special service districts, including conservation districts. These day-to-day, on-the-ground water managers are actively managing and distributing water. Insights into these 'hands-on' entities will help to better support their efforts rather than work against them.

### Utah impact

As the Great Salt Lake is experiencing declining lake levels, a trend that raises significant concerns both within Utah and regionally. This work examines areas of alignment and misalignment across local water management organizations that play critical roles in shaping future water strategies. These efforts will contribute to more holistic water management and collaborative capacity around shared water resources.

### What we did

Irrigation companies and municipalities within the Great Salt Lake basin were categorized based on their water right allocations, resulting in a typology of small to very large local water management organizations. Using this typology, irrigation companies were invited to participate in semi-structured interviews, with all companies being invited to participate in a short survey. All municipalities within the Great Salt Lake basin were also invited to participate in a short survey. Representatives from 18 companies participated in an interview, and 45 completed surveys. Water managers from 43 cities and towns in Utah completed a survey. Qualitative coding and analysis were used to understand common themes around water management, risk

### Principal Investigators:

Courtney Flint (PI, Environment and Society)
David Tarboton (Co-PI)

### Student:

Bailey Holdaway (MS)

### Geographic Areas:

Study Areas: Great Salt Lake basin, northern Utah

Areas Benefited: Water management, water policy, Great Salt Lake interests, water rights

### Contact:

**Courtney Flint**
435.797.8653
courtney.flint@usu.edu

### Publication:

B.M. Holdaway (2025). *Risk Perceptions and Water Governance: Experiences of Irrigation Companies in the Great Salt Lake Basin of Northern Utah, United States*. All Graduate Theses and Dissertations, Fall 2023 to Present. 509. https://digitalcommons.usu.edu/etd2023/509

### Date Set:

B. Holdaway, C.G. Flint (2025). *Utah Irrigation Companies in the Great Salt Lake Basin - Interviews and Surveys*. HydroShare. http://www.hydroshare.org/resource/8e57a8a77b8143bab76b12546b89b33b

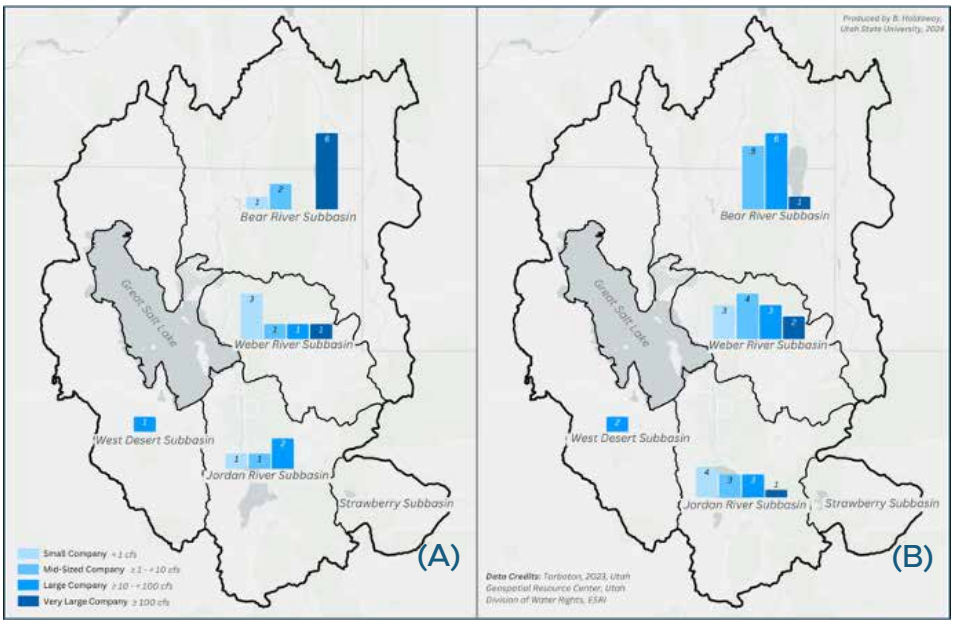
perceptions, decision-making, their perceived seat at the table, and their integration of the Great Salt Lake into their water management actions.

## What we found

Findings show that local water management organizations are multifaceted and diverse. These entities work to conserve water and become more efficient. However, different perspectives arose about the Great Salt Lake, highlighting the need for more dialogue and understanding between local water management organizations, the public, and policymakers. One-size-fits-all approaches to solving water management challenges will be ineffective and will likely isolate local water management organizations, decreasing the opportunity for collaboration and interactive capacity.

## Work plan FY 25–26

This project is nearing completion. We will briefly explore special service districts to further our understanding of their role in local water management organizations as well as their relationship with other entities. One paper from this research is under review and another is in preparation, with expectations to submit in early 2026.




*(A). Irrigation company interview participation counts, and (B) Irrigation company survey participation counts.*

### Presentations:

- B. Holdaway, C. Flint (2025). *Trying to be 'at the table' instead of 'on the menu': Irrigation Company Perspectives on Managing Water in Utah*. International Association for Society and Natural Resources, Vancouver, Canada. June 2025, oral.
- C Flint, B. Holdaway. *Diverse Perspectives Among Municipal Water Managers in Utah.* International Association for Society and Natural Resources, Vancouver, Canada. June 2025, oral.
- B. Holdaway, C. Flint. *Data Complexities with Irrigation Company Water Rights in Utah, USA*. USU Spring Runoff & Northern Utah Water Users Conference in Logan, Utah. March 2025, poster.
- C. Flint, B. Holdaway, A. Alvord. *A Survey of Utah Municipal Water Managers on Priorities and Challenges.* USU Spring Runoff & Northern Utah Water Users Conference in Logan, Utah. March 2025, oral.
- B. Holdaway. *Conservation efforts of Irrigation Companies in the Great Salt Lake Basin*. Salt Lake County Watershed Symposium, West Valley, Utah, November 2024, oral.
- B. Holdaway. *Urban and Rural Local Water Management Organizations in the Great Salt Lake Basin, Utah, USA: Perceptions and Adaptions to Water Challenges*. Rural Sociological Society Conference, Madison, Wisconsin, July 2024, paper.

# Logan River Observatory (LRO)

## Research Summary:

The Logan River Observatory (LRO) provides long-term, comprehensive hydrologic data to inform local and statewide water management decisions based on Utah-specific hydrologic research. It also serves as an outdoor laboratory for training the next generation of engineers and scientists who will become Utah's future water managers. Detailed watershed data (discharge, water quality, climate) combined with growing expertise allow us to (1) address existing Utah water issues, (2) support new research to advance understanding of Utah's watersheds, and (3) prepare for future water supply challenges.

### Why this research?

In 2012, $20 million in National Science Foundation (NSF) funds were awarded to Utah State University and other Utah universities to establish a monitoring network in the Logan River and two other Utah watersheds. When the State of Utah became ineligible for EPSCoR funding and NSF's ongoing maintenance and operations support of these stations ended, the Logan River Observatory (LRO) was established. The Logan River monitoring network was expanded to include 21 discharge stations, 6 full water quality stations, 14 partial water quality stations, 5 full climate stations, and 2 partial climate stations, making it one of the most highly instrumented watersheds in the US. This infrastructure and the associated data position Utah as a national leader in water-related research and the development of innovative water management approaches in water-scarce regions. Through integration of research, teaching, and collaboration with community members and local and state government entities, LRO supports critical water management decision making statewide.

### Utah impact

LRO data are critical for understanding water supply and water quality monitoring in northern Utah and the Great Salt Lake basin. The Logan River watershed spans wilderness, Forest Service, urban and agricultural areas, so the lessons learned and methods developed are highly transferrable to watersheds throughout Utah and the western US.

The LRO meets many identified water management needs across the state: Utah Division of Water Resources uses LRO flow and water quality data for water management and potential water development projects within the Logan River basin. These data are critical for quantifying the water entering the Bear River and eventually the Great Salt Lake. Utah Division of Water

### Principal Investigators:

Bethany Neilson (PI)
Jeffery S. Horsburgh (Co-PI)
Patrick Strong (Co-PI)
Abby Johnson (Co-PI)

### Students:

Hyrum Tennant (PhD)
Michael Lasswell (PhD)
Devon Hill (MS/PhD), Braedon Dority (MS), Abby Johnson (BS/MS), Marie Foster (BS), Brook Bondley (BS), and other students listed at: https:/LRO.usu.edu

### Research Collaborators:

Local: Logan City, Cache Water District

State: Utah Divisions of Water Resources and Water Quality

Federal: USGS Utah Water Science Center

### Geographic Areas:

Study Areas: Logan River watershed

Areas Benefited: The information gained and methods developed are applicable to the entire State of Utah and similar watersheds in the western US

### Contacts:

**Bethany Neilson**
435.797.2772
bethany.neilson@usu.edu

**Jeffery Horsburgh**
435.797.2946
jeff.horsburgh@usu.edu

Website:

https://lro.usu.edu

Publications:

13 publications in scientific journals and theses/dissertations. See the LRO website at https://uwrl.usu.edu/lro/research/publications

Presentations:

21 oral and poster presentations at local, state, and national conferences and meetings. See the LRO website at https://uwrl.usu.edu/lro/research/publications

Reports:

6 reports to stakeholders, including to US Forest Service, Utah divisions of Water Rights and Water Resources, Utah legislature, and Utah's governor at https://uwrl.usu.edu/lro/research/publications

Media Coverage:

11 written and video news articles, about Logan River Observatory work are available at: https://uwrl.usu.edu/lro/news/

## Work plan FY 25–26

We will continue data collection to support ongoing research, including refining methods of data collection and dissemination as we update our data interface tools. We will also continue to support new proposals that will focus research efforts in the Logan River watershed and utilize the Logan River Observatory data.

Rights, working with the LRO, has expanded gaging in the Logan and other watersheds to facilitate water-related communication with the public and water managers. Utah Division of Water Quality will use LRO data to assess compliance with state water quality standards, determine funding needs for additional stream restoration projects, and identify and address water quality problems. Cache County Water Conservancy District and Logan City use LRO data to monitor drinking water source status and protection, inform stormwater management, and meet their missions of protecting and managing Cache County water resources.

## What we did

Long-term legislative funding and local support have strengthened partnerships and enabled projects such as (1) supporting Logan City and the Great Salt Lake basin in anticipating changes to water availability in the Logan River and similar regional watersheds with changing snow patterns via a related NSF-funded research grant that uses LRO monitoring infrastructure; (2) working with various Logan River stakeholders to determine appropriate minimum instream flowrates needed to maintain instream temperatures when redesigning a primary diversion structure and addressing fish passage concerns; (3) assisting canal companies in understanding flow rates and groundwater exchanges with nearby streams and rivers when considering piping options in Cache Valley; (4) collaborating with USGS and University of Utah to investigate groundwater recharge across Cache Valley and (5) working with the Division of Water Rights to further understand the challenges associated with gaps in gaging infrastructure and shepherding leased water through distribution systems to downstream locations (e.g., the Great Salt Lake).

## What we found

We continue to improve, maintain, relocate and expand the number of LRO sites; maintain and update the LRO website; refine quality control procedures; publish real-time flow data online; involve faculty and staff and support and train students in research (https://uwrl.usu.edu/lro/research/projects and https://uwrl.usu.edu/lro/people/students); expand collaborator networks; and encourage use of LRO data in research and teaching (~12 upper division/graduate classes with ~300 students, Senior Design projects, and graduate and undergraduate research efforts currently use LRO data, see https://uwrl.usu.edu/lro/resources). Many local water-related management questions rely fully or in part on LRO data.

# Modernized Standards and Tools for Sharing and Integrating Real-Time Hydrologic Observations Data

## Research Summary:

UWRL researchers built on years of experience with Hydrologic Information Systems (HIS) development to advance software tools that enable the day-to-day operational work of running streamflow gages and other environmental monitoring sites. These tools help in collecting data, managing the data, sharing data in interoperable formats, and in producing data products that can be used for modeling and decision making.

### Why this research?

Collecting, managing, and sharing environmental sensor data require hardware and software that support the day-to-day data management needs of scientists and practitioners operating environmental sensor and datalogger networks. The large data volume makes it a challenging to produce high-quality data products for operational, scientific, or decision-making contexts. Issues include field data retrieval, provisioning performant storage, metadata creation, mediation across diverse formats, standards (or lack of standards), protocols, and vocabularies used by various sensor and datalogger manufacturers, as well as data quality control, versioning, and data repository integration for sharing and publication. Existing software solutions are often outdated, leaving few reliable options for sensor data management that meet these needs. Commercial systems are often costly or tied to specific datalogger/sensor manufacturers, limiting interoperability for more diverse sensor deployments. Additionally, emerging Internet-of-Things-(IoT)-based data collection methods and devices, along with new standards for collecting, describing, and sharing sensor data, including the Open Geospatial Consortium's (OGC) SensorThings standard, improve interoperability but lack robust software implementations for easy adoption.

HydroServer, the open-source platform developed in this project, enables collection, storage, management, and sharing of data from sensors deployed at environmental monitoring sites. HydroServer also offers web-based management of sensor data, integrates OGC's SensorThings application programming interface and data model for automated data loading and querying, supports commercial cloud deployment, and integrates with the HydroShare repository for data sharing and archiving.

### Utah impact

Utah agencies, such as divisions of Water Rights, Water Resources, and Water Quality, operate or collaborate in operating continuous stream, canal, groundwater well, or water diversion monitoring stations that produce large volumes of hydrologic data. HydroServer can be used directly by state agencies


### Principal Investigator:

Jeffery S. Horsburgh (PI)

### Students:

Ehsan Kahrizi (PhD)
Sajan Neopane (MS)

### Research Collaborators:

National: Cooperative Institute for Research to Operations in Hydrology (CIROH)

State: State of Utah Division of Water Rights

### Geographic Areas:

Study Areas: Computer-based research

Areas Benefited: Research groups, local, state, and federal agencies, and many other organizations nationwide

### Contact:

**Jeffery S. Horsburgh**
435.797.2946
jeff.horsburgh@usu.edu


### Website:

HydroServer Software Open Source Code Repositories: https://github.com/hydroserver2

### Publications:


- J.S. Horsburgh, K. Lippold, D.L. Slaugh, M. Ramirez (2024). *HydroServer: A software stack supporting collection, communication, storage, management, and sharing of data from in situ environmental sensors*, Environmental

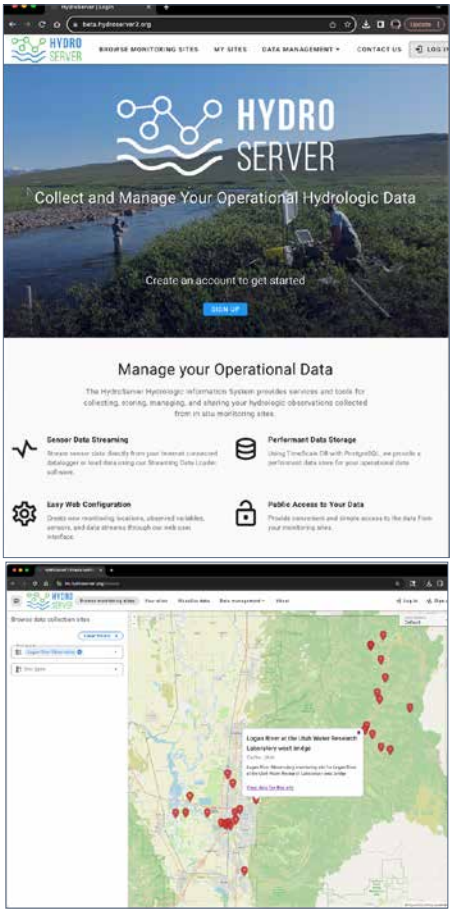
Modelling & Software, 106637, https://doi.org/10.1016/j.envsoft.2025.106637

- J.S. Horsburgh, K. Lippold, D.L. Slaugh (2025). *Adapting OGC's SensorThings API and data model to support data management and sharing for environmental sensors*, Environmental Modelling & Software, 183, 106241, https://doi.org/10.1016/j.envsoft.2024.106241
- A. Spackman Jones, J.S. Horsburgh (2025). *Hydrologic Information Systems: An Introductory Overview*, Environmental Modelling & Software, 106308, https://doi.org/10.1016/j.envsoft.2024.106308

### Presentations:

- J.S. Horsburgh, K. Lippold, D. Slaugh, M. Ramirez (2025). *Modernized standards and tools for sharing and integrating real-time hydrologic observations data*, Cooperative Institute for Research to Operations in Hydrology (CIROH) Annual Science Meeting, Tuscaloosa, AL, September 15-18
- E. Kahrizi, J.S. Horsburgh (2025). *Developing benchmark datasets for testing automated sensor data quality control algorithm performance*, USU Spring Runoff Conference, Logan, UT, March 25-26
- J.S. Horsburgh, K. Lippold, D. Slaugh (2024). *HydroServer: Advancing Software for Standards-Based Collection, Management, and Sharing of Environmental Sensor Data*, American Geophysical Union Fall Meeting, Washington, DC, 9-13 December, https://doi.org/10.22541/essoar.173457138.88670214/v1

or serve as a model that can be used by those agencies to develop their own data management and sharing systems. For example, in an ongoing project funded by Utah Division of Water Rights, USU has deployed the HydroServer software to help Water Rights modernize their statewide water use data collection system.




*HydroServer HIS website.*

## What we did

We (1) published three papers: one describing the HydroServer software, including a synthesis paper of existing HIS technologies and systems, one describing HydroServer's architecture, and one describing HydroServer's web services; (2) completed HydroServer software development and hosted it in open-source code repositories, (3) developed deployment scripts to automate the HydroServer software to commercial cloud computing platforms; (4) deployed and maintained instances of the HydroServer software stack to manage data for the Logan River Observatory (LRO), Utah Division of Water Rights, and multiple developing countries in Africa in collaboration with the World Meteorological Organization; and (5) trained multiple students on the technical skills for sensor data management and operation of Hydrologic Information Systems.

## What we found

HydroServer software meets the data management needs of organizations that operate continuous environmental monitoring sites such as streamflow gages, diversion measurement stations, water quality stations, and weather stations. HydroServer is scalable from few sites to hundreds or even thousands of sites through deployment in the in the commercial cloud (e.g., using Amazon Web Services or Google Cloud Platform). HydroServer meets the data management needs of Utah agencies, including the Division of Water Rights, which is now using HydroServer to modernize their measurement data management systems.

## Work plan FY 25–26

This project is complete.

# Pelican Lake Subsurface Drip Irrigation Pilot Program

## Research Summary:

We estimated crop water use for subsurface-drip-irrigated alfalfa compared to center-pivot-irrigated alfalfa near Pelican Lake in Utah. We are quantifying all major components of a root zone water balance (water in and water out of the soil that plant roots can access). This is the most carefully controlled comparison of subsurface drip irrigation to a conventional irrigation method in Utah to date.

### Why this research?

Studies in California, Kansas, and elsewhere have provided evidence that converting agricultural irrigation systems to subsurface drip irrigation (SDI) may be a possible means to reduce consumptive water use in irrigated agriculture. However, no data are currently available on consumptive water use of alfalfa or other forage crops irrigated with SDI in Utah and surrounding areas. We are seeking to fill this gap and find out if SDI could become part of Utah's Colorado River water management efforts.

Figure 1: *Subsurface drip irrigation line at the Pelican Lake pilot site.*

### Principal Investigators:

Burdette Barker (PI)
Alfonso Torres-Rua (Co-PI)

### Research Collaborators:

Farmers in Randlett, UT: Utah Geological Survey; AES International; Jacobs Engineering Group

### Student:

Preston Hodnett (MS)

### Funding Sources:

Central Utah Water Conservancy District and Colorado River Authority of Utah

### Geographic Areas:

Study Areas: Uintah Basin, UT

Areas Benefited: Utah and Intermountain West

### Contacts:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

### Outreach Workshops:

We hosted five workshops on subsurface drip irrigation that indirectly relate to this project.

- B. Barker. *Chemigation Safety and Irrigation Research Updates*. Sevier County Winter Crop Workshop, Richfield, UT. January 16, 2025
- B. Barker. *Irrigation Research Updates*. Carbon County Winter Crop Workshop, Price, UT. February 19, 2025
- B. Barker. *Irrigation Research Updates and the AG-DRIP Program*. Daggett County Crop School, Manilla, UT. February 25, 2025
- B. Barker. *Irrigation Research Updates and the AG-DRIP Program*. Uintah Basin Crop School, Vernal, UT. February 26, 2025
- B. Barker. *Getting the Most from Your Water Use*. Weber County Crop School, Washington Terrace, UT. February 27, 2025

## Utah impact

If SDI is proven to reduce crop water use per unit crop produced in Utah, it will be a potential tool to help farmers and policymakers maintain viable agriculture with limited water resources.

## What we did

We are measuring crop water use (evapotranspiration) using the eddy covariance method (a standard method). We are measuring soil water content to estimate drainage below the crop roots, enabling us to quantify irrigation efficiency. We are also measuring applied irrigation and yield.

## What we found

We have not processed the 2025 data yet. However, this is the most comprehensive dataset to date for subsurface drip irrigation water use in Utah.

## Work plan FY 25–26

This work will continue in the 2026 crop season.

**Figure 2:** *Soil moisture measurement site immediately after installation in one of the study fields.*

# Predicting Physical Water Quality

## Research Summary:

Fine sediment transport affects water quality, habitat, and storage. We analyzed over 40 years of USGS data from more than 1,000 rivers to create physical models for predicting sediment yield using parameters derived from geospatial and satellite data.

### Why this research?

Suspended sediment represents a critical water quality concern. Both too much and too little can be detrimental or beneficial to aquatic life, while high concentrations are detrimental for water intake structures and reservoir infilling. Predicting suspended sediment remains highly challenging across the range of scales (watershed to basin) where actionable information is needed.

### Utah impact

This project is in relatively early stages; however, the research will provide a framework and methodology for predicting suspended yields across the state, especially upstream of reservoirs and downstream of dams.

### What we did

We utilized modern and historic US Geological Survey measurements of suspended sediment concentration data from across the continental United States (CONUS) to develop a model for probabilistic predictions of sediment yield at annual to longer timescales. We then utilized publicly available geospatial datasets from across the CONUS region to determine if and how accurately the necessary model parameters can be estimated. To understand highly dynamic situations, we have begun exploring prediction of sediment yields following dam removal and throughout watersheds by leveraging satellite derived observations of water color, which strongly correlates with suspended sediment concentration.

### What we found

The CONUS-wide analysis of suspended sediment concentrations revealed a common probability distribution across the over 1,000 sites, highlighting that the frequency of low and high concentrations can be predicted. A simple model with two parameters can be used to create predictions of sediment yield at yearly timescales. These parameters can be estimated throughout a river network from geospatial watershed attributes or from remotely sensed observations of water color. For sub-yearly timescales, we've identified that

Principal Investigator:

Colin Phillips (PI)

Student:

Aaron Sigman (PhD)
Michaela Shallue (PhD)

Funding Source:

National Oceanic and Atmospheric Administration (NOAA) through the Cooperative Institute for Research to Operations in Hydrology (CIROH) at the University of Alabama.

Geographic Areas:

Study Areas: Continental United States with a specific focus on the Colorado and Green Rivers

Areas Benefited: Statewide, The Colorado and Green rivers within Utah and Colorado

Contact:

**Colin Phillips**
435.797.0938
colin.phillips@usu.edu

a simple rating curve can be used to convert water discharge to suspended sediment concentration at many sites and more dynamic rating curves may be needed following large perturbations such as dam removal or wildfire. However, this analysis indicates that many of these rivers are transporting the finest particles well under capacity, highlighting an emerging water quality management priority as erosion from intensifying precipitation due to hydroclimatic change and increasing wildfire could dramatically increase the supply of fine particles to rivers within watersheds.

## Work plan FY 25–26

This project is currently working towards leveraging satellite imagery across the continental United States to predict and eventually forecast suspended sediment concentration and load in near real time.

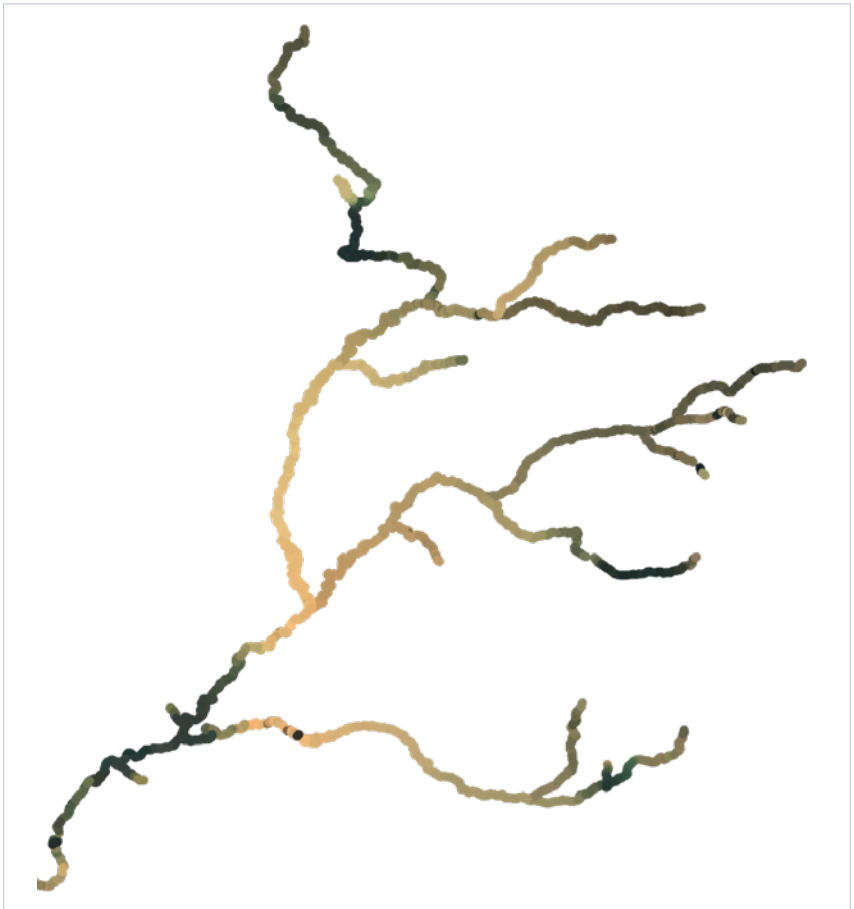


**Figure 1:** *Average summer water color for the Colorado, Little Colorado, and Green Rivers based on over 30 years of satellite observations. The water color has a direct correlation with suspended sediment concentration and yield.*

### Presentations:

- A. Sigman and C.B. Phillips (2025), *Understanding Suspended Sediment Concentration Dynamics in River Corridors Through High-Resolution Geospatial Analysis*, 2025 General Assembly, EGU, Vienna, Austria.
- M. Shallue and C.B. Phillips (2025), *Dam Removal Reveals Influence of Sediment Availability on Transport Dynamics*, Spring Runoff & Northern Utah Water Users Conference, Utah State University
- M. Shallue and C.B. Phillips (2024), *Dam Removal Reveals Influence of Sediment Availability on Transport Dynamics*, 2024 Fall Meeting, AGU.
- A. Sigman and C.B. Phillips (2024), *Climate, Soil, and Vegetation Predict Continental Patterns in Suspended Sediment Concentration*, 2024 Fall Meeting, AGU
- C.B. Phillips, A. Sigman, J. Gardner, D. Horton, and A. Packman (2024), *River Self-Organization Enables the Prediction of Watershed Fine Particle Yields*, 2024 Fall Meeting, AGU

# Post-Fire Runoff and Sediment Hazards: Predicting, Mitigating,a and Planning for Downstream Impacts to Transportation Infrastructure

## Research Summary:

This research addresses the growing threat of post-wildfire flood and sediment hazards to transportation infrastructure in the western U.S. We are developing machine learning models and geospatial toolkits to predict both direct and downstream risks over management-relevant time scales. By integrating wildfire severity, hydrology, and sediment transport processes, these tools will enable proactive planning and rapid post-fire assessments, helping state agencies prioritize infrastructure investments, mitigate hazards, and improve long-term resilience against wildfire-driven runoff and sediment impacts.

### Why this research?

Wildfires dramatically alter watershed conditions, increasing runoff and triggering erosion and debris flows that can deliver large volumes of sediment to rivers and transportation corridors. These impacts are not limited to the immediate aftermath: sediment can continue moving downstream for years, threatening bridges, culverts, and roadways. Current tools often focus on direct impacts near burned areas, leaving a critical gap in predicting secondary, routed sediment hazards over time. Addressing this gap is essential for transportation agencies to plan infrastructure upgrades, reduce maintenance costs, and protect public safety in fire-prone regions

### Utah impact

Utah's mountainous terrain and expanding wildfire risk make its transportation network and aquatic ecosystems highly vulnerable to post-fire sedimentation. Events like the Twitchell Canyon Fire have demonstrated how sediment can impact aquatic habitat after a fire. The proposed models and toolkits could allow state agencies to identify high-risk transportation corridors and aquatic habitat, prioritize mitigation measures, and coordinate with federal partners. Improved

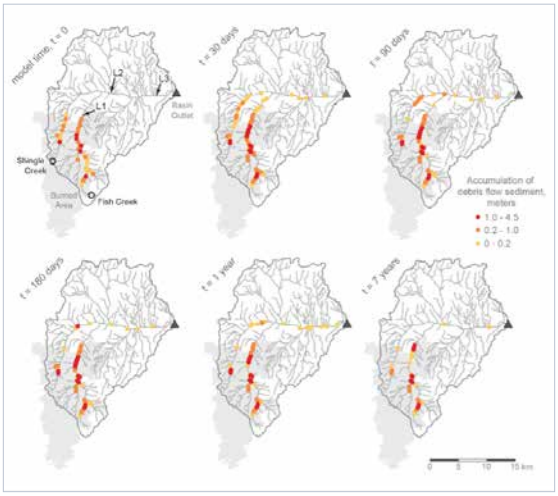



**Figure 1:** *Example simulations from previous work in Twitchell Canyon Fire, UT (Murphy et al. 2019). Starting with modeled estimates of post-fire sediment inputs (at t = 0; upper left), sediment "parcels" of different grain sizes were routed through the river network using transport equations and daily streamflow over 7 years following the sediment inputs. Each panel displays snapshots of the model run over time with locations and depths of sediment accumulation.*

Principal Investigator:
Belize Lane (PI)

Student:
Haley Canham (PhD)

Research Collaborator:
Colorado Department of Transportation

Funding Source:
Colorado Department of Transportation

Geographic Areas:
Study Areas: Colorado
Areas Benefited: Colorado and the western US including Utah

Contact:

**Belize Lane**
435.797.4145
belize.lane@usu.edu

Publication:

H. Canham, B. Lane, C.B. Phillips, B.P. Murphy (2025) *Leveraging a time-series event separation method to disentangle time-varying hydrologic controls on streamflow - application to wildfire-affected catchments*. Hydrology and Earth System Sciences. https://doi.org/10.5194/hess-29-27-2025

## Work plan FY 25–26

Future work includes:

- Integrating Models: Combine direct and downstream risk prediction tools into a unified geospatial platform.
- Expanding Case Studies: Apply models to additional watersheds to validate performance under diverse conditions.
- Enhancing User Interface: Develop a graphical interface for CDOT and partner agencies to streamline risk assessments.
- Planning Scenarios: Incorporate climate-driven wildfire and rainfall projections to support long-term infrastructure planning.
- Training and Deploying: Conduct workshops with transportation agencies to implement tools for both pre-fire planning and post-fire emergency response.

predictive capabilities could support both rapid post-fire response and long-term planning for critical corridors such as I-15 and I-70, reducing economic and safety impacts statewide.

## What we did

This project is combining several complementary efforts: predicting direct sedimentation impacts, downstream flooding and sedimentation impacts, and pre-wildfire sediment planning. We are developing machine learning models to forecast post-fire streamflow changes and burn severity, then integrating these with sediment transport simulations to estimate time-varying sediment accumulation at downstream infrastructure sites. We are also building geodatabases of past sedimentation events and automated GIS tools to rapidly assess direct post-fire debris flow risks along transportation corridors. These tools will use publicly available datasets and burn severity maps to identify catchments likely to generate debris flows under different rainfall scenarios. Both projects emphasize user-friendly interfaces and automation to reduce manual processing and enable rapid deployment after wildfire events.

## What we found

Our preliminary models demonstrate that post-fire sediment routing can continue for five or more years post-fire, with significant deposition risks at downstream culverts and bridges. The geospatial toolkit successfully automates catchment delineation and debris flow risk mapping, reducing analysis time from days to hours. Outputs include sediment depth and grain size predictions, debris flow probabilities, and rainfall intensity thresholds for triggering flows. These capabilities will help agencies prioritize infrastructure upgrades and emergency response actions, improving resilience and reducing costs.

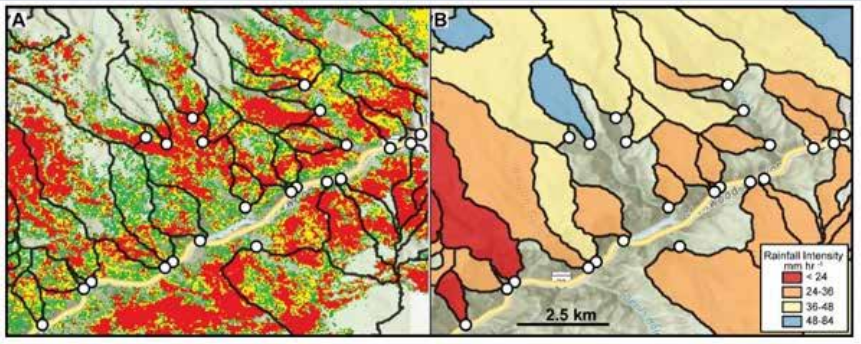



**Figure 2:** *Example of automated catchment delineation and debris flow risk assessment along I-70 using burn severity data from the Grizzly Creek Fire. White dots show outlet points and catchments are outlined in black. A) Catchment delineation overlaid with burn severity map. B) Post-fire debris flow risk map based on burn severity (panel A), showing 15-min rainfall intensity thresholds predicted to produce a debris flow.*

# Quantifying Dynamic River Gains and Losses Using Inverse Water Temperature Modeling

## Research Summary:

This research focused on developing a method for quantifying unmeasured gains and losses (lateral flow) to streams using water temperature modeling. The work utilized flow and temperature data collected along a section of river in Logan Canyon where significant gains and losses driven by groundwater are known to occur. The results demonstrated the important role unmeasured gains and losses play in regulating river flow and temperature, particularly in karst mountain watersheds like those in the Bear River range.

### Why this research?

Quantifying dynamic lateral gains and losses (net lateral flow) in river systems is critical for effective water resource management but is challenging in complex systems, such as those with significant unmeasured groundwater-surface water interactions like the Logan River. Traditional methods for estimating net lateral flows are often logistically intensive, expensive, and limited in their temporal and spatial scope, making it difficult to understand changes in flow regimes and the associated shifts in the stream ecology over time and space.

### Utah impact

Improving the identification and quantification of lateral flows helps refine conceptual models of river flow regimes and provides valuable insights for current and future water resource planning. This approach is also transferable to other complex river systems across Utah. In the case of the Logan River, karst geology plays a major role in shaping the river's flow dynamics, as groundwater lateral flows represent a dominant component of the river flow. By better quantifying these lateral flows, predictions of river temperature patterns and in-stream water quality can also be enhanced. Because lateral flows, particularly cold groundwater inflows, strongly influence a river's thermal characteristics, quantifying and monitoring their effects enables resource managers to better assess ecological conditions and make more informed management decisions.

### What we did

An inverse water temperature modeling approach was used to estimate lateral inflows and outflows over time. The approach utilized the fact that large lateral water exchanges (like cold groundwater inflows) create detectable shifts in river temperature.


### Principal Investigators:

Bethany Neilson (PI)
Tianfang Xu (ASU PI Lead)
Dennis Newell (USU Geosciences, Co-PI)
Jim McNamara (BSU, Co-PI)

### Research Collaborators:

Local: Logan City, Cache Water District

### Students:

Hyrum Tennant (PhD)
Devon Hill (MS)



### Funding Source:

NSF grant #2044051 and 2043150, UWRL


### Geographic Areas:

Study Areas: Logan River Watershed

Areas Benefited: Logan City, Cache County, similar watersheds in State of Utah and the western US


### Contact:

**Bethany Neilson**
435.797.7369
bethany.neilson@usu.edu

## Publication:

H. Tennant, B.T. Neilson, D. Hill, D. Newell, T. Xu, (In Review). *Quantifying Dynamic River Gains and Losses Using Inverse Water Temperature Modeling*. Water Resources Research.

## Presentations:

- H. Tennant, B.T. Neilson, D. Hill, D. Newell, T. Xu, 2025. *Estimating Dynamic Gains and Losses to Rivers Using Temperature Models*. 2025 USU Spring Runoff Conference and Northern Utah Water Users Conference. March 25-26, 2025. Logan, UT
- B.T. Neilson, H. Tennant, D. Hill, D. Newell, J. McNamara, T. Xu, 2025. *Quantifying Dynamic River Gains and Losses Using Inverse Temperature Modeling*. GSA Connects 25. October 19-22, 2025. San Antonio, TX

We deployed inexpensive temperature loggers along a 25-km section of the Logan River and calibrated a one-dimensional water temperature model using flow data from a two-day low-flow seepage study from October 2022. The calibrated model was then applied retrospectively over a five-month period (to May 2022) to estimate lateral inflows and outflows by adjusting the lateral flow quantities in discrete sections until modeled temperatures aligned with observed river temperature values. Analyses were conducted at three resolutions (low, medium, high) corresponding to the different numbers of temperature sensors in the river (3, 6, and 10).

## What we found

The high-resolution model, using 10 temperature sensors, most accurately reflected conditions observed during synoptic sampling events where lateral flows were measured. The medium-resolution model also performed well, showing significant improvement over the low-resolution model. Importantly, the high-resolution model identified areas where unmeasured springs and hidden groundwater gains and losses to the river play a critical role in maintaining cool temperatures and suitable fisheries habitat in the Logan River.

## Work plan FY 25–26

This project is complete.

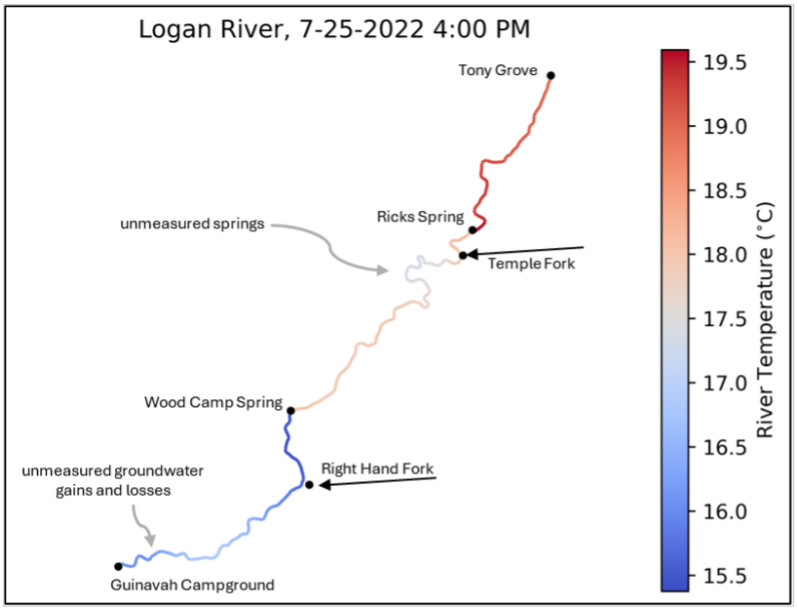



**Figure 1:** *Modeled water temperature for the studied 25-km section of Logan River on July 25th, 2022, at 4:00PM. Black dots indicate locations where water temperature and flow are measured by Logan River Observatory gages. The immediate cooling downstream of Ricks Spring and Wood Camp Spring is apparent, but additional cooling is observed due to unmeasured springs below Temple Fork and groundwater exchanges with the river above Guinavah Campground identified and quantified by the model.*

# Quantifying the Rate of Future Decline of the Great Salt Lake's Water Level


## Research Summary:

The Great Salt Lake's future water level remains uncertain, with predictions indicating a continued decline due to a combination of human diversions and climate variability. This research uses groundwater models and total water storage projections to quantify future trajectories of the lake's decline and aims to communicate the nuanced risks associated with this decline, emphasizing the importance of both stochastic variability and long-term climate trends.


### Why this research?

The Great Salt Lake, the largest endorheic lake in the western hemisphere, has been experiencing a significant decline in water levels, exacerbated by human activities and climatic changes. Understanding the rate of and potential future decline is crucial for ecological preservation and mitigating the environmental risks, including ecosystem collapse and health hazards from exposed lakebed toxins.

### Utah impact

The research informs water management decisions that are critical to sustaining local agriculture, wildlife, and tourism. The lake supports over 10 million migratory birds and contributes to regional snowpack, which is essential for water supply. Insights from the study can help policymakers mitigate risks, improving the long-term sustainability of Utah's water resources.

### What we did

The study combined historical observations from the USGS National Water Information System and simulations from the CESM2 Community Land Model to project lake level trends under future climate scenarios (SSP370). Groundwater data from 66 wells within the lake's watershed were used to explore the relationship between groundwater recharge and lake level fluctuations.

### What we found

The projections suggest a continued, gradual decline in lake water levels, with potential critical low points being reached within the next few decades. While complete desiccation is unlikely before 2100, the risks associated with reduced lake levels remain substantial, including increased dust storms and loss of habitat for migratory birds.


### Principal Investigator:

Simon Wang (Plants, Soils and Climate, PI)

### Students:

Matthew LaPlante (PhD)
Piyush Dahal (PhD)

### Geographic Areas:

Study Areas: Great Salt Lake watershed

Areas Benefited: State of Utah

### Contact:

**Simon Wang**
435.797.3121
simon.wang@usu.edu

## Publication:

M.D. LaPlante, (2025) *Climate Prediction as an Adaptive Force-Multiplier: Reasons for Hope in a Rapidly Changing World"* (2025). All Graduate Theses and Dissertations, Fall 2023 to Present. 389. https://digitalcommons.usu.edu/etd2023/389 and https://doi.org/10.26076/e59c-0b92

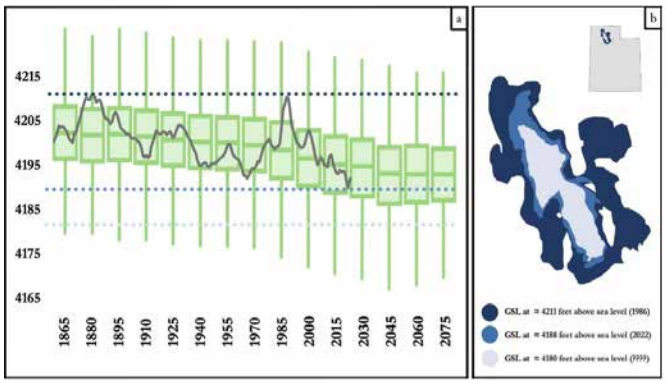



**Figure 1.** *(left) A historical simulation and future projection for the Great Salt Lake's elevation (GSLE), derived from the CESM2 Community Land Model (CLM) hydrologic variables of Volumetric Soil Moisture (Purple box and whisker plot), and Total Water Storage (green box and whisker plot). The data are computed every 25 years, with 100 members each using quantile mapping. The top (bottom) of each whisker represents the maximum (minimum) modeled outcome; the top (bottom of each box represents the 75th (25th) percentile: and the line within the box represents the median value. The gray line is the annual average elevation of the Great Salt Lake, and the dark, medium and light blue dotted lines represent GSLE at 4,211, 4,188, and 4,180 feet, respectively. (right) The Great Salt Lake at its observed historic high in 1986 (dark blue), observed historic low in 2022 (medium blue), and minimum future low as modeled by the CML's hydrological variables (light blue).*

## Work plan FY 25–26

The research is complete.

# Sevier River Gap Analysis

## Research Summary:

This project is enhancing water supply resiliency within the Sevier River Basin by identifying data gaps through a comprehensive review of current gaging and telemetry infrastructure. This analysis incorporates local stakeholder input to identify opportunities for increased water data transparency and to promote increase information sharing among diverse water user groups.

### Why this research?

Gaging infrastructure in the Sevier River Basin is a critical component of managing and maintaining the resiliency of Utah's water supply by providing an understanding of how water moves through the basin. However, data gaps emerging from missing or limited measurement infrastructure impact effective water distribution, management, and planning.

### Utah impact

The Gap Analysis will provide a comprehensive review of existing water measurement infrastructure in the Sevier River Basin and will identify and prioritize additional measurement needs. This will support the need for timely and accurate information by local stakeholders and the Utah Division of Water Rights. The analysis will also inform the future measurement infrastructure planning that is critical for addressing current infrastructure gaps in the basin.

### What we did

The purpose of this effort is to evaluate existing stream and diversion measurement infrastructure systems and to document water movement into and out of 20 priority river systems and two canals. For each system, Flow Balance Diagrams are being developed to illustrate water movement and describe the knowledge of local experts regarding system operations. In addition, Gaging Information Worksheets are being created to document the

Figure 1: *The Sevier Valley and Piute Canal and Monroe South Bend Canal near Cove, Utah.*


### Principal Investigator:

Bethany T. Neilson (PI)

### Research Engineers:

Eileen Lukens, Hyrum Tennant, Mia Campbell

### Research Collaborators:

State: Utah Division of Water Rights



### Funding Source:

Utah Division of Water Rights


### Geographic Areas:

Study Areas: Sevier River Basin, Utah

Areas Benefited: Sevier River Basin, Utah


### Contact:

**Bethany T. Neilson**
435.797.7369
bethany.neilson@usu.edu

### Outreach:

Ongoing meetings with the Utah Division of Water Rights representative, the Sevier River commissioners, and other stakeholders.

### Work plan FY 25–26

We are working to finalize results in preparation for annual distribution meetings in February 2026. The report will be finalized and available by June 2025.

status of measurement devices, telemetry, locations, and structures within each system. The project also involves identifying and collecting time series data not currently held by the Utah Division of Water Rights.

Another key component of this work is understanding the measurement gaps identified by local stakeholders within existing water distribution systems and providing an independent analysis of where new or updated measurement infrastructure would be most beneficial. Based on these findings, a prioritized list of recommended improvements will be created to best serve Utah citizens by enhancing water distribution and management. All findings, analyses, and supporting materials will be compiled and presented as part of the final report.

## What we found

Currently, we have completed the primary development of required materials across all systems and are nearing the completion of analysis in 14 of 22 systems.

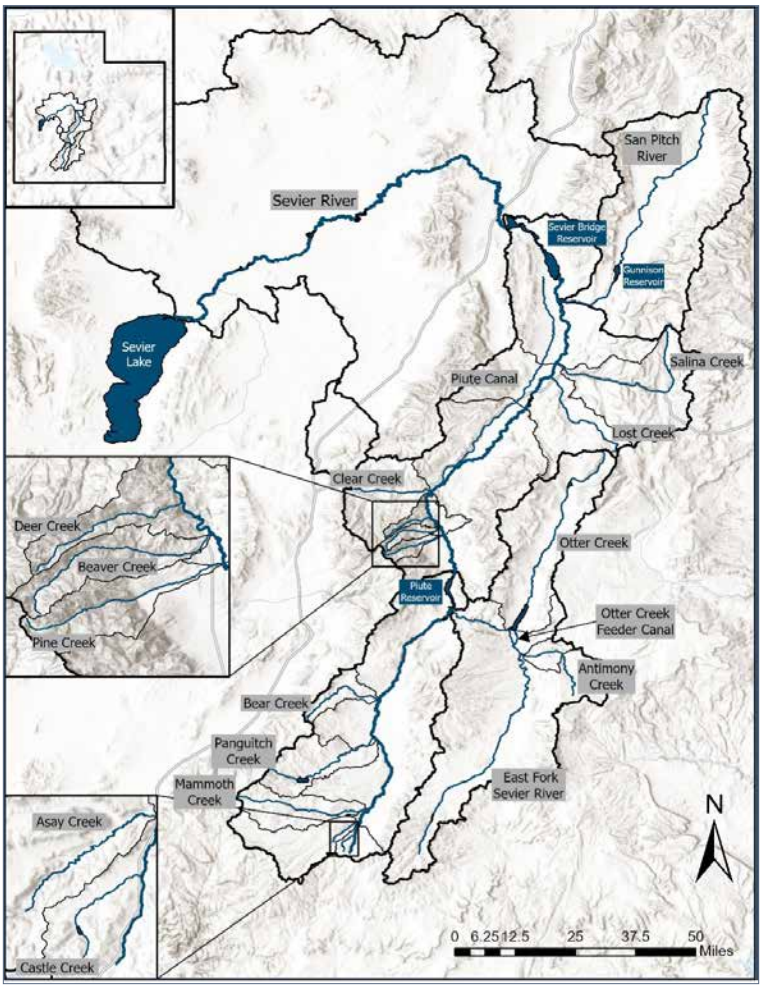



**Figure 2:** *Twenty-two systems included in the Sevier River Gap Analysis.*

# Subsurface Drip Irrigation Evapotranspiration

## Research Summary:

We measured and modeled crop water use for subsurface-drip-irrigated alfalfa and sprinkler-irrigated alfalfa and are currently comparing water use and production. Preliminary results indicate that the subsurface-drip field used more water than the sprinkler field. This is part of a larger effort we are making to understand water use and production related to SDI in different regions of Utah.

### Why this research?

Converting agricultural irrigation systems to subsurface drip irrigation (SDI) has been identified as a possible means to reduce the consumptive water use of irrigated agriculture. Studies in California, Kansas, and elsewhere have provided evidence that this may be the case. However, no data are currently available on consumptive water use of alfalfa or other forage crops irrigated with SDI in Utah and surrounding areas. We are seeking to fill this gap.

### Utah impact

The collected data will help the State of Utah, including the Department of Agriculture and Food's Agricultural Water Optimization Program, to estimate the return on investment in funding SDI systems. The results will also help producers understand water use and production relative to sprinkler irrigation.

### What we did

We used the eddy covariance method, a standard practice method, to measure crop water use (evapotranspiration) from SDI-irrigated alfalfa and sprinkler-irrigated alfalfa in production fields near Richmond, UT. We used our limited dataset to calibrate an evapotranspiration model to extend our period of observation. We also collected yield data. Data were collected during part of the 2024 growing season and modeling occurred 2023 and 2024.

### What we found

Preliminary results indicate that more water was used for the subsurface-drip field than the sprinkler field. We are currently validating these findings.

### Work plan FY 25–26

This work is nearing completion with an MS student expected to finish their thesis in December 2025 and to subsequently prepared for submission to a refereed journal.


### Principal Investigator:

Burdette Barker (PI)

### Student:

Namuna Dhak (MS)

### Research Collaborators:

Industry: Two farmers in Richmond, UT

### Funding Source:

Utah Agricultural Experiment Station

### Geographic Areas:

Study Areas: Cache Valley, Utah

Areas Benefited: Utah and the Intermountain West

### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu


### Outreach Workshops:

We hosted five workshops on subsurface drip irrigation that indirectly relate to this project.

- B. Barker. *Chemigation Safety and Irrigation Research Updates*. Sevier County Winter Crop Workshop, Richfield, UT. January 16, 2025
- B. Barker. *Irrigation Research Updates*. Carbon County Winter Crop Workshop, Price, UT. February 19, 2025

- B. Barker. *Irrigation Research Updates and the AG-DRIP Program*. Daggett County Crop School, Manilla, UT. February 25, 2025
- B. Barker. *Irrigation Research Updates and the AG-DRIP Program*. Uintah Basin Crop School, Vernal, UT. February 26, 2025
- B. Barker. *Getting the Most from Your Water Use*. Weber County Crop School, Washington Terrace, UT. February 27, 2025

### Presentations:

- N. Dhakal, B. Barker, L. Hipps, A. Torres-Rua, and B.T. Neilson. *Measuring Subsurface-Drip-Irrigated Alfalfa Evapotranspiration with Eddy Covariance in the Intermountain West*. College of Engineering Research Week Poster Session, Utah State University, Logan, UT. April 2025
- N. Dhakal, B. Barker, L. Hipps, A. Torres-Rua, and B.T. Neilson. *Measuring Subsurface-Drip-Irrigated Alfalfa Evapotranspiration with Eddy Covariance in the Intermountain West*. Northern Utah Water Users and Spring Runoff Conference, Logan, UT. March 26, 2025.

**Figure 1:** *Eddy covariance measurement system installed at the edge of the SDI-irrigated alfalfa field (foreground) near Richmond, UT.*

# Water Use Assessment in Golf Courses and Urban Green Areas

## Research Summary:

The TURFEX project provides important innovation in the science, methodologies, and tools (drones and satellites) for directly monitoring water use of turfgrass as a major urban vegetation in Utah cities. A main goal of the TURFEX project is generating new knowledge regarding water use tracking that can be extended to other cities across the Western US.

### Why this research?

Water management in urban green areas (such as golf courses and parks) are facing increasing challenges of water shortages and greater plant transpiration as climate changes result in hotter summers and reduced water availability. Efforts to improve urban water management (like USU WaterMAPS https://extension.usu.edu/cwel/watermaps) are becoming more relevant in Utah and across western states. Exploring innovations in science, information, and tools to further adapt recommendations for urban water management are necessary as climate change and water shortages continue. The Turfgrass tree Urban Remote sensing and energy Fluxes Experiment (TURFEX) is using remote sensing sources such as information from drones (USU's AggieAir: https://uwrl.usu.edu/aggieair/) and satellites (OpenET https://openetdata.org/) to quantify water use and turfgrass quality, as well as the relationship between water use and turfgrass quality, and develop recommendations for aesthetic urban turfgrass landscape and water use/irrigation needs.

### Utah impact

Severe drought conditions such as the 2021 water year resulted in severe limitations on the water available to maintain urban green areas across Utah, especially in large city parks and golf courses. These limitations impaired turfgrass regrowth and risked replanting costs, in addition to other negative

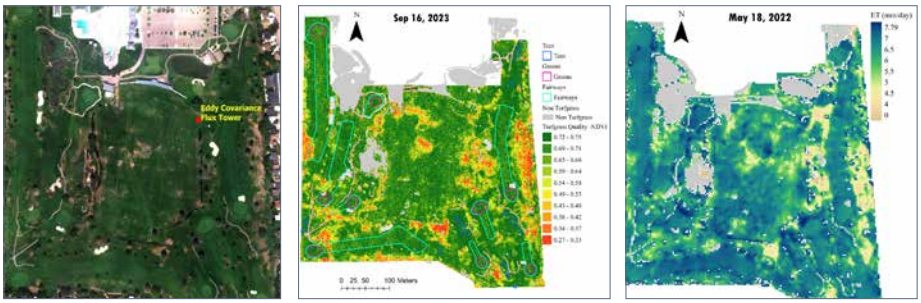



Figure 1: *Eagles Lake Golf Course (left) and example maps of turfgrass quality (middle) and turfgrass water use (evapotranspiration) (right) using drone imagery in 2023.*


### Principal Investigators:

Alfonso Torres-Rua (PI)

Lawrence Hipps (College of Agriculture, Co-PI)

### Student:

Karem Meza (PhD)

### Research Collaborators:

Local: Eagles Lake Golf Course, Roy, UT

USU: Kelly Kopp, USU WaterMAPS, College of Agriculture

Federal: Bill Kustas, Agricultural Research Service - USDA

International: Hector Nieto, Spanish National Research Council, CSIC - Institute of Agricultural Sciences, Spain


### Geographic Areas:

Study Areas: Roy, UT

Areas Benefited: Utah and the western US


### Contacts:

**Alfonso Torres-Rua**
435.797.0397
alfonso.torres@usu.edu

**Lawrence Hipps**
435.797.0209
lawrence.hipps@usu.edu

impacts to human, urban, environmental, and water management services. The work by TURFEX aims to generate information such as (1) the amount of additional irrigation needed to recover brown or yellow turfgrass to a healthy green condition, (2) the locations across the golf course (or park) needing additional irrigation, and (3) the water usage in such areas. With that information, golf course/park managers and city planners can identify opportunities for water conservation or prioritize water application.

## What we did

In early 2021, we installed multiple instruments (eddy covariance system) at the Eagles Golf Course, in Roy, UT, which was selected for its size and project fit. The eddy covariance system is considered the gold standard for plant water use quantification. Several Utah State University students quantified turfgrass quality, obtained drone imagery, developed a collaboration with the OpenET team, and developed models and protocols, which helped us to ensure drone and satellite results are adequate to quantify water use and map turfgrass quality across the golf course area.

## What we found

Based on information from 2021, 2022 and 2023, we confirmed that drone information can adequately describe turfgrass water use and its variability across the golf course. This was more visible in 2022 (extreme drought year), when certain golf course areas were no longer irrigated, and priority was given to others based on water availability. Similarly, we found that turfgrass quality conditions and changes can be adequately quantified by the same drone imagery. These findings open the opportunity to relate water use and turfgrass quality and quantify irrigation needs to maintain and recover healthy green turfgrass conditions.


**Figure 2:** *High (a), intermediate (b), and low (c) turfgrass quality, team preparing an AggieAir drone for flight at Eagles Lake Golf Course (d), and the eddy covariance surface energy balance system (e,f).*

**Figure 3:** *TURFEX logo.*

### Publications:

- K. Meza-Capcha, et al. (2024) *Spatial Estimation of Actual Evapotranspiration over Irrigated Turfgrass Using sUAS Thermal and Multispectral Imagery and TSEB Model*. Irrigation Science. https://link.springer.com/article/10.1007/s00271-023-00899-y
- K. Meza, A.F. Torres-Rua, L. Hipps, K. Kopp, C.M. Straw, W.P. Kustas, L. Christiansen, C. Coopmans, I. Gowing. (2025). *Relating spatial turfgrass quality to actual evapotranspiration for precision golf course irrigation*. Crop Science, 65(1), p.e21446. https://acsess.onlinelibrary.wiley.com/doi/full/10.1002/csc2.21446
- One other article has been submitted to scientific journals for publication.

### Work plan FY 25–26

This project is complete.

# ENVIRONMENTAL

## ACTUAL, BUDGETED AND PLANNED EXPENDITURES OF MINERAL LEASE FUNDS

| ENVIRONMENTAL: PI | Project Name | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|---|
| McLean, J. | Advanced Analytical Support for Research Efforts in Environmental Quality | $159,357 | $164,137 | $169,061 |
| Moor, K. | Biodegradable Mulch Films: Leachate Generation and Impacts on Agricultural Soils | $28,465 | $29,318 | $30,197 |
| Hou, L. | Characterization of Multidrug Resistant Bacteria and Assessment of Natural Antimicrobial Compounds | $92,636 | $95,415 | $98,277 |
| Sims, R. | Clean Water Microalgae for Nutritional Supplement for Meat | --- | --- | --- |
| Su, Y. | Detection and Removal of the Co-Contaminants of Nanoplastics (NPs), Heavy Metals, Per- and Polyfluoroalkyl Substances (PFAS) and Pesticides from Water | $137,862 | --- | --- |
| Young, S. | Evaluating Cyanobacteria and Cyanotoxins in Surface Water Aerosols near Utah Lake | $29,804 | --- | --- |
| Dupont, R. | Evaluating the Presence, Fate and Exposure Pathways of PFAS Compounds in Northern Utah Communities | $24,378 | $17,899 | $18,435 |
| Barker, B. | Irrigation Performance Impacts on Nutrients in Big Creek, Utah | $3,045 | --- | --- |
| Gowing, I | Mapping Invasive Wetland Grass (Phragmites australis) over the Great Salt Lake, Utah, using a small Unmanned Aerial System (sUAS) | $22,895 | --- | --- |
| Gowing, I | Mapping Invasive Wetland Grass (Phragmites australis) over Utah Lake, using a small Unmanned Aerial System (sUAS) | $22,895 | $23,581 | $24,288 |
| Sims, J. | Mitigation of Methane Emissions from Anthropogenic Sources | $14,112 | $14,535 | $14,971 |
| Moor, K. | Pyrogenic Dissolved Organic Matter Photochemistry: Impacts of Wildfires on Surface Water Processes | $14,566 | --- | --- |
| Dupont, R. | Reducing PFAS Contaminants in Municipal Biosolids through High-Temperature Composting | $78,226 | $73,362 | $75,562 |
| Moor, K. | Toxicity Screening of Leachates from Engineered Biocomposites | $54,462 | $56,095 | $57,777 |
| Martin, R. | Vertical Ozone Profiles near the Great Salt Lake | $43,357 | $44,657 | $45,996 |
| | *Undesignated projects in program area* | | *$20,000* | *$20,000* |
| | **TOTALS** | **$726,060** | **$538,999** | **$537,564** |

# Advanced Analytical Support for Research Efforts in Environmental Quality

## Research Summary:

We are developing methods for analyzing contaminants in water, soil, and air. These efforts support the research of faculty and students at the Utah Water Research Laboratory and of various faculty across the USU campus and provide services to state and local agencies in evaluating environmental health.

### Why this research?

The Environmental Quality Laboratory (EQL) provides technology, expertise, services, and training in advanced analytical science supporting today's water and environmental students, researchers, and stakeholders. Environmental research at the EQL emphasizes an integrated engineering and science approach to the environmental quality of land, water, and air. A multidisciplinary group of engineers and scientists conducts basic and applied laboratory and field research aimed at understanding and finding sustainable solutions to water challenges that occur in the innumerable interactions between humans and water. These pressing challenges include: monitoring and preventing harmful algal blooms and cyanotoxin production; evaluating cyanobacteria DNA presence as an early warning of cyanotoxin release; assessing the fate and transport of pharmaceuticals, personal care products, and fluorinated substances in biosolids from wastewater

Figure 1: *Air and water sampling to quantify the amount of cyanotoxins are in the aerosols generated off the surface of Utah Lake.*


### Principal Investigators:

Joan E. McLean (PI)
Xia Li (Co-PI)

### Co-Researchers:

R. Ryan Dupont
Yiming Su
Joanna Hou
Randy Martin
Kyle Moor

### Research Collaborators:

Departments across USU
Bear River Health Department
City of Logan


### Geographic Areas:

Study Areas: All counties in Utah

Areas Benefited: All counties in Utah

Contact:

**Joan E. McLean**
435.797.3199
joan.mclean@usu.edu

## Work plan FY 25–26

We continue to develop advanced analytical methods to serve the research needs of UWRL faculty and the USU campus. These advance analytical methods also support various Utah agencies.

treatment applied to soils and crops; investigating the breakdown of plastics and microplastics in the environment; toxicity screening of aged natural fiber; photochemistry of wildfire derived organic matter; monitoring pollutant loading from stormwater; and other urgent matters that arise.

## Utah impact

The EQL provides advanced analytical support to researchers across the USU campus and to state and local agencies. Development of analytical methods for emerging contaminants in environmental samples is needed for accurate assessment of the impact of emerging contaminants on soil health and air and water quality, leading to the development and evaluation of remediation technologies.

## What we did:

Methods under development include nano- and micro-plastic analysis in environmental samples, single particle analysis of nano materials in plant-soil systems, cyanotoxin sampling and analysis in air (Fig 1), DNA analysis as a tool for early warning of harmful algal blooms.

## What we found:

Analytical procedures have been developed for pharmaceutical and personal care products (PPCPs) in water, soil, and plants; per- and polyfluorinated alkyl substances (PFAS) in water, biosolids, soil, and plants using LCQqQ (Fig 2); cyanotoxins in drinking and ambient waters; plant and rhizosphere metabolites; and trace element analysis.

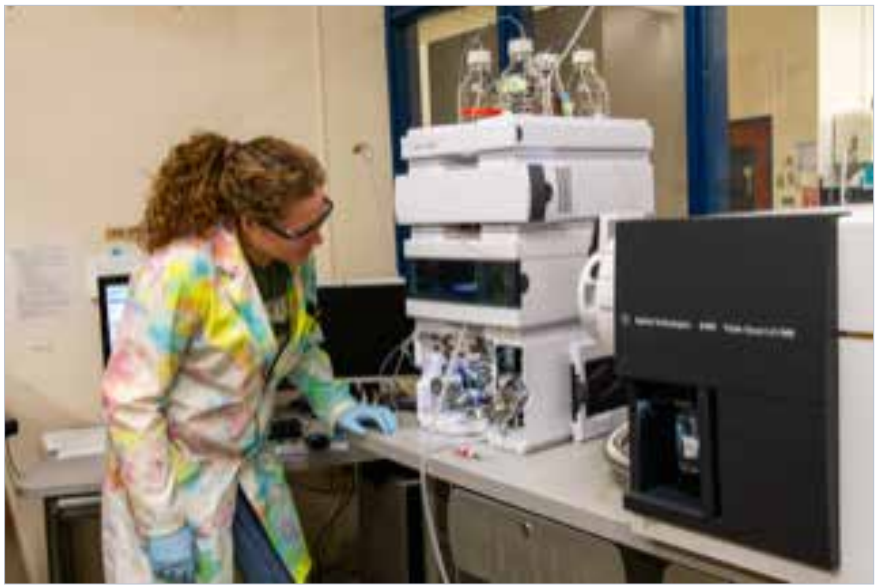


Figure 2: *Newly acquired liquid chromatograph triple quad mass spectrometer (LCQqQ) will greatly improve our ability of quantify environmentally. relevant concentrations of PFAS compounds in water, soil and plants and will increase our throughput time.*

# Biodegradable Mulch Films: Leachate Generation and Impacts on Agricultural Soils


## Research Summary:

Plastic mulch films are widely used in specialty crops to minimize irrigation needs and increase crop yields. However, these mulch films threaten soil health because they can release micro- and nano-plastics to soil after their application. Additionally, mulch films can release a wide variety of chemicals that may have detrimental effect on soil health and crop production. The complex mixture of chemicals released from plastic mulch films during use are majorly overlooked and may cause great harm to Utah farmlands.


### Why this research?

Conventional polyethylene (PE) mulch films resist degradation and are not environmentally sustainable. In contrast, biodegradable (BD) mulch films used as a promising alternative are manufactured such that 90% of the material can degrade within 2 years of their application in the field. However, BD mulch films have high potential to release a wide range of chemicals during their degradation, many of which may persist in soils. In this research, we investigate how mulch films release a complex mixture of organic chemicals in different weathering conditions. We examine the effect of light exposure and quantify the release of organic chemicals using dissolved organic carbon (DOC) as a metric for the complex mixture of additives and transformation products released as plastic mulch films weather. Additionally, we explore the use of excitation emission matrix spectroscopy (EEMs) as a tool to quantify this complex chemical mixture in agricultural soils.

### Utah impact

In Utah, approximately 1.2 million acres of crops are harvested from 11 million acres of farms and ranches. In many of these areas, mulch films are used extensively. However, mulch films can release a wide variety of degradation products under sunlight that can negatively affect soil and plant health. Understanding the amount of organic chemicals released from mulch films is the first step in understanding their impacts on soil health and function.

### What we did

We weathered a variety of mulch films under ultraviolet (UV) lamps that mimic solar UV light, focusing on three commonly used commercial mulch films. We observed the amount of organic chemicals released (quantified DOC) with UV exposure in air and water environments, performed weathering experiments for up to 3 months, corresponding to 6 months of


### Principal Investigator:

Kyle J. Moor (PI)

### Student:

Shahin A. Sujon (PhD)


### Geographic Areas:

Study Areas: Laboratory research

Areas Benefited: Utah agriculture and farmland resources


### Contact:

**Kyle Moor**
435.797.0937
kyle.moor@usu.edu

### Presentations:

- S. Sujon and K.J. Moor. *Wavelength dependent photo-dissolution of microplastics into dissolved organic carbon*, oral. American Chemical Society National Meeting. Denver, CO. August, 2024.
- S. Sujon, P. Madany, L. Hou, K.J. Moor, *Agricultural plastic mulch films: Weathering-induced leachate formation from biodegradable materials*, poster. Association of Environmental Engineering and Science Professors Research and Education Conference. Durham, NC. May 2025.

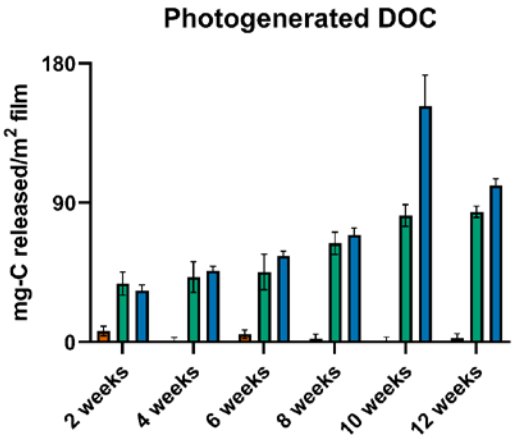
in-field weathering and analyzed the organic chemicals released with excitation emission matrix spectroscopy.

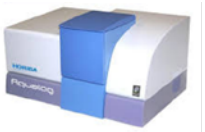
## What we found

We have found the release of organic chemicals from BD mulch films to be significantly higher than from conventional PE film. UV light exposure causes an increased release of organic chemicals, suggesting photodegradation of the mulch films. The amount of organic chemicals released increases with UV exposure times, indicating that the BD films start to degrade while still in use. Excitation emission matrix spectroscopy analysis found a strong signal for BD mulch films, likely related to a degradation product of the biodegradable polymer. This signal increases with UV exposure. The strong signal can potentially be used to monitor BD mulch film degradation in soils.

## Work plan FY 25–26

Over the coming year, we plan to publish a paper on the results of this project and further develop the excitation emission matrix spectroscopy method to quantify BD mulch films and their products in agricultural soils.



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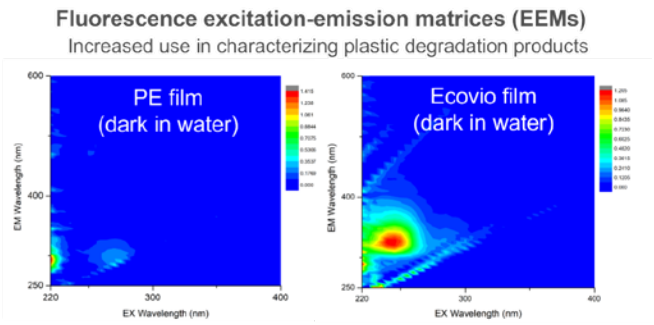



EEMs signals in protein-like region

# Characterization of Multidrug-Resistant Bacteria and Assessment of Natural Antimicrobial Compounds


## Research Summary:

This project identified and characterized antibiotic-resistant bacteria isolated from treated wastewater and evaluated natural antimicrobial compounds as potential mitigation strategies. The findings highlight that wastewater effluents can serve as reservoirs of multidrug-resistant bacteria and that certain natural compounds, such as curcumin and emodin, may help inhibit resistant strains.


### Why this research?

Antibiotic resistance (AR) is a growing global health threat that reduces the effectiveness of life-saving medications and increases healthcare costs. Wastewater treatment plants (WWTPs) are key hotspots for the spread of antibiotic-resistant bacteria (ARB) and antibiotic resistance genes (ARGs) because they collect waste from households, hospitals, and industries. Even after treatment, residual bacteria and resistance genes can remain in treated effluent. When discharged or reused, these effluents can introduce ARB and ARGs into surface waters, soils, and agricultural systems, where resistant microbes can persist and spread through irrigation, biofilms, and interactions with native soil and plant microbiomes. These pathways can ultimately affect human and animal health through environmental exposure and food-chain contamination. Understanding which bacteria survive treatment, the genetic basis for their resistance, and whether environmentally safe antimicrobials can help limit their spread is critical for improving wastewater management and protecting public health in Utah and beyond.

### Utah impact

Utah's growing population and arid climate have increased reliance on treated wastewater for landscape and agricultural irrigation. While water reuse supports sustainability, it also presents a potential route for reintroducing resistant microorganisms into the environment. This study addresses a problem relevant to Utah's water systems: identifying resistant bacteria in treated wastewater and exploring natural, low-toxicity compounds as possible control agents. Characterizing these bacteria and testing natural antimicrobials will provide data that can inform future policies and risk assessments related to water reuse, public health, and environmental protection. The outcomes will benefit local wastewater utilities, state regulatory agencies, and agricultural producers by helping them manage microbial risks sustainably and cost-effectively. This research also strengthens Utah State University's leadership in environmental microbiology and supports statewide goals for maintaining safe, resilient, and water-efficient communities.


## Principal Investigators:

Liyuan Hou (PI)
Yi Rao (Co-PI, USU Department of Chemistry)

## Students:

Tahira Rahman (MS)
Angela Zhan (High school concurrent enrollment)

## Co-Researchers:

Mingyue Li (visiting scholar from Shandong University of Technology, Zibo China)



## Funding Sources:

USGS 104(b) 2023 program (grant G21AP10623-03) and NSF (grant 2345709)


## Geographic Areas:

Study Areas: Logan, UT

Areas Benefited: State of Utah, the nation, the world


## Contact:

**Liyuan Hou**
435.797.1533
liyuan.hou@usu.edu



## Publication:

M. Li, A. Zhan, T. Rahman, T. Jiang, and L. Hou (2025). *From wastewater to resistance: characterization of multidrug-resistant bacteria and assessment of natural antimicrobial compounds*. Frontiers in Microbiology 16(2025): 1612534

## Presentations:

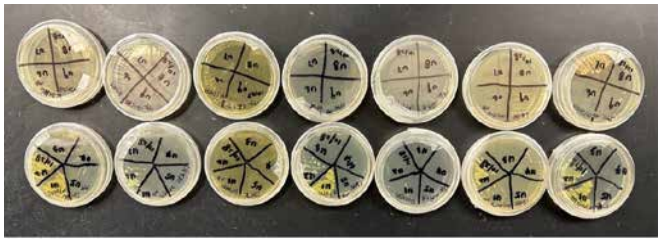
- M. Li, A. Zhan, T. Rahman, T. Jiang, and L. Hou. *From wastewater to resistance: characterization of multidrug-resistant bacteria and assessment of natural antimicrobial compounds*. poster, American Society for Microbiology (ASM). June 20-22, 2025
- L. Hou. *From wastewater to resistance: characterization of multidrug-resistant bacteria and assessment of natural antimicrobial compounds.* oral presentation, University Academic Alliance in Taiwan(UAAT) and University of Illinois Joint Symposium in Sustainability. October 6, 2025

## Media Coverage:

- Magazine article: https://www.frontiersin.org/news/2025/07/10/chemicals-turmeric-rhubarb-could-help-fight-antibiotic-resistant-bacteria-frontiers-microbiology. Frontiers
- Radio segment: https://ici.radio-canada.ca/ohdio/premiere/emissions/les-annees-lumiere/segments/rattrapage/2118994/antibioresistance-et-bassins-epuration-explications-alexandre-touchette. Radio Canada.

## What we did

Effluent samples were collected from a local WWTP in Logan, Utah, and cultured on growth media containing multiple antibiotics to isolate resistant strains. The isolated bacteria were identified using 16S rRNA gene sequencing and whole-genome sequencing (WGS) to determine taxonomy and genetic resistance mechanisms. Nine multidrug-resistant isolates were recovered, representing genera such as *Microbacterium*, *Chryseobacterium*, *Lactococcus lactis*, and *Psychrobacter*. Four representative strains were selected for detailed genomic analysis, which revealed genes encoding [beta]-lactamases, efflux pumps, and sulfonamide and tetracycline resistance.



To evaluate potential mitigation strategies, eleven natural antimicrobial compounds—including curcumin, emodin, quercetin, and cinnamaldehyde—were tested for their ability to inhibit bacterial growth, biofilm formation, and motility. Laboratory assays measured changes in cell density and surface behavior, while microscopy confirmed biofilm disruption and cell morphology changes under treatment.

## What we found

All isolates demonstrated resistance to multiple antibiotic classes, confirming that treated wastewater can serve as a source of multidrug-resistant bacteria. Genomic data showed a wide array of ARGs and stress-response genes, suggesting potential for horizontal gene transfer between environmental and pathogenic microbes. Curcumin and emodin were particularly effective, significantly reducing growth and biofilm formation in several Gram-positive strains, while *Chryseobacterium* (a Gram-negative bacterium) remained highly resistant. These results suggest that natural plant-derived compounds could supplement current disinfection approaches, though their efficacy varies among bacterial types.

Overall, this research establishes the first strain-level baseline for ARB in Utah's treated wastewater and provides insight into using natural products as sustainable antimicrobial alternatives. The findings will inform strategies to minimize the environmental spread of antibiotic resistance, protect public health, and enhance Utah's water quality resilience.

## Work plan FY 25–26

Future work will expand isolation efforts across multiple Utah wastewater facilities to develop a statewide library of ARB associated with the plastisphere, test natural antimicrobial compounds within mixed microbial consortia using biofilm reactors to better simulate real-world conditions and evaluate the removal of resistant bacteria from microplastics and other surfaces.

# Clean Water Microalgae for Nutritional Supplement for Meat


## Research Summary:

To expand the resource potential of the Utah bioeconomy through the creation of a low-cost supply of algae biomass for nutrients for animal cells, we tested the extraction and survival of amino acids from algae as protein building blocks for animal cells. All 20 standard amino acids and Vitamin B12 were recovered from the freshwater algae.


### Why this research?

One method to lower the cost of cell culture is cultivating and using algae as a nutrient source. Plant nutrients, which typically come from agricultural crops like soy or wheat, require significant land, water, and time, and they are used for other products. Algae offers a sustainable alternative that is biochemically robust and uses less land and water than traditional crops. *Chlorella vulgaris* is particularly dense biochemically, and includes vitamins D and B12, which other plant-derived food sources lack. *C. vulgaris* also contains a high protein content, approximately 59% of the biomass dry weight, and its biomass contains substantial concentrations of all 20 standard amino acids. Nutrient dense and classified as Generally Recognized as Safe (GRAS) by the FDA, *C. vulgaris* is an ideal component to be used in the production of agriculture meats.

Animal cell culture requires many specific nutrients and growth-promoting factors, which drive the high cost of animal cell culture, while the ethics of producing growth factors under debated. Growth factors are generally found in animal-derived serums, with fetal bovine serum (FBS) being the most common serum currently used in animal cell culture. FBS is collected as a part of the cattle slaughtering practice. Apart from ethical concerns around slaughter practices, FBS collection has associated ethical concerns. Two common growth factors used in cell culture are costly, for example, 1 microgram from a bovine source is $775.

Limited published information exists on replacing media and growth factors with algae such as *Chlorella vulgaris* amino acids and vitamins, but those sources suggests that the use of that algae increases cell growth and robustness. The available published information does not agree on whether algae can serve as a complete replacement for media and growth factors. This lack of available information on these important ethical, cost, and technical issues, supports the need for testing and analysis to determine if algae amino acids and vitamins can replace growth factors and media.


### Principal Investigators:

Ronald Sims (PI)
Luguang Wang (Co-PI)

### Students:

Elise Barton (MS)
Maelyn Andreasen (BS)
Sophia Hessami (BS)

### Research Collaborator:

Business/Industry: Cameron Copeland (UPSIDE Foods)



### Funding Source:

Upside Foods


### Geographic Areas:

Study Areas: Utah, Intermountain West, U.S. areas with limited land and water resources

Areas Benefited: Biotech companies cultivating animal meat


### Contact:

**Ron Sims**
435.797.3156
ron.sims@usu.edu

## Presentations:

- M. Andreasen, S. Hessami, E. Sheley, and E. Barton. *Freshwater Microalgae as Nutrient Supplement for Meat Agriculture in Areas with Limited Water and Land Resources*. Poster. Intermountain Biological Engineering Conference, Utah State University. November 2, 2024.
- E. Barton and R.C. Sims *Comparison of Algae Types for Amino Acid and Vitamin B12 Content for Cellular Agriculture*. Poster Institute of Biological Engineering Annual Conference, 2024, Atlanta, Georgia.

## Work plan FY 25–26

We plan to scale up the procedure for algae cultivation and enzyme splitting (lysing) to assess issues related to mixing of algae chemicals and effects of mixing on meat production and quality related to cell stress due to shearing forces within the reactor.

## Utah impact

Algae cultivation is low cost and represents a non-animal source of nutrient biochemicals that also do not cause immune responses in humans, as can soy or what products. Therefore, testing and analysis of the amount or concentrations of amino acids and vitamins in different types and strains will provide important information concerning the commercial scale production of algae-based nutrients, which is promising for lowering the cost and increasing the speed of production of cell cultured meat that can be utilized as a source of protein. This research and testing would provide support for the Utah bioeconomy through biotechnology and biomanufacturing pathways and supports the food-water-bioeconomy nexus.

## What we did

We tested two different types of algae that are classified by the U.S. Food and Drug Administration (FDA) as "Generally Recognized As Safe" (GRAS) for the presence and concentrations of building blocks of proteins for animal cells (amino acids) using different methods of releasing cell contents for uptake by chicken cells. Acids, bases, and enzymes were used to lyse or split open the algae cells to release cell amino acids that would be available for uptake by animal (meat) cells for growth.

## What we found

Results suggest that the best method for releasing the amino acids from the algae cells was the use of enzymes rather than acids or bases. Acids and bases can cause amino acids to react and degrade, while enzymes produced no decreases in any amino acids.

As demonstrated in the graphic, amino acid building blocks for animal protein were identified in both algae sources tested. These results support the use of algae-based nutrients for animal cell culture and provide a basis for the algae cultivation industry to expand the bioeconomy of Utah and the Intermountain West by providing feedstock for the animal cell culture industry. These results are especially useful in areas of the Intermountain West with limited water resources for livestock and animal farming.

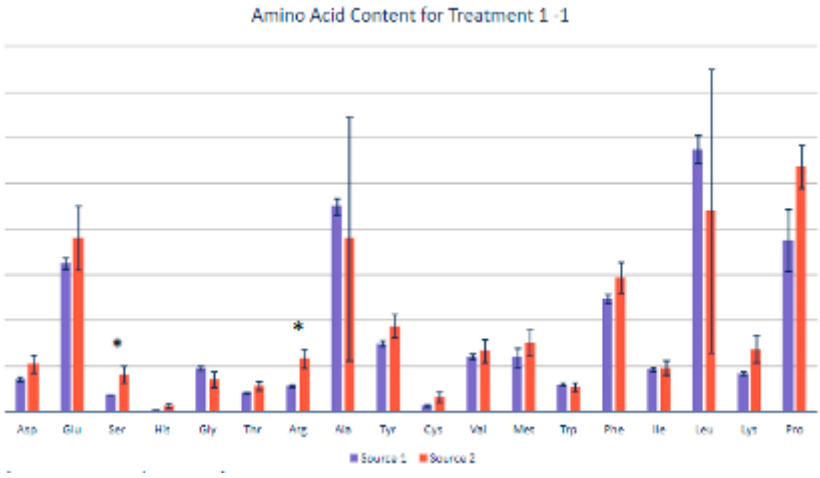



**Figure 1:** *Results of testing two algae sources of amino acids supplementation for animal cell culture.*

# Detection and Removal of the Co-Contaminants of Nanoplastics (NPs), Heavy Metals, Per- and Polyfluoroalkyl Substances (PFAS) and Pesticides from Water

## Research Summary:

This work addressed two major water quality threats by developing an innovative nanoalloy hybrid to achieve high-efficiency destruction of persistent PFAS and creating a highly sensitive Py-GC–MS method to accurately quantify micro- and nanoplastics (MNPs) in Logan City's tap water.

### Why this research?

Contaminants that current technologies cannot effectively eliminate challenge Utah's water security and raising public health concerns. This research targets two of the most critical emerging pollutants: (1) Per- and Polyfluoroalkyl Substances (PFAS). These are persistent, carcinogenic chemicals ubiquitously detected in the environment. They are resistant to degradation, necessitating a robust, scalable destruction technology. (2) Micro- and Nanoplastics (MNPs). These particles (even smaller than 1 um) are found in drinking water, raising questions about human exposure, especially for vulnerable populations like infants and toddlers who may ingest up to four times more per body weight than adults. Accurate detection is hampered by conventional methods.

### Utah impact

The findings of this research directly impact Utah's strategy for managing limited water resources.:

- Protecting Drinking Water: The microplastics study quantified MNPs in Logan City tap water, revealing concentrations of 0.03 to 0.32 ug/L. This provides Utah with a local baseline for contamination.
- Infrastructure Risk: The work found MNPs concentrations vary by sampling site, suggesting the distribution network and pipe materials may influence contamination levels, particularly as pipes age. This is critical for assessing the long-term health of Utah's water infrastructure.
- Groundwater Vulnerability: The reliance of Logan City on groundwater sources (springs and wells) is challenged by global findings confirming that groundwater is increasingly vulnerable to microplastic and PFAS contamination, a key concern for maintaining Utah's pristine water supply.
- Sustainable Remediation: The PFAS technology offers a novel, energy-efficient solution to destroy persistent chemicals. By achieving up to 99% removal of PFOA and PFOS and demonstrating defluorination, this technology is a highly promising, environmentally sustainable pathway for a challenging problem facing water utilities statewide.

### Principal Investigators:

Yiming Su (PI)
Ryan Dupont (Co-PI)
Joan McLean (Co-PI)

### Students:

Junjie Tang (PhD)
Chenwei Liu (PhD)

### Research Collaborators:

Yanqing Su (Aerospace & Mechanical Engineering, University of OK)

### Geographic Areas:

Study Areas: Utah

Areas Benefited: worldwide application. This research provides critical data and novel treatment technologies to protect Utah's drinking water quality and infrastructure from emerging contaminants, specifically PFAS and Micro/Nanoplastics (MNPs). Findings are immediately relevant to Logan City's water distribution and groundwater systems, the whole state of Utah, the United States, and the world, and offer a scalable remediation solution for PFAS pollution across the state.

### Contact:

**Yiming Su**
435.797.1534
yiming.su@usu.edu

## Publications: (selected)

- A.S. Eltaweil, N. Harby, A. Osman, M. Alrasheedi, Y. Su, E.M. El-Monaem (2025) *Engineering of a wafer-shaped titanium-based catalyst of TiO2/MIL-125(Ti)@Ti3C2 for enhanced Fenton-like degradation of Congo red: Optimization, mechanistic study, and reusability*. Journal of Industrial and Engineering Chemistry. https://doi.org/10.1016/j.jiec.2024.09.017
- J. Tang, A. Eltaweil, A.S. Adeyemi, A. Jacobson, D. Britt, J.E. McLean, Y. Su (2025) *Tracking the Translocation of Nanoplastic from Soil to Plant: Comparison of Different Analytical Techniques*. Journal of Hazardous Materials 488, 137357. https://doi.org/10.1016/j.jhazmat.2025.137357

## Presentations:

- C. Liu, Y. Su, et al. *Per- and Polyfluoroalkyl Substances Removal by Nano Metal Alloy doped Carbon-based Materials*, 13th Annual Meeting of Sustainable Nanotechnology Organization, Rhode Island, US, poster. November 2024.
- J. Tang, Y. Su, et al. *Biochar (BC) Reduces the Nanoplastics (NPs) Uptake by Lettuce and Alleviate Its Toxicity to Plant*, 13th Annual Meeting of Sustainable Nanotechnology Organization, Rhode Island, US, oral. November 2024.

## What we did

For PFAS destruction, we used a sophisticated approach, starting with Density Functional Theory (DFT) calculations to rationally design a material: a sulfidized (Fe2Zn nanoalloy on carbon nanotubes (SFeZnCNT). The theoretical work predicted that the nanohybrid would reduce the C-F bond dissociation energy, making chemical destruction easier. Laboratory tests confirmed this prediction, showing that the SFeZnCNT achieved high removal rates (up to 99.27% for PFOS) and defluorination, converting a portion of the PFOA carbon into volatile carbolic acids.

## What we found

1. PFAS Solution: The SFeZnCNT nanohybrid demonstrated an excellent ability to adsorb PFAS and facilitate its reductive defluorination. PFOA was found to be more readily defluorinated than PFOS.
2. MNPs Presence: MNPs were detected in tap water across Logan City at concentrations (0.03 to 0.32 ug/L) slightly lower than most global reports (>0.5 ug/l).
3. Pipe Integrity: No significant MNP release was observed from new PVC pipes under short-term hydraulic scouring. However, the literature indicates that factors like pipe aging, UV exposure, and long-term disinfectant use can accelerate particle release, suggesting a future risk for aged distribution systems.

## Work plan FY 25–26

Future work will focus on optimizing the SFeZnCNT nanohybrid material and reaction conditions to achieve near-quantitative defluorination for a broader range of PFAS compounds. Efforts to address microplastics will center on implementing in-line filtration methods to minimize contamination, incorporating size fractionation to improve accuracy across all particle size classes, and establishing standardized monitoring protocols to reliably assess and guide mitigation strategies for drinking water systems in Utah and the United States.


*Yiming Su (center) with students Chenwei Liu and Junjie Tang presenting at the 13th Annual Meeting of Sustainable Nanotechnology Organization, Rhode Island, US.*

# Evaluating Cyanobacteria and Cyanotoxins in Surface Water Aerosols near Utah Lake

## Research Summary:

This project investigated whether harmful algal bloom (HAB) cyanotoxins become airborne at Utah Lake and under what environmental conditions aerosolized microcystins can be detected. Through coordinated air- and water-sampling campaigns, the study documented microcystin congeners in both air and water and identified wind-driven processes that influence toxin aerosolization.

### Why this research?

Cyanobacterial harmful algal blooms (HABs) are a recurring public-health and water-quality concern in Utah Lake. Although cyanotoxins in water are routinely monitored, much less is known about their potential to become airborne and become an inhalation risk. Prior research shows that microcystins can aerosolize through wave breaking, wind, and recreational disturbances, but little work has been conducted in arid inland lakes such as Utah Lake. Understanding airborne toxin transport is particularly important for Utah because climate, wind patterns, lake size, and recreational use may create unique conditions for HAB exposure. This research fills a critical data gap by evaluating airborne microcystins at Utah Lake, where no standardized methodology exists and where toxin behavior may differ from humid or coastal environments studied previously.

### Utah impact

Utah Lake is one of the state's most heavily used recreational water bodies, supporting boating, fishing, camping, and shoreline activities. HAB-related advisories occur annually, and exposure pathways beyond

Figure 1: *cyanobacteria at Utah Lake*

### Principal Investigators:

Sierra Young (PI)
Joan McLean (Co-PI)
Randy Martin (Co-PI)

### Student:

Dylan McPeake (MS)

### Funding Source:

United States Geological Survey (USGS 104b)

### Geographic Areas:

Study Areas: Utah Lake

Areas Benefited: This project is focused on water quality only at Utah Lake, but the methods may be applied to sample aerosols potentially containing cyanotoxins at other freshwater lakes in the State of Utah and beyond

### Contact:

**Sierra Young**
435.797.1519
sierra.young@usu.edu

### Publication:

D. McPeake (2025). *Evaluating Cyanotoxins in Surface Water and Aerosols Near Utah Lake*. All Graduate Theses and Dissertations, Fall 2023 to Summer 2025. https://doi.org/10.26076/c315-393e

ingestion, particularly inhalation, may influence decisions on public health, risk communication, and lake management. By establishing the first measurements of airborne microcystins at Utah Lake, this work improves understanding of toxin movement in Utah's arid climate. It supports agencies responsible for HAB monitoring and advisories. The findings can inform sampling protocols, public health guidance, and future research on aerosolized toxins in Utah and similar western water bodies.

## What we did

The project conducted a preliminary study followed by two intensive field campaigns at Lincoln Beach Marina and Utah Lake State Park, sites affected by recurring HABs. Airborne microcystins were sampled using low-volume air samplers distributed across each site, while water samples were collected in parallel. Meteorological data were gathered from the Provo Airport MesoWest station to characterize wind speed, wind direction, temperature, and humidity. All water and air samples were analyzed for microcystin congeners using EPA-validated methods adapted for aerosol filters. Together, these methods generated the first coordinated air-water microcystin dataset for Utah Lake.

## What we found

Microcystins were detected in the water at both sites, but water concentrations were significantly higher at Lincoln Marina than at Utah Lake State Park. In contrast, airborne microcystin concentrations were consistently higher and more frequently detected at Utah Lake State Park. All nine air samplers detected microcystins at Utah Lake State Park, while only five of nine did so at Lincoln Marina. Air-to-water microcystin ratios at Utah Lake State Park ($10^{-6}$ to $10^{-7}$) were 10–100 times higher than ratios at Lincoln Marina, aligning with the stronger winds and favorable lake-to-shore wind directions observed at that site. High wind speeds—especially peak winds exceeding 10 m/s—were strongly associated with elevated airborne toxin concentrations. Flux-footprint analysis indicated that the most influential source areas for aerosolized microcystins were within 25–50 meters of each sampler and frequently aligned with boat-traffic corridors, supporting the role of wave disturbances and wind in aerosol generation. Overall, this study provides clear evidence that aerosolized microcystins occur at Utah Lake under certain environmental conditions and establishes a methodological foundation for future HAB air-monitoring work in Utah.

**Figure 2:** *Air sampling on the shore of Utah Lake.*

## Work plan FY 25–26

This project is complete.

### Presentations:

- D. McPeake, K. Francom, J. McLean, R. Martin, S. Young. *Evaluating Cyanobacteria and Cyanotoxins in Surface Water and Aerosols near Utah Lake*. American Society of Agricultural and Biological Engineers Annual International Meeting, July 28–31, 2024. Anaheim, CA
- R.S. Martin, S. Young, J.E. McLean, D. McPeake, K. Francom. *Examining the Potential for Aerosolization from Harmful Algal Blooms (HABs) from a lake in central Utah.* 105th Annual Meeting of the American Meteorological Society. January 2025
- D. McPeake, R.S. Martin, J.E. McLean, S. Young, K. Francom. *Measuring Aerosolization from Harmful Algal Blooms (HABs) at Utah Lake*. Air Quality: Science for Solutions. March 2025

### Media Coverage:

KSL.com (news story) https://www.ksl.com/article/51098429/researchers-study-the-toxicity-and-airborne-spread-of-algal-blooms. August 14, 2024

# Evaluating the Presence, Fate, and Exposure Pathways of PFAS Compounds in Northern Utah Communities


## Research Summary:

To determine the risk that wastewater biosolids land application represents to northern Utah communities, we evaluated the presence and distribution of PFAS compounds in wastewater treatment plant (WWTP) biosolids and in soils, plants, and grazing animal manure in areas where biosolids were applied. PFAS concentrations were found to be very high in municipal biosolids, and those levels were reflected in soil, plant and grazing animal manure samples in locations where the biosolids were applied. Concentrations were found to decrease over time following biosolids application due to regular plant harvesting when biosolids applications were not carried out on the same fields on an annual basis, and, to a lesser extent, due to compound migration through the upper soil layer. Annual, repeated biosolids applications will require pretreatment of biosolids to reduce the risks this practice poses to human health and the environment.


### Why this research?

PFAS compounds represent a wide range of polyfluorinated alkyl substances that have been used in consumer products and firefighting foams since the 1940s. These chemicals persist in the environment and in the human body and are associated with significant adverse human health effects including increased cholesterol levels, low infant birth rates, cancer, and adverse effects on the immune system and on thyroid hormone production. This project is generating PFAS concentration data for various potential exposure routes (municipal biosolids, land application area soils, plants grown in areas of biosolids application, etc.) in northern Utah.

### Utah impact

This study provides the first data from northern Utah describing PFAS fate and transformation in WWTPs and documenting the potential risks of PFAS compounds in their generated biosolids. Results show that plant uptake does occur, but concentrations drop as plant growth and harvesting occur over time following biosolids application if done on a 2- or 3-year application cycle. Treatment options for biosolids prior to land application are being evaluated in an attempt to limit PFAS risks with on-going biosolids

Figure 1: *Field sampling of soil and plant samples from a biosolids application area in northern Utah, 2024*


### Principal Investigators:

R. Ryan Dupont (PI)
Joan E. McLean (Co-PI)

### Technician:

Marissa Li

### Students:

Anna Fabiszak (MS)
Lexi Aragon (MS)

### Research Collaborators:

Local: Angie Pritchette, Superintendent, Hyrum Wastewater Treatment Plant; Tyler Richards, Logan City Wastewater Treatment Plant; Phil Heck, General Manager, Central Valley Water Reclamation Facility



### Funding Source:

USDA


### Geographic Areas:

Study Areas: Logan, Hyrum, and Ogden UT; Cache and Weber counties, UT

Areas Benefited: Other areas within Utah currently utilizing or planning water and biosolids reuse projects


### Contact:

**R. Ryan Dupont**
435.797.3227
ryan.dupont@usu.edu

PRESENTATION:

A. Fabiszak, R.R. Dupont, J.E. McLean, X. Li (2024). *Determining the fate of PFAS compounds in municipal biosolids used for agriculture.* Platform presentation. Presented at the 2024 WEAU Mid-Year Conference, Salt Lake City, Utah, November 12, 2024.

## Work plan FY 25-26

We will complete a final biosolids and forage growth and cutting cycle. Findings from a companion biosolids composting study will also be incorporated into final recommendations to WWTPs regarding their management (application frequency and pre-treatment alternatives) and utilization of biosolids to minimize risk and maximize benefits of using their biosolids into the future.

application, providing essential information to those communities considering developing or continuing beneficial biosolids use projects in the future. Results from this study can be broadly applied to other semi-rural regions in the State considering beneficial use of WWTP-generated biosolids.

## What we did

We collected triplicate samples of treatment plant biosolids, soil, irrigation water and plant samples from biosolids application areas (Figure 1) for analysis of an expanded list of 42 PFAS parent compounds and their transformation intermediates detected in the samples. Soil, irrigation water, plant, and biosolids sample extraction and analytical methods were validated using standard procedures from U.S. EPA Method 1633. Liquid samples and solids extracts were cleaned and concentrated through solid phase extraction using WAX cartridges also as specified in EPA Method 1633. We then analyzed samples for PFAS using an Agilent 6490 Triple Quad LC/MS. We used all Method 1633 quality control procedures (blanks, spikes, extraction standard and internal standard recoveries) to ensure the validity and representativeness of all reported results.

## What we found

We identified a range of PFAS compounds in municipal biosolids and soils and forage crops grown in biosolids-amended fields. Figure 2 shows the PFAS compounds detected in the biosolids, biosolids amended soils, and adjacent unamended control soils, as well as the decrease in soil PFAS concentration over time when biosolids are applied at 2-year intervals and two to three grass harvests/year. Figure 3 shows corresponding PFAS concentrations in hay from biosolids-applied and control sites, again indicating reductions in plant PFAS levels over time toward background levels: rapidly for some compounds (PFOS, PFPeA, PFHxA, PFHpA, PFHxS, PFNA, PFDA) and much more slowly for others. Results indicate that application intervals of 2-years or longer can significantly reduce soil and subsequent plant PFAS concentrations, lowering exposure risks for both animals and humans. Pre-treating biosolids to reduce initial PFAS concentrations would provide additional protection against unwanted PFAS exposure.

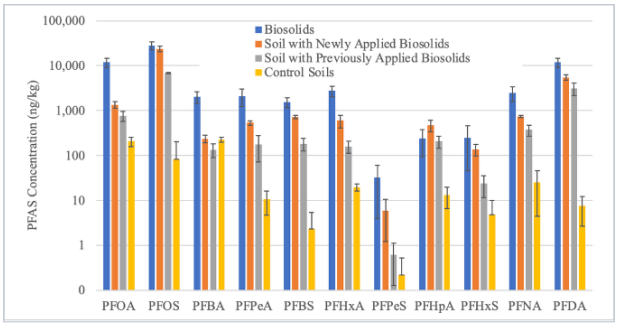



**Figure 2:** *PFAS distribution in biosolids and soils 1 year after application (Newly Applied) and 3 years after application (Previously Applied) compared to concentrations in adjacent control soils. Error bars represent 95% confidence intervals of triplicate measurements.*

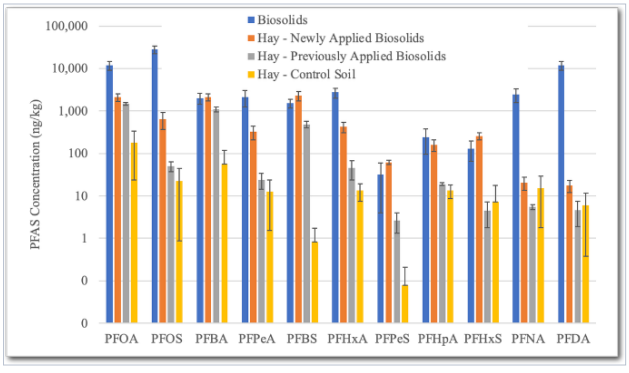



**Figure 3:** *PFAS distribution in biosolids and forage hay 1 year after application (Newly Applied) and 3 years after application (Previously Applied) compared to concentrations in adjacent control soils. Error bars represent 95% confidence intervals of triplicate measurements.*

# Irrigation Performance Impacts on Nutrients in Big Creek, Utah


## Research Summary:

We measured nutrient concentrations in Big Creek, a tributary of Bear Lake near Laketown, Utah, and soil nutrient concentrations in sprinkler- and surface-(flood)-irrigated fields. We also quantified irrigation performance for these fields using field-based measurements. Despite the significant differences in evapotranspiration from sprinkler- and surface-irrigated fields, no significant differences were observed in soil nutrient concentrations. Irrigation efficiency was generally low for both irrigation system types in the study area. Given the strong hydraulic connection with surface water sources and crop types grown in the region, we could see little incentive or potential benefit from improving irrigation efficiency in the region under current conditions.


### Why this research?

The ongoing strain on water resources in Utah and the Intermountain West in recent years has prompted an increased effort to reduce agricultural consumptive water use. Interest originally focused on converting surface (flood) irrigation systems to other methods. However, changes to sprinkler irrigation often result in increased consumptive water use. This understanding has

*Students evaluating a wheel line sprinkler system near Laketown, Utah.*


### Principal Investigators:

Burdette Barker (PI)
Reganne Briggs (Extension, Co-PI)
Matt Yost (Plants, Soils, & Climate, Co-PI)

### Student:

Sena Bildim (MS)

### Research Collaborators:

6 farmers in Laketown, UT


### Funding Source:

Utah Division of Forestry, Fire and State Lands

### Geographic Areas:

Study Areas: Bear Lake Valley

Areas Benefited: Utah's high mountain valleys


### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

lead to a move by many away from converting surface irrigation to sprinklers. While maintaining surface irrigation may be beneficial from the standpoint of reducing consumptive water use, in some cases, water quality is more of a concern than water quantity. Such may be the case with Bear Lake. We set out to investigate whether surface irrigation, with its greater return flows, might contribute more nutrients to streams around Bear Lake than sprinkler irrigation.

## Utah impact

The results provide information to help the State and Utah irrigators understand that the benefits and environmental costs of changing irrigation systems are strongly situation dependent in Utah. One-size-fits-all solutions may not be appropriate, even within hydrologic basins.

## What we did

We measured nutrient concentrations in Big Creek, a tributary of Bear Lake near Laketown, Utah. We also measured soil nutrient concentrations in sprinkler- and surface-(flood)-irrigated fields and quantified irrigation performance for these fields based on field measurements. We also compared crop water use (evapotranspiration) between the irrigation system types.

## What we found

Despite significant differences in evapotranspiration from sprinkler- and surface-irrigated fields, no significant differences were observed in soil nutrient concentrations. Overall irrigation efficiency was low for both irrigation system types in the study area. Based on the close hydraulic connection with surface water sources and the types of crops grown, we found little incentive or potential benefit from improving irrigation efficiency in the study area from a water resources standpoint.

## Work plan FY 25–26

This project is complete.

### Publication:

S. Bildim (2025). *Irrigation Performance Connection to Water Quality in Big Creek.* MS Thesis, All Graduate Theses and Dissertations, Fall 2023 to Present. 474. https://digitalcommons.usu.edu/etd2023/474

# Mapping Invasive Wetland Grass (*Phragmites australis*) over the Great Salt Lake, Utah using a small Uncrewed Aerial System (sUAS)


## Research Summary:

This project demonstrated the use of small Uncrewed Aerial Systems (sUAS) equipped with high-resolution multispectral sensors to map *Phragmites australis*, an invasive wetland grass, in Howard Slough on the east shore of the Great Salt Lake. Six flights covering 2,200 acres captured 10-band imagery during peak bloom in August 2025. The data will enable the Utah Department of Natural Resources (UDNR) to classify vegetation, assess *Phragmites* extent and develop eradication strategies, while showcasing the effectiveness of using drones for time-sensitive, high-resolution ecological monitoring and water resource applications.


### Why this research?

This research acquired timely, high-resolution multi-spectral aerial imagery of *Phragmites australis*, within Howard Slough, on the East side of Great Salt Lake, Utah. This tall, non-native, invasive perennial wetland grass, ranging in height from 3–20 ft, is commonly known to outcompete native vegetation and subsequently lower the overall local plant diversity. It also forms thick, dense stands that are unsuitable for native wildlife. The vegetation is extremely difficult to control, and the only effective control/eradication treatment is burning it over several growing seasons.

Analysis of the imagery will provide UDNR with a complete and highly detailed map of the invasive wetland grass in and around Howard Slough on the East shores of the Great Salt Lake. It will help UDNR to assess and differentiate, using spectral signatures from the different vegetation types, a vegetation classification map of the entire region. This information can be used to formulate eradication strategies within UDNR and to potentially monitor the outcome of the eradication process in the coming years.

### Utah impact

This project illustrates the effectiveness of using small Unmanned Aerial Systems (sUAS) with high-resolution multi-spectral sensors to capture time sensitive, extremely high-resolution imagery of non-native invasive vegetation in and around Great Salt Lake. It will also provide the UDNR with incredibly accurate information about the location and extent of *Phragmites australis*, which is a primary concern. Additionally, this imagery will provide UDNR with the ability to investigate and identify


### Principal Investigators:

Ian Gowing (PI)
Alfonso Torres-Rua (Co-PI)
Austin Washke (Co-PI)
Bradon Curdy (Co-PI)
Calvin Coopmans (Co-PI)

### Research Collaborators:

State: Tommy Thompson, Gabriel Svobodny, and Keith Hambrecht, Utah Department of Natural Resources, Division of Forestry, Fire and State Lands


### Geographic Areas:

Study Areas: Howard Slough, Great Salt Lake, Utah

Areas Benefited: Any regions affected by growth and spread of non-native invasive vegetation.


### Contact:

**Ian Gowing**
435.797.3159
ian.gowing@usu.edu

### Work plan FY 25–26

The processing and analysis of the imagery is on-going by UDNR. This project is complete.

other vegetation types. The project also highlights the creative use of drones and multi-spectral sensors and how they can be used in a variety of water resource applications, especially in time-sensitive applications.

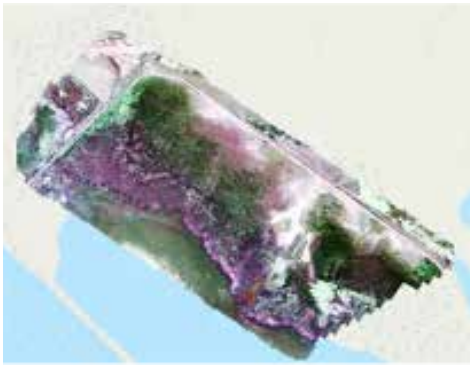
## What we did

High-resolution aerial imagery was captured flying a hybrid VTOL/Fixed wing small Unmanned Aerial System (sUAS) at 120m above ground level. Imagery was captured and stored on an AgEagle Dual camera sensor. This sensor captured 10 spectral bands. Data capture took place over 2 days during mid-August 2025, when the invasive plant was in full bloom. A total of 6 drone flights, covering approximately 2200 acres, were flown in accordance with the AggieAir Certificate of Waiver (C.O.A) 2023-WSA-13621-COA provided by the Federal Aviation Administration.

## What we found

We found the use of drones to be effective in time-sensitive research applications where other sources of multi-spectral aerial imagery may not be available or may not contain a high enough pixel resolution. The findings highlight the general effectiveness of using drones for map non-native invasive vegetation in research applications. All imagery and flight logs have been provided to UDNR for processing and further analysis.

*A drone preparing to launch over the Great Salt Lake to capture high-resolution multi-spectral imagery.*



*Aerial imagery illustrating flights over Howard Slough, GSL.*

# Mapping Invasive Wetland Grass (*Phragmites australis*) over Utah Lake, Utah, Using a Small Uncrewed Aerial System (sUAS)


## Research Summary:

This project demonstrated the use of small Uncrewed Aerial Systems (sUAS) equipped with high-resolution multispectral sensors to map *Phragmites australis*, an invasive wetland grass, around Utah Lake. Six flights covering 2,200 acres captured 10-band imagery during peak bloom in August 2025. The data will enable the Utah Department of Natural Resources (UDNR) to classify vegetation, assess *Phragmites* extent and develop eradication strategies, while showcasing the effectiveness of using drones for time-sensitive, high-resolution ecological monitoring and water resource applications.


### Why this research?

This research acquired timely, high-resolution, multi-spectral aerial imagery of *Phragmites australis*, around Utah Lake, Utah. This tall, non-native, invasive, perennial wetland grass, ranging in height from 3–20 ft, is known to outcompete native vegetation and subsequently lower the overall local plant diversity. It also forms thick dense stands that are unsuitable for native wildlife. The vegetation is extremely difficult to control, and the only effective treatment of control/eradication is burning it over several growing seasons.

Analysis of the imagery will provide Utah Lake Authority with a complete and detailed map of where and to what extent, the invasive wetland grass has spread throughout the Lake. Additionally, it will provide them with the ability to assess and differentiate between different vegetation types. This information will be used to formulate eradication strategies and to potentially monitor the outcome of the eradication process in the coming years.

### Utah impact

This project illustrates the effectiveness of using small Unmanned Aerial Systems (sUAS) with high-resolution multi-spectral sensors to capture time sensitive, extremely high-resolution imagery of non-native invasive vegetation in and around Utah Lake. It will also provide the Lake Authority with incredibly accurate information as to the location and extent of *Phragmites australis*, which is a primary concern. Further analysis of the imagery will help the Utah Lake Authority to investigate and identify all vegetation types in the imagery. This project also highlights the creative use of drones and multi-spectral sensors and how they can be used in a variety of water resource applications, especially in time-sensitive applications.


## Principal Investigators:

Ian Gowing (PI)
Alfonso Torres-Rua (Co-PI)
Austin Washke (Co-PI)
Bradon Curdy (Co-PI)
Calvin Coopmans (Co-PI)

## Research Collaborators:

Local: Addy Valdes, Utah Lake Authority

State: Tommy Thompson, Gabriel Svobodny, and Keith Hambrecht, Utah Department of Natural Resources, Division of Forestry, Fire and State Lands


## Geographic Areas:

Study Areas: Utah Lake, Utah

Areas Benefited: Any regions affected by growth and spread of non-native invasive vegetation.


## Contact:

**Ian Gowing**
435.797.3159
ian.gowing@usu.edu

## Work plan FY 25–26

Drone flights are planned to resume in late summer 2026, but exact flight scheduling will be discussed and coordinated with Utah Lake Authority. Image processing is ongoing.

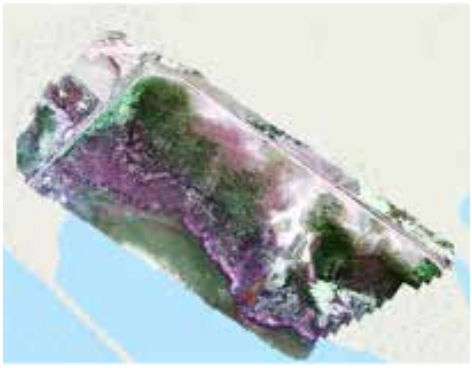
## What we did

High-resolution multi-spectral aerial imagery was captured using both a hybrid VTOL/Fixed wing small Unmanned Aerial System (sUAS) and a N.D.A.A compliant PRSIM Lite vertical Take-Off & Landing (VTOL) drone at 200m above ground level. Imagery was captured and stored on two AgEagle Sensors, an AgEagle Dual camera sensor and an AgEagle Altum-PT sensor. The first sensor captures 10 spectral bands, while the second sensor captures 7 spectral bands, including a thermal band. Drone flights began in August 2025 when the invasive plant was in full bloom. Data capture will continue through late summer 2026. All flights will be flown in accordance with the AggieAir Certificate of Waiver (C.O.A) 2023-WSA-13621-COA provided by the Federal Aviation Administration.

## What we found

This project has shown the effectiveness of using drones in time-sensitive applications where other sources of aerial imagery may not be available or may not contain a high enough pixel resolution. It has highlighted the effectiveness of using drones to map non-native invasive vegetation in research applications. All the imagery and flight logs have been delivered to the Utah Lake Authority for processing and further analysis.

*A drone launch over Utah Lake to capture high-resolution multi-spectral imagery.*



*Aerial imagery (RGB) showing the North shore of Utah Lake.*

# Mitigation of Methane Emissions from Anthropogenic Sources

## Research Summary:

The use of *Methylotuvimicrobium alcaliphilum*, a methane-degrading microorganism, for the bioremediation of methane ($CH_4$), appears to be a promising method for reducing the negative environmental impacts of $CH_4$ emissions while simultaneously providing an economic incentive through the production of ectoine, a high value by-product. Ectoine is used as an active ingredient in skin care and sun protection products.

### Why this research?

Rising greenhouse gas (GHG) concentrations demand strategies to reduce emissions and enhance treatment. Carbon dioxide ($CO_2$) GHG emissions receive most of the attention due to its volume, but methane ($CH_4$) is far more potent—over 25 times more effective than $CO_2$ at trapping heat in the atmosphere over a 100-year period. $CH_4$ is the second largest contributor to the total global atmospheric greenhouse effect, accounting for ~20% of emissions on a $CO_2$ equivalent basis. In 2020, global $CH_4$ emissions were estimated at 9,390 million metric tons of $CO_2$ equivalent (MMTCO2E). Atmospheric $CH_4$ exceeded 1850 ppb in 2018, over 2.5 times the estimated pre-industrial equilibrium value in 1750, primarily due to anthropogenic sources such as agriculture, energy production, and waste decomposition in landfills, wastewater treatment and composting.

Anthropogenic $CH_4$ is challenging to mitigate. This project investigated the feasibility of converting $CH_4$ from sources like landfills, wastewater sites, mining, and agriculture into value-added products using *M. alcaliphilum* Research on scaling *M. alcaliphilum* cultures to industrial levels is limited. We tested upstream and downstream processes at bench scale (10 L) to evaluate methane removal efficiency and the potential for industrial $CH_4$-to-ectoine conversion.

### Utah impact

Potential pilot scale studies of the technology could be applied at Utah locations, including landfills in Cache and Carbon counties as well as anaerobic digestors at the Central Valley Water Reclamation Facility located in Salt Lake County, and others throughout the state.

### What we did

We designed an experiment to study factors that could contribute to methane removal by *M. alcaliphilum 20Z* in a 10 L reactor setting, including adjusting culture temperature between 21 and 28 C, adjusting sparger pore size from 1 mm to 0.5 µm diameter, and inputting methane and air either separately or

### Principal Investigators:

Judith L. Sims (PI)

Ronald Sims (Biological Engineering, Co-PI)

Charles Miller (Biological Engineering, Co-PI)

### Students:

Jaden Storrer (MS)
BoDee Hancock (BS)
Tansley Mazurkiewicz (BS)

### Research Collaborators:

Local: Issa Hamud, City of Logan, Environmental Director

Industry: Phillip Heck, General Manager, Central Valley Water Reclamation Facility

### Funding Source:

Utah Water Research Laboratory

### Geographic Areas:

Areas Benefited: Methane emitting facilities and sources throughout the State of Utah

### Contacts:

**Judith L. Sims**
435.797.3230
judith.sims@usu.edu

**Ronald Sims**
435.797.3156
ron.sims@usu.edu

### Publications:

- J. Storrer (2025). *Strategies For Increasing Methane Removal In Methanotroph Bench-Scale Systems for the Production*

*of Ectoine*. All Graduate Theses and Dissertations, Fall 2023 to Present. 396. https://digitalcommons.usu.edu/etd2023/396

- J. Storrer, T.M. Mazurkiewicz, B. Hancock, R.C. Sims (2025) *Strategies for Increasing Methane Removal in Methanotroph Stirred-Tank Reactors for the Production of Ectoine*. Bioresour.Bioprod. 2025, 1(2) 7. https://doi.org/10.3390/bioresourbioprod1020007

PRESENTATION:

J. Parkinson, J.L. Sims, R.C. Sims (2024). *Halotolerant Bacterium used for Methane Remediation from Landfills*. Examines in Marine Biology & Oceanography, 7(2). EIMBO. 000656. https://doi.org/10.31031/EIMBO.2024.07.000656

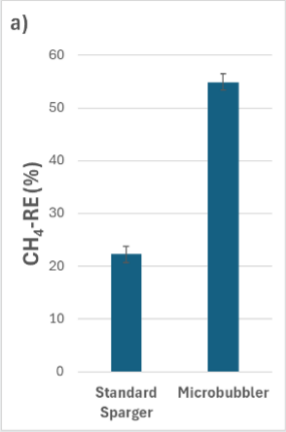



**Figure 2:** *Mean values for the standard sparger (1 mm) and the micro-bubbler (0.5 µm) to measure the influence of sparger pore size on methane removal efficiency.*

premixed into the culture (Figure 1). We chose temperature for its effects on methane solubility in water as well as enzyme kinetics for methane uptake. We chose the method adjusting sparger pore size and gas input as these can affect mass transfer of methane from gas to liquid phase.

A 2x2x2x3 factorial design was implemented with the three chosen factors and two levels while also accounting for a time factor so that all combinations of factors and levels could be tested to see effects of individual factors along with potential interactions between factors. A total of 8 tests were conducted.

We determined the ectoine content of cultures and collected ectoine using a 'Bio-milking' method that implemented tangential flow filtration (TFF). Bio-milking is accomplished by alternating osmotic shocks from high salinity to low salinity environments that impact the bacteria, resulting in release of ectoine from microbial cells into the media for easier separation and harvesting. Previous literature for bio-milking *M. alcaliphilum* 20Z utilized a centrifugation method making this TFF method novel research. Ectoine was further isolated and quantified using high performance liquid chromatography (HPLC).

## What we found

Adjusting sparger pore size from 1 mm diameter to 0.5 µm diameter had the most pronounced effect on methane removal (Figure 2). Increasing temperature to 28 C and using a premixed gas input also improved methane removal in a less pronounced way. Bio-milking with TFF proved successful, showing an ability to excrete 22-32 mg ectoine/g dry cell weight. Unlike with methane removal, the factorial design did not identify the chosen factors having a significant effect on ectoine production.

## Work plan FY 25–26

This project is complete

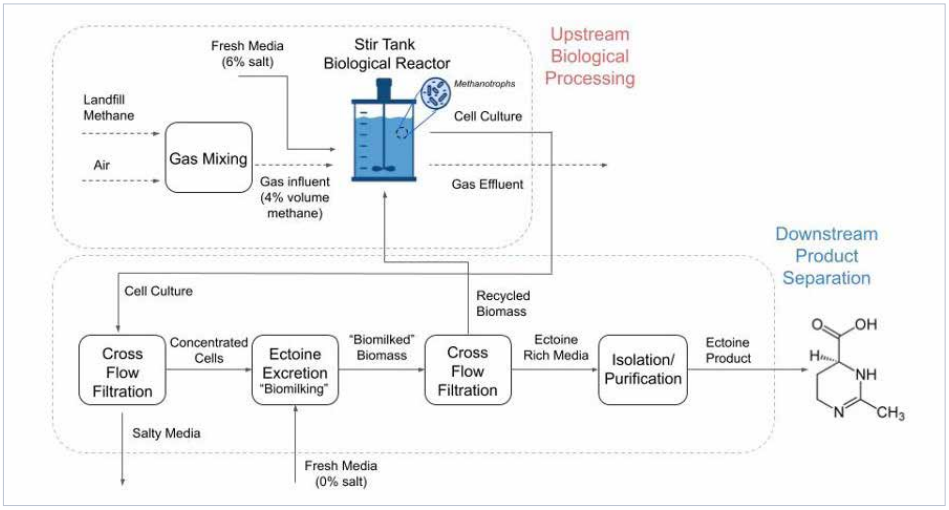



**Figure 1:** *Preliminary design visual for a M. alcaliphilum based method of landfill gas treatment.*

# Pyrogenic Dissolved Organic Matter Photochemistry: Impacts of Wildfires on Surface Water Processes


## Research Summary:

Wildfires can threaten safe drinking water. They produce pyrogenic dissolved organic matter (pyDOM) which is more difficult to treat with in conventional methods, leading to more toxic disinfection byproducts during chlorination. At the same time, sunlight can break down pyDOM in surface waters, potentially improving pyDOM treatability. Our research studies the photochemistry of pyDOM, advancing understanding of the impacts of wildfires on drinking water supplies and how pyDOM treatability changes during transport in sunlit surface waters. These findings will help inform efficient water treatment strategies in downstream rural and urban communities to limit formation of disinfection byproducts and protect human health.


### Why this research?

Inputs of pyDOM into surface waters influence many biogeochemical processes, including aquatic photochemistry, a key pathway for transforming pollutants, microorganisms, and dissolved organic matter (DOM) itself. Compared to typical aquatic DOM, pyDOM is a stronger sensitizer, more efficiently generating reactive species like singlet oxygen ($^1O_2$). Because $^1O_2$ is a key reactive intermediate in indirect photolysis processes, wildfire-derived pyDOM is expected to enhance photochemical processing in sunlit surface waters. This affects the fate and transport of both pollutants and pyDOM after wildfires, potentially decreasing their adverse impact on surface water quality.

A prime example is drinking water. Forested watersheds supply much of our drinking water, yet they are greatly threatened by wildfires. In downstream communities, pyDOM is only partly removed during treatment, potentially leading to formation of toxic disinfection byproducts. While wildfires threaten safe drinking water, sunlight-driven photochemistry may partially oxidize pyDOM before treatment, making it easier to remove and reducing harmful byproduct formation. Understanding pyDOM's ability to generate $^1O_2$ and undergo photochemical transformation is critical to determining the impacts of wildfires on drinking water and human health.

### Utah impact

Wildfire exposure has increased in Utah, driven by rising temperatures and prolonged droughts. In 2025, Utah experienced 1,146 wildfires that burned 164,707 acres (reported by the Utah Fire Information dashboard). The state's


### Principal Investigator:

Kyle J. Moor (PI)

### Student:

Monika Madhiyan (PhD)


### Geographic Areas:

Study Areas: Laboratory research

Areas Benefited: Utah's wildfire-impacted watersheds


### Contact:

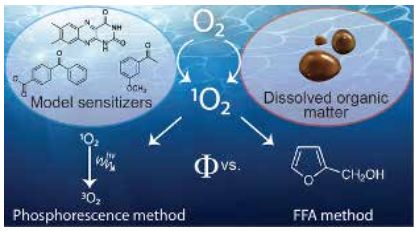
**Kyle Moor**
435.797.0937
kyle.moor@usu.edu

forested watersheds are important sources of drinking water, yet they are susceptible to influxes of pyDOM from these wildfires. Thus, understanding pyDOM's role in surface water photochemistry is essential for designing effective treatment methods and safeguarding Utah's water supply.

## What we did

To assess pyDOM's impact on surface water photochemistry, we measured its efficiency in generating 1O2, an important reactive intermediate in surface waters. We calculated quantum yields using two different methods for quantifying 1O2: a chemical probe method and a spectroscopy method (phosphorescence). We examined ^1$O_2$ production from pyDOM derived from lab-combusted wood chars and a wildfire-sourced char sample then compared pyDOM 1O2 quantum yields to reference DOM isolates to understand if pyDOM increases 1O2 levels in surface waters post-wildfire.

## What we found




We found that pyDOM had mostly similar 1O2 quantum yields to terrestrial DOM isolates. We observed that the chemical probe method yielded lower 1O2 quantum yields than the spectroscopy method, but the general trend was apparent in both methods. The outlier was the wildfire-derived pyDOM (Grizzly Creek). Using the chemical probe method, Grizzly Creek pyDOM had a significantly higher 1O2 quantum yield than terrestrial DOM isolates and lab-combusted char pyDOM samples. This suggests that wildfire-derived pyDOM will increase 1O2 levels in surface waters post-wildfire, potentially increasing DOM (and pyDOM) photochemical processing. This also points to key chemical differences between real wildfire chars and those prepared with laboratory combustions.

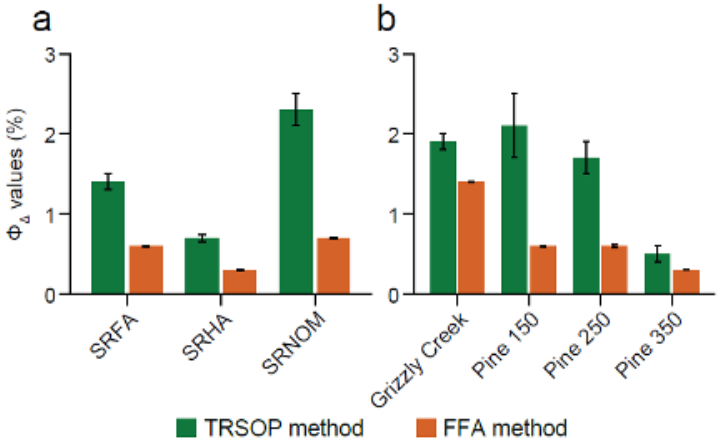



**Figure 1:** *$\Phi_\Delta$ values for (a) DOM isolates and (b) PyDOM. Green and orange bars represent $\Phi_\Delta$ obtained via the TRSOP method ($\Phi_{\Delta,P}$) and the FFA method ($\Phi_{\Delta,F}$), respectively. Error bars represent the standard deviation among the triplicate values.*

### PUBLICATION:

M. Madhiyan and K.J. Moor (2024). *Comparative Analysis of Two Singlet Oxygen Quantum Yield Measurement Techniques: Chemical Probe vs. Time Resolved Phosphorescence*. In Review

### PRESENTATIONS:

- M. Madhiyan and K.J. Moor. *Singlet oxygen phosphorescence: A spectroscopic tool to assess pyrogenic organic matter photochemistry*. Invited oral presentation (Moor). American Chemical Society National Meeting. Denver, CO. August 2024.
- M. Madhiyan and K.J. Moor. *Quenching of sensitizer triplet excited states with furfuryl alcohol*. Moor oral presentation. American Chemical Society National Meeting. San Diego, CA. March 2025.

## Work Plan FY 24–25

We will begin to investigate pyDOM (and DOM) 1O2 quantum yields at water treatment relevant wavelengths. pyDOM is not readily removed in typical water treatment processes and may still be present in UV water treatment operations. This research will advance understanding on the impacts of wildfires on downstream water treatment processes, including UV disinfection or advanced oxidation processes.

# Reducing PFAS Contaminants in Municipal Biosolids through High-Temperature Composting

## Research Summary:

Polyfluorinated alkyl substances (PFAS) are a significant and growing human health and environmental concern in Utah wastewater biosolids. We are evaluating biosolids treatment options to reduce and/or sequester PFAS, thereby limiting their release to the environment during beneficial use of biosolids.

### Why this research?

PFAS compounds have been used extensively in many industrial and consumer products and have been detected in virtually all environments. Concerns about human exposure to these chemicals has increased as more information has become available regarding their negative human health and environmental effects as reflected in EPA's 2024 published primary PFAS drinking water standards. A significant pathway for their release to the environment is via land application of biosolids from wastewater treatment plants (WWTPs).

### Utah impact

Biosolids are considered a valuable resource due to their beneficial effects of improving soil water holding capacity and soil organic content as well as their nutrient value. They do, however, contain a wide range of organic and inorganic compounds that are not removed in conventional wastewater treatment, including PFAS compounds. Developing inexpensive, effective, and easy-to-implement biosolid treatments to destroy or sequester PFAS could greatly reduce risks to human health and the environment.

### What we did

We have begun a laboratory study of municipal biosolids composting (Figure 1) using biosolids from two local WWTPs to evaluate the effects of different compost treatments (with and without biochar, with and without iron- and zinc-doped biochar) on the rate and extent of PFAS transformation within these biosolids. Triplicate measurements will be made using a 30-day compost period, for a total of 32 treatments completed over the course of the 2-year study. Initial biosolids samples, along with weekly compost samples are collected, and extracts are cleaned and concentrated through solid phase extraction using WAX cartridges as

Figure 1: *Laboratory composters used to evaluate the effectiveness of various treatments on PFAS transformation over time*

### Principal Investigators:

R. Ryan Dupont (PI)
Joan E. McLean (Co-PI)

### Technician:

Marissa Li (Co-PI)

### Student:

Chase Fry (MS)

### Research Collaborators:

Local: Angie Pritchett, Superintendent, Hyrum Wastewater Treatment Plant; Tyler Richards, Logan City Wastewater Treatment Plan

### Geographic Areas:

Study Areas: Cache County, UT

Areas Benefited: Other areas within Utah currently utilizing or planning biosolids reuse projects

### Contact:

**R. Ryan Dupont**
435.797.3227
ryan.dupont@usu.edu

### Media Coverage:

KSL News video: *Rollback of EPA regulations on 'forever chemicals' could increase health risks, costs,* Mike Anderson, KSL TV May 14, 2025

Utah State Today article: *USU Researchers Working to Reduce 'Forever Chemicals' in Wastewater Biosolids Used in Ag*, Mike Anderson, KSL TV February 26, 2025

### Publication:

Project brief within *Report to the Governor and Legislature on Utah's Land, Water, and Air*. Institute for Land, Water, and Air, Utah State University. https://www.usu.edu/ilwa/reports/

## Work plan FY 25–26

Our work will focus on completing the laboratory biosolids composting study with biochar additives. Results of this laboratory composting study will be incorporated into recommendations on how to more effectively manage and utilize biosolids from these WWTPs to minimize risk and maximize benefits from beneficially using their biosolids in the future.

specified in EPA Method 1633. We then analyze samples for 42 PFAS compounds using an Agilent 6490 Triple Quad LC/MS. We use all Method 1633 quality control procedures (blanks, spikes, extraction standard and internal standard recoveries) to ensure the validity and representativeness of all reported results.

## What we found

Figure 2 shows preliminary results for short- and long-chain PFAS compounds as defined by the Interstate Technology Regulatory Council (ITRC) Guidance for conventional compost (C), 1% biochar (BC1), and 1% metals-doped biochar (Doped BC1) treatments. All treatments achieved substantial PFAS reductions (≈50% to 70%), with the 1% doped biochar treatment representing the most efficient treatment option for PFAS transformation observed so far. Figure 3 shows results for PFPrA and TFA, the terminal products of PFAS breakdown, quantified in the 1% biochar treatment. These data confirm the first-order defluorination of PFAS during composting with biochar in these laboratory reactors.

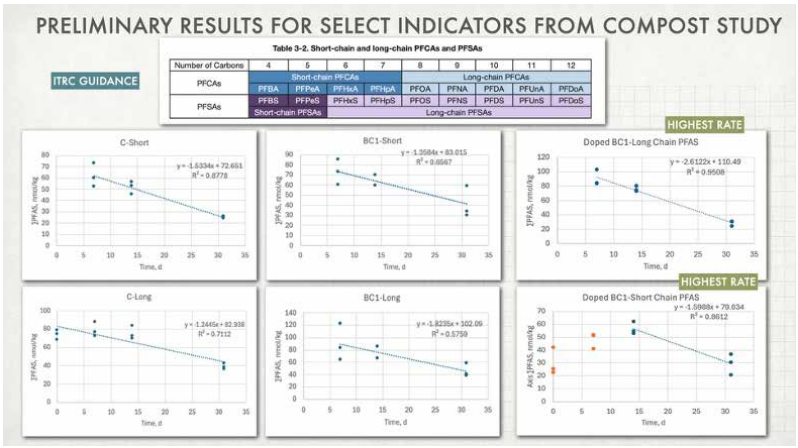



**Figure 2:** *PFAS biosolids compost indicator (∑short-chain, ∑long-chain PFAS compounds) concentrations as a function of compost treatments from preliminary laboratory studies.*

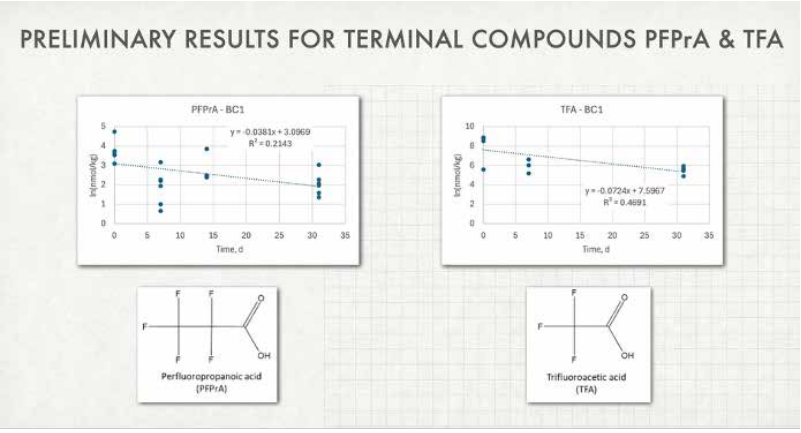



**Figure 3:** *Terminal PFAS compounds PFPrA and TFA concentrations in the 1% biochar compost treatment from preliminary laboratory studies*

# Toxicity Screening of Leachates from Engineered Biocomposites


## Research Summary:

There is growing interest in bio-based materials due to the environmental concerns associated with petroleum-based plastics. The increasing use of bio-based materials, particularly plant-based materials (PBMs), as substitutes for petroleum-based plastics requires a deeper understanding of their environmental fate and potential impacts, particularly in aquatic ecosystems. However, little is known about the release of the complex chemical mixtures called leachate, from PBMs as they weather in sunlit aquatic environments, or about the ecotoxicity of this leachate.


### Why this research?

The environmental consequences associated with plastic production, unintentional environmental release, and end-of-life waste have intensified the search for alternative materials to replace conventional petroleum-based plastics. Common alternatives include bio-based and biodegradable materials. Bio-based materials are made from renewable, non-petroleum resources derived from microbial generated products or plant polymers (e.g., cellulose, protein, starch, and lignin), often referred to as plant-based materials (PBMs).

Because they are bio-based, biodegradable material manufacturers often claim that they are less harmful to the environment than conventional plastics, but current findings imply that these materials may still pose risks to the environment. One important potential impact is the release of complex mixtures of chemicals into aquatic environments during weathering; this mixture is often simply called 'leachate.' Although bio-based, biodegradable materials are made from feedstocks generally viewed as safe (e.g., starch, cellulose, PLA, natural rubber), their leachates may negatively impact aquatic environments. The chemical risks posed by leachates from bio-based, biodegradable materials are still poorly understood.

### Utah impact

Plastics are part of daily life for nearly all Utahns. After use, they are discarded and enter either the waste stream or the environment. Using new bio-based, biodegradable materials as alternatives to conventional plastics enables more rapid degradation in managed and unmanaged environments, enhancing plastic waste management and reducing plastic pollution. Their use ultimately helps protect Utah's precious wildlands, farmlands, and water resources. Before


### Principal Investigators:

Kyle J. Moor (PI)
Kimberly Hageman (USU, Chemistry, Co-PI)

### Student:

Malavige Lamal Jasura Perera (PhD)

### Research Collaborators

Business/Industry: Dr. Stephen Taylor, Natural Fiber Welding, Inc.


### Geographic Areas:

Study Areas: Laboratory research

Areas Benefited: Sunlit surface waters and terrestrial environments

Contacts:

**Kyle Moor**
435.797.0937
kyle.moor@usu.edu

**Kimberly Hageman**
435.797.0114
kim.hageman@usu.edu

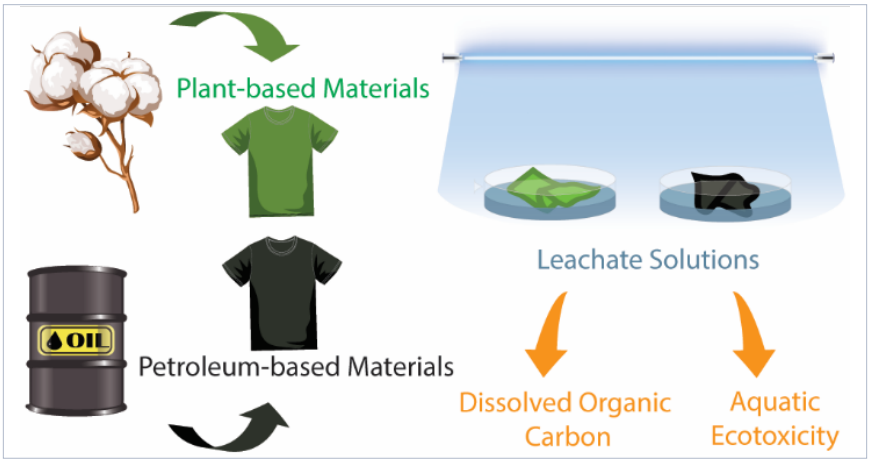
Publication:

L. Perera, S.A. Sujon, A. Fabiszak, M. Almatani, A. Benninghoff, S. Taylor, K. Hageman, K.J. Moor. *Engineered Biocomposites as Plastic Alternatives: Photo-induced Generation of Leachate and its Toxic Effects in Surface Waters*. Submitted.

these new bio-based, biodegradable materials can be used, their impacts on receiving environments (e.g., surface waters) need to be more fully evaluated.

## What we did

We focused on better understanding PBM impacts on surface waters, where they would be exposed to sunlight. We measured the amount of leachate released from PBMs during ultraviolet (UV) light irradiation by quantifying the amount of dissolved organic carbon generated. We then determined the ecotoxicological response of each PBM's leachate to the marine bacterium *Aliivibrio fischeri* and the aquatic crustacean *Daphnia magna*. We also compared the behavior of these PBMs to two petroleum-based plastics within the same consumer use classes (e.g., textiles).




## What we found

We found that DOC concentrations in the leachate solutions for all PBMs were higher than in those from the two petroleum-based plastics, particularly under UV light, which increases DOC release. PBM leachates surprisingly often displayed higher or similar ecotoxicological responses as petroleum-based counterparts. Our results highlight the critical need to evaluate the environmental fate and ecotoxicity of PBMs and not rely on their assumed safety based on their non-hazardous feedstocks.

## Work plan FY 25–26

We have completed the main experiments and are currently working on a manuscript for publication. Future work may explore environmentally relevant concentrations of these material leachates.

# Vertical Ozone Profiles near the Great Salt Lake


## Research Summary:

In this 2024 UAS/$O_3$ study, an AggieAir drone, equipped with a Portable Ozone Monitor (POM) and supporting instrumentation, flew various times and locations around the Great Salt Lake in stacked horizontal layers to determine near-surface ozone profiles during peak season for local ozone formation. Analysis showed typical morning minimums nearest the surface, while later in the day the profile suggested more complete mixing and/or formation as the day progressed. The instrument package also successfully delineated vertical particulate and meteorological profiles.


### Why this research?

Understanding and remediating summertime ozone ($O_3$) has become an increasingly difficult challenge along the northern Wasatch Front. In early 2025, the airshed was redesignated to the "serious non-attainment" category; however, recent EPA administrative changes have paused that redesignation. As part of the much larger, multi-agency 2024 Utah Summer Ozone Study (USOS), we used a miniaturized $O_3$ monitor on AggieAir's uncrewed aerial system (UAS) platforms to characterize vertical ozone profiles from ground level to approximately 1000 ft agl, a region of the atmosphere not available to typical ground stations nor NOAA's Twin Otter sampling package used during the USOS program.

### Utah impact

A more complete understanding of the local atmospheric behavior of ozone throughout the regional boundary layer directly aids the State of Utah, through the Division of Air Quality, to develop the most effective and economical remediation scenarios.

### What we did

We conducted on average four flights per day (9:00, 12:00, 15:00, and 18:00)) over four days at three near-shore locations around the Great Salt Lake: Saltair, Unicorn Point (southern tip of Antelope Island), and the east side of Promontory Point Causeway). During each flight, the UAS flew a series of horizontal legs in a square pattern then ascended approximately 100 ft to repeat the pattern at the next elevation, continuing this sequence through the targeted elevations. Along with the $O_3$ instrumentation, we added low-cost sensors to examine the profiles of PM10/PM2.5, temperature,


### Principal Investigators:

Randal Martin (PI)
Cal Coopmans (Co-PI)
Sierra Young (Co-PI)

### Students:

Donald Olsen (MS)
Himalaya Sapkota (MS)

### Research Collaborators:

USU: Ian Gowing, AggieAir/UWRL

State: Rachel Edie and Chris Pinnel, Utah Division of Air Quality (UDAQ)

National: numerous personnel from US EPA and NOAA



### Funding Source:

Utah Division of Air Quality


### Geographic Areas:

Study Areas: Areas all around the Great Salt Lake, including urban and rural areas

Areas Benefited: Along the north and south Wasatch Front and the northern Wasatch Front $O_3$ non-attainment area


### Contact:

**Randal Martin**
435.797.1585
randy.martin@usu.edu

### Media Coverage:

KSL TV (Channel 5) (article/video) *Researchers use drone to track ozone pollution in the state*. August 6, 2024. https://ksltv.com/668413/researchers-use-drone-to-track-ozone-pollution-in-the-state/

### Presentations:

The $O_3$ studies were presented as poster sessions at the 2024 American Geophysical Union conference in December 2024 and the Utah-centric Science for Solution conference in Logan, UT in March 2025. Related area halogen concentration studies were also presented at the same conferences.

### Data Set:

The UAS $O_3$ and supporting data sets have been uploaded in the ICARTT format to the NOAA USOS website: https://csl.noaa.gov/groups/csl7/measurements/2024usos/data.html

## Work plan FY 25–26

Remaining tasks include (1) compiling our work into the NOAA final report for the overall USOS project (to be submitted to UDAQ), (2) Publishing a manuscript currently in review, and (3) Supporting a graduate student completing and defending their MS thesis.

and relative humidity and used the UAS flight control system to derive wind speed and direction profiles. FAA restrictions limited flight ceilings to 750 ft at the Saltair and Unicorn Point and 1100 ft at the Causeway.

## What we found

Overall, the AggieAir UAS, equipped with the selected instrumentation, proved to be an effective platform to characterize local boundary layers. Results showed differing vertical behaviors according to time of day and location (Figure 1). Morning flights typically showed the lowest $O_3$ concentrations and often the most significant gradient profiles. We observed higher $O_3$ concentrations and more homogeneous distributions as the day progressed, likely due to ground-level photochemistry and potential mixing from aloft. However, upper-level ozone concentrations were not consistent across the various flights, as contour maps (Figure 2) show noticeable variation across each face of the transect.

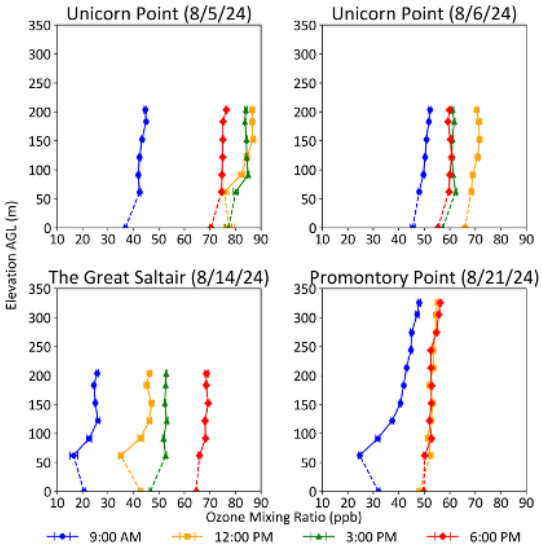



Figure 1: *Averaged $O_3$ vertical profiles for each day and flight.*

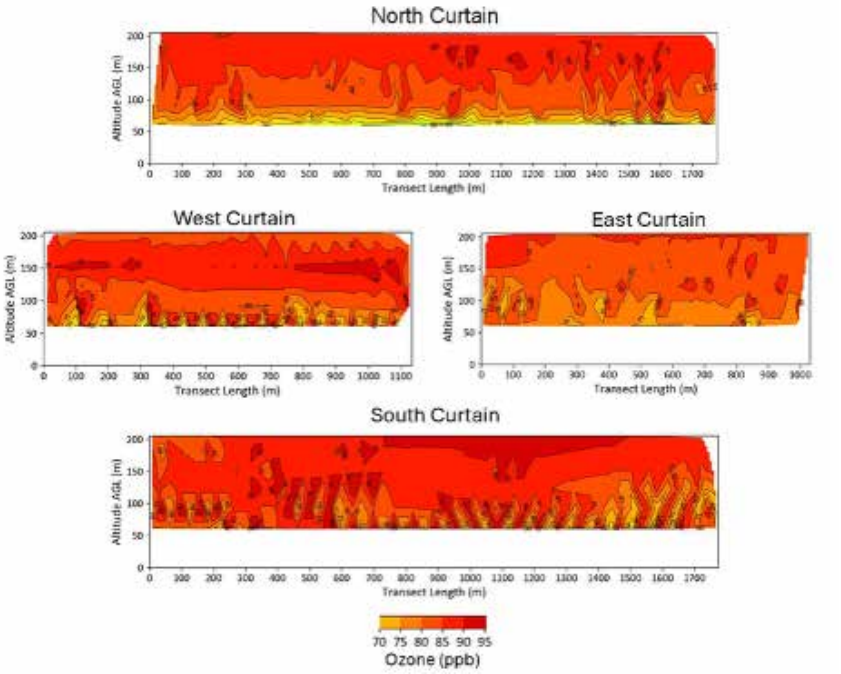



Figure 2: *Sample contour plots of each section or "curtain" of the transects from Unicorn Point (12:00 on Aug. 8, 2024).*

# Hydraulics

## ACTUAL, BUDGETED AND PLANNED EXPENDITURES OF MINERAL LEASE FUNDS

| HYDRAULICS: PI | Project Name | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|---|
| Rice, J. | Backward Erosion Piping : Evaluating Multiple Loading Effects and Head Loss Variability through Laboratory Experiments and Three-Dimensional Modeling | $34,994 | --- | --- |
| Phillips, C. | Collaborative Research: Separating the Climate and Weather of River Channels: Characterizing Dynamics of Coarse-Grained River Channel Response to Perturbations across Scales | $69,399 | $71,481 | $73,625 |
| Crookston, B. | Community Vulnerabilities to Water Disasters | $37,645 | $38,774 | $39,937 |
| Bay, J. | Laboratory Device on Assessing Infiltration Effects on Layered USCS-Classified Soils: A Large-Scale and A Small-Scale Model Analysis | $29,470 | --- | --- |
| Crookston, B. | Research in Water Infrastructure Sustainability | $37,645 | $38,774 | $39,937 |
| Sharp, Z. | Typical Model Study at the Utah Water Research Laboratory | $7,213 | --- | --- |
| | *Undesignated projects in program area* | | *$10,000* | *$2,000* |
| | **TOTALS** | **$216,366** | **$159,029** | **$155,499** |

# Backward Erosion Piping: Evaluating Multiple Loading Effects and Head Loss Variability through Laboratory Experiments and Three-Dimensional Modeling

## RESEARCH SUMMARY:

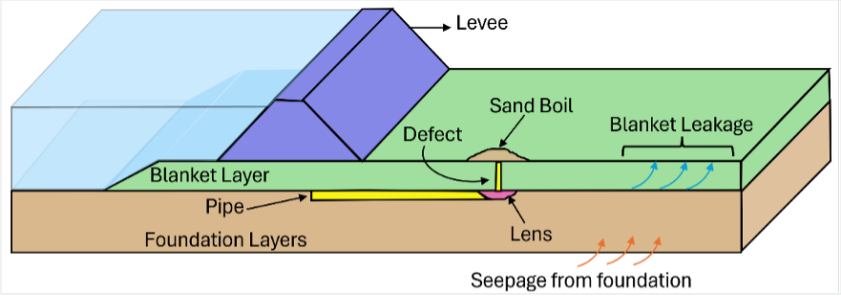
This research addresses two fundamental gaps in the current understanding of backward erosion piping (BEP): (1) how multiple floods affect BEP progression in dam and levee foundations, and (2) how head loss varies within vertical defects of different sizes and soil types during erosion. A series of controlled laboratory experiments has been designed using a cylindrical seepage apparatus developed at US Army Corps of Engineers (USACE) and later modified at Utah State University (USU) that enables water to flow radially inward toward a central defect, replicating 3D erosion behavior

### Why this research?

Backward erosion piping (BEP) is an internal erosion mechanism that causes progressive removal of sandy material beneath water-retaining structures such as dams and levees. This process initiates at an unfiltered exit point and advances in the direction opposite to the seepage flow, leading to shallow pipe formation beneath the cohesive layer. BEP accounts for nearly one-third of levee and dam failures worldwide, yet its complex, nature remains not fully understood. Most existing experimental studies and analytical models assume steady-state, single-event, two-dimensional (2D) conditions, which fail to capture how BEP progresses under repeated hydraulic loading and realistic three-dimensional (3D) flow conditions.

### Utah impact

Utah has many dams and canal bank structures, many aging and posing potential risks to surrounding communities. Internal erosion, and particularly BEP), is a leading cause of dam and levee failures worldwide. This research advances understanding of BEP by addressing knowledge gaps on how multiple loading events influence its potential, evaluating three-dimensional




*Schematic of testing apparatus.*

## PRINCIPAL INVESTIGATORS:

John Rice (PI)
James Bay (Co-PI)

## STUDENT:

Deepika Ghorasaini (PhD)

## FUNDING SOURCES:

United States Society on Dams scholarship

## GEOGRAPHIC AREAS:

Study Areas: Laboratory modeling project

Areas Benefited: The dam and levee engineering community in Utah and beyond

## CONTACTS:

**John Rice**
540.808.8061
john.rice@usu.edu

**James Bay**
435.797.2947
jim.bay@usu.edu

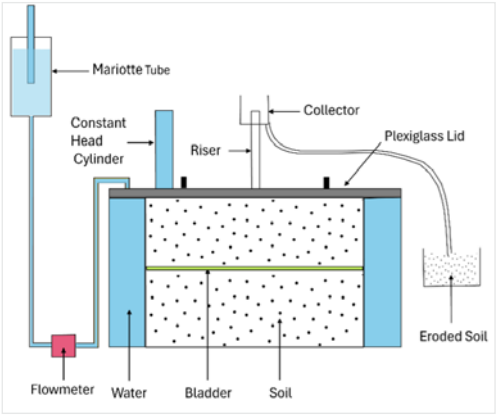
## PRESENTATIONS:

- Ghorasaini, Rice, and Ahmed (2025) *Three-dimensional flow and components of backward erosion piping*. United States Society on Dams Annual Conference, April 2025
- Ghorasaini, D., and Rice, J. (2025). *The Effects of Multiple Loading Events on Backward Erosion Piping Progression*. GeoCongress 2026 Conference, ASCE. (Accepted for the GeoCongress 2026 Conference)

components, and assessing head loss within defects. The results will improve risk assessment for Utah's dams and levee-like structures and provide valuable insights for the broader dam and levee engineering community.

## What we did

In the first objective, we test four risers and three soil types including Quartz sand, Fine sand, and Graded Ottawa under repeated hydraulic loading cycles to evaluate the effect of multiple loads on the piping process, with eight differential pressure transducers installed around the exit and at the bottom of the riser. Three-dimensional finite element software is used to mimic the erosion that occurs for each test. Calibration uses the results of the experimental data to calculate the critical horizontal gradient at the channel.



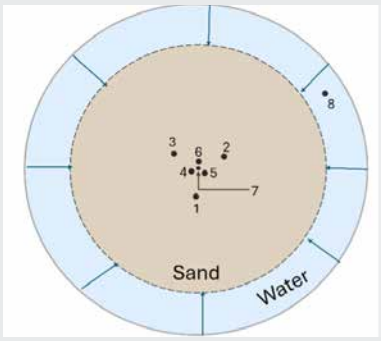

For the second objective we measure head loss along three different vertical risers using the same soil types as in the first objective. These experiments assess how defect geometry and soil type affect head loss within the defect. Although different countries use varying head loss values without experimental validation, actual head loss depends on defect size and soil properties. Pressure transducers positioned at key locations along the riser tube will record pressure variations, allowing calculation of head loss at different points within the riser tube. The resulting experiments aim to improve understanding of the factors influencing head loss and help refine predictive models for BEP.

## What we found

Due to multiple, successive, and expensive problems that developed with the various components of the testing device, the actual testing has been delayed. With the apparatus how properly functioning we are now collecting test results with scheduled completion during the second semester of 2026.

### AWARD:

D. Ghorasaini received 1st place in the Kim de Rubertis Student Scholarship at the USSD 2025 Conference in Kansas City, MO. https://www.ussdams.org/scholarships/




## Work plan FY 25–26

We will use the laboratory device described above to gather the primary dataset for the student's dissertation research. Testing and data analysis will continue, and the results will also be modeled in three-dimensional software to evaluate the 3D aspects of BEP and head-loss behavior. Full findings will be summarized in the completed dissertation.

# Collaborative Research: Separating the Climate and Weather of River Channels: Characterizing Dynamics of Coarse-Grained River Channel Response to Perturbations across Scales

## Research Summary:

This project is developing physical models to assess the sensitivity of mountain river channels to changes in discharge and their associated hazards and will help to identify where river channels are susceptible to significant change. Expected results will aid researchers and engineers in determining which river systems are vulnerable to erosion due changing flood magnitudes and land use and provide a foundation for treating rivers dynamically within the next generation of river flood hazard forecasting models.

### Why this research?

Mountain rivers play distinctive roles: as the primary agents of distributing sediment and nutrients from mountains to lowlands, as critical freshwater source areas for the western United States, and as vital aquatic habitats. However, mountain rivers are highly susceptible to the compound hazards presented by extreme storms and shifting precipitation patterns. Increasing rainfall intensity can lead to more frequent flooding and landsliding, while increasing drought severity enhances the threat of wildfire, vegetation loss, and extreme erosion risks. This research to understand how mountain river channel geometry dynamically responds to flooding and other watershed perturbations is organized around the central question of separating river response due to a perturbation from the inherent natural variability present within watersheds. Separating change signals from variability involves three components: (1) a physics-based model for the expected river conditions under natural forcing, (2) quantifying the inherent natural variability within the river channel system across the riverbed and reach scale, and (3) a physical description with quantified adjustment times for river response to perturbations across these scales.

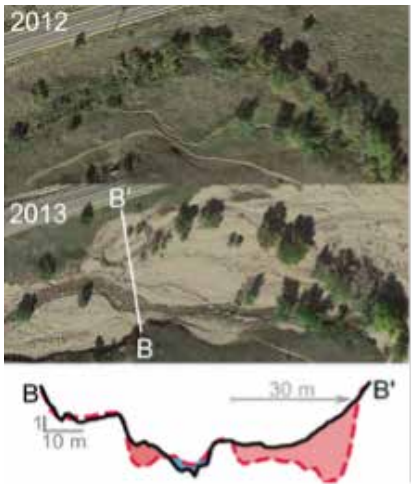



**Figure 1:** *Top: Fourmile Canyon Creek in Colorado prior to the 2013 Boulder Floods. Middle: Extreme flooding resulted in over 30 meters of erosion.*

### Utah impact

This research enhances our understanding of how mountain rivers respond to changing hydroclimates and landscape disturbances, leading to better flood and erosion management.

### Principal Investigators:

Colin Phillips (PI)

Claire Masteller (University of Washington in St. Louis, Co-PI)

### Student:

Jesse Bower (MS)

### Research Collaborator:

Logan River Observatory

### Funding Sources:

National Science Foundation

NOAA through Cooperative Institute for Research on Hydrology, University of Alabama

### Geographic Areas:

Study Areas: Field sites in Eel River, northern California, Logan and Strawberry rivers, Utah; the Colorado Front Range; and North Carolina

Areas Benefited: This research is beneficial to rivers throughout the United States

### Contact:

**Colin Phillips**
435.797.0938
colin.phillips@usu.edu

The results provide a framework for guiding sustainable restoration practices and managing aquatic habitats in rivers that are expected to change. Additionally, the project has provided hands-on STEM learning experiences for undergraduate and high-school students. Ultimately, this work will help identify and ensure a more resilient future for all Utah residents.

## What we did

We first determined the baseline natural variability within river system's channel shape and form by developing a flexible set of digital tools to extract channel geometry from high-resolution topography for entire watersheds. The extraction tools allowed us to characterize natural variability within selected watersheds across the continental United States and establish a methodology to determine if river change is within or outside the bounds of natural variability.

## What we found

Rivers naturally have a consistent shape and geometry that can be described using a common probability distribution. By measuring natural variability, we can identify when a river has been disturbed from its baseline state. Our digital tools enable us to quickly determine the baseline variability of river channels from high-resolution topographic data. Utilizing these tools, we can observe how rivers have changed following extreme perturbations (wildfire & debris flows and 100-year floods). These observations of natural variability and river change after extreme events form the basis for predicting the extents of erosion within river systems. Natural variability can result in channel widening or narrowing on the order of 10–20% of the channel width, while extreme events can result in greater than 200% changes in width. Rivers respond differently to sediment pulses and major floods. Large floods result in channel widening through bank erosion while substantial sediment pulses result in channel aggradation and eventual widening through overbank flow.

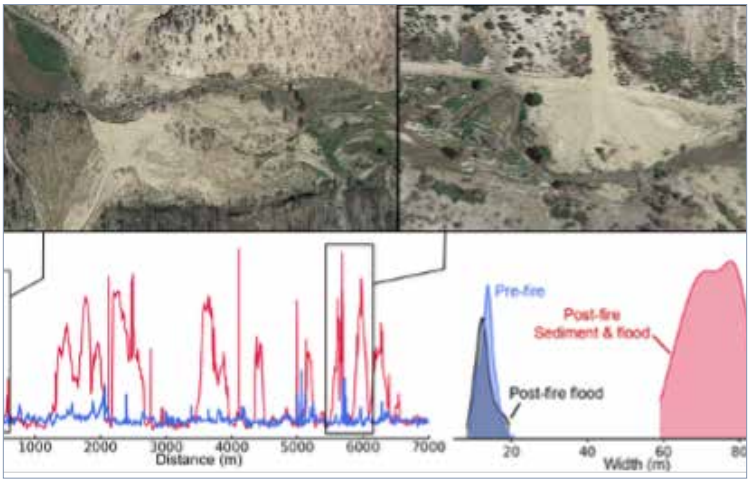



**Figure 2:** *High-resolution river width measurements within the Strawberry River prior to (blue line) and following the flood after the Dollar Ridge fire. Probability distributions highlight how the river width has changed post fire due to the flood (black) and large sediment inputs into the river (red).*

### PUBLICATION:

C.B. Phillips, C.C. Masteller, J. Blaylock, F. Van Iwaarden, & J.P.L. Johnson (2024), *Variability in river width reveals climatic influence on channel geometry*. Geophysical Research Letters, 51, e2024GL111789. https://doi.org/10.1029/2024GL111789

### DATA SET:

C.B. Phillips (2024). *Alluvial River Width Variability*, HydroShare, https://doi.org/10.4211/hs.56e0ac25249d4451845a843eb3154954

### PRESENTATIONS:

- J. Bower, C. Masteller, and C.B. Phillips (2024), *River Channel Response to a Destabilizing Flood*, 2024 Fall Meeting, AGU
- R. Kostynick, C. Masteller, and C.B. Phillips (2024), *Detecting disequilibrium through deviations in channel width and slope in alluvial rivers*, 2024 Fall Meeting, AGU.

## Work plan FY 25–26

This project is currently in a no cost extension and is focusing on producing a generalizable model for understanding how rivers respond to large floods and sediment pulses (landslides & debris flows) through the use of field data analysis and laboratory experiments for rivers following the 2013 Boulder Floods, the Dollar Ridge Fire in central Utah, and North Carolina following Hurricane Helene.

# Community Vulnerabilities to Water Disasters

## Research Summary:

The World Meteorological Organization (2021) reported that, in the past 50 years, more than 8,745 water disasters have impacted communities throughout the world, resulting in 1.1 million reported deaths and $3.1 trillion in economic damages (https://public.emdat.be). Storms and floods are by far the most significant of all natural disaster types in event magnitude, number of events, mortality, and monetary losses. Even Cache Valley in northern Utah recently experienced flooding along the Logan and Black Smith Fork Rivers. However, community vulnerability to water disasters is due not only to a changing climate, but also to human generated influences such as urbanization of floodplains and aging infrastructure. Indeed, risk mitigation efforts (such as flood and hazard mapping) often do not consider the most recent conditions of a river, the condition of infrastructure in a river reach, nor the effects of sediment on flooding.

### Why this research?

Considerable research has been done on flood management and river restoration efforts to increase natural flood protection and catchment management efforts to reduce runoff during storm events. However, improving flood management efforts and reducing impacts from flooding require flood studies based on flood models that incorporate the latest river corridor surveys (bathymetry and adjacent terrain), appropriate boundary conditions and roughness, a variety of climatic scenarios, and consideration for infrastructure. This research is preparing high-accuracy flood maps and identifying the inundation extents and macro hydraulic properties such as flood stage and average flow velocities to identify hazards and impacts amid urbanization and climate change. Flood maps often rely on pre-scripted generalized map development guidance and flood models are often based on limited terrain and hydrologic information, limiting the accuracy or reliability of the flood map and the usefulness of the results.

This research study is strongly aligned with the Utah Water Research Laboratory's mission statement and will focus on these research questions:

1. What are the primary characteristics of flood risks in the US by region?
2. Why are US communities and the built environment so vulnerable to flood impacts, and will this change in the future? Is a new framework needed for the future?


Principal Investigator:
Brian Crookston

Student:
Ishwar Joshi (PhD)


Geographic Areas:

Study Areas: Cache Valley and Intermountain West

Areas Benefited: This research is of benefit to the State of Utah as it focuses on current and future flood hazards in Cache Valley in the context of current urbanization trends and climatic shifts


Contact:

**Brian M. Crookston**
435.797.0247
brian.crookston@usu.edu

3. Which paths forward are most viable in effectively modeling floods to reduce flood impacts?

## Utah impact

This research benefits the State of Utah and the communities in Cache Valley where we actively mapped flood conditions in 2024 and continued flood modeling efforts through 2025. Using technology to better estimate flood impacts is of interest to Logan City and others in Utah.

## What we did

Previous work included field work along the Blacksmith and Logan rivers, including sediment sampling, and hydraulic measurements, as well as cross-section surveys and data mining from the current Logan Flood Model in RAS 1D. We have documented flood scenario uncertainties for the Logan River using high-resolution data and 2D CFD flood modeling, obtained PMF estimates and 2- to 500-year return period flows for modeling scenarios, communicated project progress and results with Utah Dam Safety and FEMA, and compiled flood data and USGS stream gage data for upcoming river flood modeling efforts.

## What we found

This project has quantified effects of urbanization and climate on flood impacts in Cache Valley including the role of bridges and in-stream structures.

**Figure 1:** *Field work along the Blacksmith Fork and Logan rivers.*

### PUBLICATION:

I. Joshi, B. Crookston (2024) *Flooding impacts to agricultural lands with changing climates*. World Journal of Agriculture and Soil Science, Iris Publishers (9)2, doi: 10.33552/WGASS.2024.09.000707. https://irispublishers.com/wjass/abstract/flooding-impacts-to-agricultural-lands.ID.000707.php

## Work plan FY 25–26

Calibration and validation of the model is nearly complete. Three other publications are under review or in preparation.

# Laboratory Device on Assessing Infiltration Effects on Layered USCS-Classified Soils: A Large-Scale and A Small-Scale Model Analysis


## Research Summary:

A small-scale benchtop infiltration model has been developed to offer a cost-effective, time-efficient means of studying infiltration trends. This model replicates the conditions of the large-scale experiments (that were also conducted at USU) but in a more accessible and scalable format. By testing various combinations of United Soil Classification System (USCS)-classified soils in both base and top layers, the research aims to develop calibration factors for volumetric water content (VWC) sensors and analyze the repeatability of infiltration measurements. The study will provide a small-scale model for designers to use in evaluating the compatibility of the soils in a layered design with respect to infiltration.


### Why this research?

In arid and semi-arid regions in Utah, the sustainable management of water resources is critical, particularly in urban areas where low-intensity rainfall can carry significant pollutants into stormwater runoff, adversely affecting water quality. This research focuses on providing a small -scale apparatus for testing the compatibility of soils in layered systems for use in rainwater runoff filter strips. Development of the bench-top model, the focus of this research, enables the measurement of surface runoff and infiltration through layered soils systems, using a rainfall simulator to deliver uniform water distribution. Data collected from this model provides valuable insights into the effects of various configurations of layered soils on infiltration rates, particularly in the context of the Utah Department of Transportation's (UDOT) BMP design requirements.

### Utah impact

In addition to advancing the understanding of infiltration behavior in layered soils, this research addresses a significant gap in current best management design practices, particularly regarding surface treatment options for different slopes. The Utah Department of Transportation's guidelines for Municipal Separate Storm Sewer System (MS4) permits require the retention of stormwater but provide limited guidance on the appropriate materials and configurations for filter strips under varying conditions. By systematically analyzing the infiltration trends of different soil combinations, this study will offer critical data that can be directly applied to enhance the design and effectiveness of filter strips. The findings will support the


### Principal Investigators:

James Bay (PI)
John Rice (Co-PI)

### Student:

Pranish Dahal (PhD)

### Research Collaborator:

Utah Department of Transportation


### Geographic Areas:

Study Areas: Computer modeling project

Areas Benefited: This research will benefit highway designers, environmental engineers, and hydrologists as they design highway embankments that are capable of infiltrating runoff from commonly encountered rainstorms.

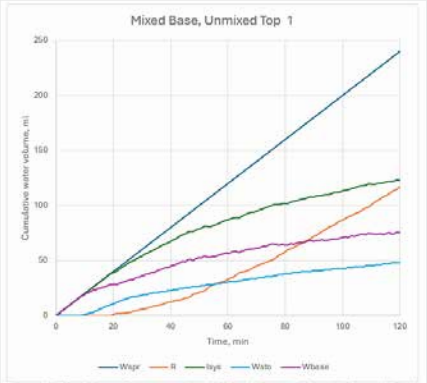
CONTACTS:

**James Bay**
435.797.2947
jim.bay@usu.edu

**John Rice**
435.797.8611
john.rice@usu.edu

## Work plan FY 25–26

This project is complete.

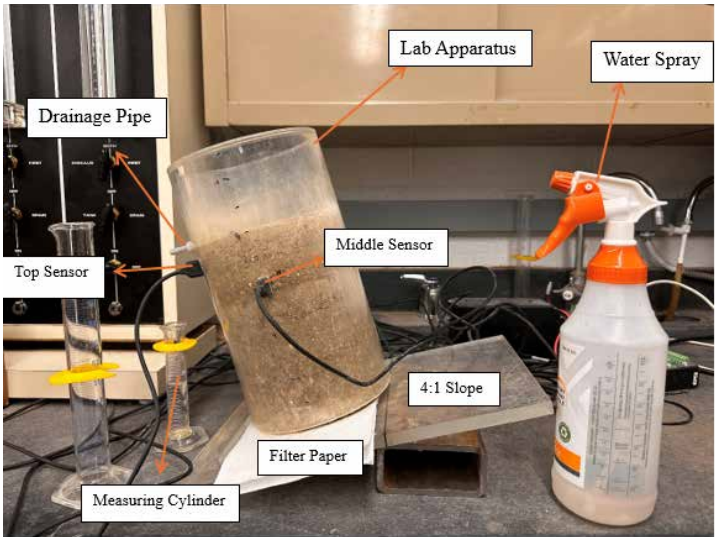



*Water volume balance vs time for mixed base soil, unmixed topsoil, Trial 1*

development of more robust and reliable strategies for managing stormwater runoff, particularly in challenging environments, ensuring that urban water resources are better protected from pollution. This research contributes to the field of geotechnical engineering and has practical implications for the sustainable management of urban water resources, providing valuable tools and insights for engineers and policymakers in Utah and beyond.

## What we did

This project developed a testing apparatus for evaluating the compatibility of layered soils proposed for use in a rainwater infiltration filter strip. The apparatus is a small-scale, benchtop device that could be adopted by consultants and designers to aid in the design of filter strips for highway embankments. The developed apparatus was tested using four different soil configurations. Three tests of each configuration were performed to assess the repeatability of the tests.




*Apparatus with sensors, drainage pipe, spraying bottle, measuring cylinder and support mount. (Bottom Sensor not pictured in this photograph)*

## What we found

While the results of the testing did provide a good comparison of the infiltration behavior of the four soil configurations, a numerical assessment of the results was more difficult than anticipated. We found that slight differences in initial water contents in the soils affected the early behavior of the models during testing. To accommodate these differences, we adopted a method that compares the infiltration that occurs once the upper soil has reached a critical or equilibrium water content that allowed for a more direct comparison of the different configurations. We also found that, with a few exceptions, the tests were reasonably repeatable as long as care was taken to start the tests with similar initial water contents.

# Research in Water Infrastructure Sustainability

## RESEARCH SUMMARY:

Water infrastructure is under significant strain due to population trends, water usage changes, and climatic events. The PI's research and engineering efforts are focused on water sustainability and resiliency in the areas of hydraulic structures, fluvial hydraulics, and modeling and technology with a particular focus on spillways, energy dissipators, river and canal systems, scour and erosion, public safety at hydraulic structures, physical modeling, computational fluid dynamics, flooding and flood risk, instrumentation and technology, surface hydrology, and ecohydraulics.

### Why this research?

This research directly supports water infrastructure challenges to Utah, various US Federal agencies, and practitioners.

### Utah impact

This research study is strongly aligned with the mission statement of the UWRL. The PI often receives multiple calls per week soliciting free expertise and guidance as it relates to hydraulic structures.

Figure 1: *Recent training workshop organized by Crookston and University of Liege.*

## PRINCIPAL INVESTIGATOR:

Brian Crookston (PI)

## RESEARCH COLLABORATORS:

Academic: University of Liege, Belgium; Norwegian University of Science and Technology, Norway; Imperial College, London; Aachen University, Germany

Industry: Various

State: Utah Department of Natural Resources

National: US Army Corps of Engineers

## GEOGRAPHIC AREAS:

Study Areas: Utah

Areas Benefited: The State of Utah , with a focus on infrastructure sustainability and water storage and supply, the Great Salt Lake, flood hazards and flood protection

## CONTACT:

**Brian M. Crookston**
435.797.0247
brian.crookston@usu.edu

## SELECTED PUBLICATIONS:

- D. Dunn, B.M. Crookston, S. Dutta, B.T. Neilson (2025). *Modeling Great Salt Lake Water Levels and Salinities to Capture Current Adaptive Management Actions*. Journal of Hydrology: Regional Studies, 62:102768, https://doi.org/10.1016/j.ejrh.2025.102768 and data set at https://

www.hydroshare.org/resource/267e083484a74866927d91bdef60f8d6/

- M. Panthi, B. Crookston (2025). *Non-cohesive sediment cleaning patterns and processes upstream of a Type A piano key weir for steady and unsteady flow conditions*. Journal of Hydrology and Hydromechanics/Sciendo, 73:3, 310-321. https://doi.org/10.2478/johh-2025-0024
- B.M. Crookston, C.R Arnold (2025). *Utilizing deep learning and object-based image analysis to search for low-head dams in Indiana, USA*. Water, 17:6, 876. https://doi.org/10.3390/w17060876
- M.R. K.C. B.M. Crookston, K. Flake, S. Felder (2025). *Enhancing flow aeration on an embankment sloped stepped spillway using a labyrinth weir*. IAHR Journal Hydraulic Research, 63:1, 32-47. https://doi.org/10.1080/00221686.2024.2448238
- S. Sadeghfam, N. Fahmfam, R. Khatibi, B. Crookston, M. Vadiati, M. Moazamnia (2025). *Introducing Reservoir Sustainability Indexing to Investigate Reservoir Operations and Piloting it at the Basin of Lake Urmia with Sparse Data*. Environmental and Sustainability Indicators, 25:(2025) 100577, 1-13. https://doi.org/10.1016/j.indic.2024.100577
- B.R. Pandey, M.R. K.C., B.M. Crookston, G. Zenz (2024). *Numerical Investigation of Different Stepped Spillway Geometries over a Mild Slope for Safe Operation Using Multi-Phase Model*. Water, 16:11, 1635. https://doi.org/10.3390/w16111635

## What we did

The PI participated in organizing and editing events and trainings related to water structures, including an international workshop, webinars, journal edits, leadership and committees. He published 10 articles in scientific journals, 3 event proceedings and 4 contributions to international workshop proceedings.

## What we found

The research published represents the latest results and innovations in the field of hydraulics, such as labyrinth and piano key weirs, dams engineering, civil engineering, and hydraulic structures engineering, and serves as a useful guide for students, researchers and professionals.

## Work plan FY 25–26

The PI will teach 3 courses at USU, continue hydraulic structure research at the UWRL, continue with outreach to Utah and practitioners, publish findings in various forms, including conference presentations and papers, workshops and webinars, journal papers, and trade journal articles.

# Typical Model Study at the Utah Water Research Laboratory


## RESEARCH SUMMARY:

An example project at the Utah Water Research Laboratory (UWRL) focused on constructing a scale model of a reservoir system, including key hydraulic structures such as a control section with gated and ungated weirs, a spillway chute and terminating structure, a plunge pool, and the downstream river channel. After construction, the model was instrumented to measure flow rates, pressures, and velocities, providing critical data to evaluate the hydraulic performance of the design. Dam safety was a primary design criterion, which influenced data collection limits and guided construction material selection for building the prototype structure. UWRL projects encompass a wide range of hydraulic structures and systems, offering students critical training, hands-on modeling and analysis experience and practical skills in hydraulic engineering, which are highly valued in both industry and academia.


### Why this research?

This report highlights how projects at the Utah Water Research Laboratory (UWRL) benefit the state of Utah. While it does not focus on a single specific project in detail, it demonstrates how investment of Mineral Lease funds for tools and equipment strengthens the UWRL's capacity to undertake complex hydraulic projects. These resources enhance faculty capabilities and provide students with hands-on experience that is critical for their professional development.

The example project featured here supported the engineering design of an upgraded reservoir spillway chute and terminate structure, which represents a typical UWRL project. Each project exposes students to real-world hydraulic challenges, preparing them to address pressing water infrastructure needs. Engineering and design firms consistently report shortages of professionals with the expertise to design and oversee these types of projects. UWRL-trained graduates are well-equipped to fill this gap, becoming the next generation of water engineering experts who will, in turn, create the projects that will allow the UWRL to continue mentoring and training future engineers in similar ways.

### Utah impact

This project was completed in the first Utah office of an Engineering firm whose entire team earned graduate degrees from Utah State University. Each engineer


PRINCIPAL INVESTIGATORS:

Zachary B. Sharp (PI)
Michael C. Johnson (Co-PI)


RESEARCH COLLABORATORS

Business/Industry: Private professional businesses (typically engineering firms or dam owners/operators)

STUDENTS:

Graduate and undergraduate engineering students employed at the UWRL.


FUNDING SOURCE:

Private Sources


GEOGRAPHIC AREAS:

Study Areas: worldwide

Areas Benefited: Numerous engineering graduates from the UWRL are now working in Utah

CONTACTS:

**Zac Sharp**
435.797.3167
zac.sharp@usu.edu

**Michael Johnson**
435.797.3176
michael.johnson@usu.edu

## PROJECT OUTCOMES:

The immediate outcome of these projects is generally a report delivered to the funding agency as specified in the contract. A notable long-term impact example is the establishment of a new Utah office by a Pennsylvania-based engineering company. The firm's five lead engineers—all graduates with master's or doctoral degrees from Utah State University—conducted their research at the Utah Water Research Laboratory, demonstrating the broader influence of these projects on workforce development and regional expertise.

## Work plan FY 25–26

The project featured in this report will continue into the spring, with additional components to be constructed and tested to further optimize spillway chute performance. Beyond this effort, new projects will follow, providing Utah students with exposure to some of the world's most challenging hydraulic engineering problems at UWRL.

conducted their graduate research at the UWRL, demonstrating the lab's role in developing talent that remains in Utah and contributes directly to the state's water infrastructure and economy.

## What we did

For this project, we built and tested a physical model with an engineering design developed by the highly qualified team of UWRL-trained engineers who are now applying their expertise in the state.

## What we found

Several components of the physical model were improved and optimized during testing. More importantly, this project showcased the exceptional skill of these engineers and their significant, ongoing impact on Utah's water resources.


*These photos highlight scale model components fabricated using Mineral Lease Fund–supported equipment. This advanced machinery not only enables precise construction but also provides students with hands-on training in modern fabrication techniques, which skills they carry forward into their professional careers.*

# Education, Outreach and Technology Transfer

## Actual, Budgeted and Planned Expenditures of Mineral Lease Funds

| Education, Outreach and Technology Transfer: PI | Project Name | Actual FY2025 | Budgeted FY2026 | Planned FY2027 |
|---|---|---|---|---|
| Barker, B. | Agricultural Demonstration, Research, and Implementation Program (AG-DRIP) | $3,045 | $3,136 | $3,230 |
| Barker, B. | Agricultural Irrigation Collaborative | $3,045 | $3,136 | $3,230 |
| Barker, B. | Agricultural Optimization Depletion Quantification Framework and Report | $3,045 | --- | --- |
| McFarland, M. | Development of Biosolids Beneficial Use Operator Certification Training Program | $47,184 | $48,599 | $50,056 |
| Sims, J. | Development of a On-Site Demonstration Site at the Ash Creek Special Services DIstrict | $3064 | $3,155 | $3,249 |
| Rosenberg, D. | Immersive modeling of a Cache Valley Water Bank to Shepherd Water to Great Salt Lake | $6,980 | $7,189 | $7,404 |
| Rosenberg, D. | Increasing the Impact of Utah State University's Extension Water Check Program with 5-Second Metering | $9,699 | --- | --- |
| Dupont, R. | Logan City Renewable Energy and Sustainability Advisory Board (RESAB) | $3,378 | $17,899 | $18,435 |
| Barker, B. | Management and Technical Consulting for Agricultural Resiliency and Demand Management Pilot Program | $3,045 | $3,136 | $3,230 |
| Barker, B. | Opportunities and Costs for Agricultural Water Optimization and Leasing | $3,045 | $3,136 | $3,230 |
| Tarboton, D. | Planning for an Uncertain Future with Great Salt Lake | $62,981 | $64,870 | $66,816 |
| Tullis, B. | State of Utah Drinking Water Board | --- | --- | --- |
| Tullis, B. | State of Utah Operators Certification Commission | --- | --- | --- |
| Barker, B. | Utah Agricultural Water Teaching, Extension, and Research Network (Ag WaTER Net) | $3,046 | $3,136 | $3,230 |
| Sims, J. | Utah On-Site Wastewater Treatment Training Program | $3,064 | --- | --- |
| Barker, B. | Wine Grape Irrigation Water Requirements in Utah | $3,045 | $3,136 | $3,230 |
| | *Undesignated Projects in program area* | | *$10,000* | *$2,000* |
| | **TOTALS** | **$167,666** | **$170,528** | **$167,340** |

# Agricultural Demonstration, Research, and Implementation Program (AG-DRIP)

## Research Summary:

We are collaborating with the Colorado River Authority of Utah and the Central Utah Water Conservancy District to provide irrigation management resources to farmers using Colorado River water in Utah. Participants receive soil moisture sensors, flow meters, irrigation system evaluation, and credits to use for alternative crop seed and irrigation supplies. The intent is to build capacity in the participants to improve irrigation management in the face of limited water supplies.

### Why this research?

Ongoing shortages in the Colorado River System create the need to provide agricultural producers with the resources and knowledge they need to maintain viable agriculture in the face of reduced water supplies.

### Utah impact

In many ways, Utah farmers have faced the social and economic brunt of drought and limited water resources. Along with our collaborators we are helping build capacity in on-farm irrigation management so that farmers can be more resilient.

Figure 1: *An irrigation system is being evaluated as part of the AG-DRIP program.*

### Principal Investigators:

Matt Yost (PI)
Burdette Barker (PI)
Elisa Flint (Co-PI)
Silas Ekadu (Co-PI)

### Research Collaborators:

Many farmers

### Students:

Tejinder Singh, (PhD, Plant Science)
Lizabeth Pugliese (BS)

### Funding Sources:

Central Utah Water Conservancy District, Colorado River Authority of Utah

### Geographic Areas:

Study Areas: Colorado River Basin in Utah

Areas Benefited: Utah

### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

## What we did

We provide participating farmers with face-to-face trainings, soil moisture sensors, flow meters, irrigation system evaluations, and credits to use for alternative crop seed and irrigation supplies. We also help them develop irrigation management plans.

## What we found

Over 80 fields have been enrolled in the program to date. Many farmers have made changes to their irrigation management as a result. Some have applied more water and some less than they feel they otherwise would have. As a whole, active participants are gaining valuable knowledge and skills for scientific irrigation management.

## Work plan FY 25–26

We will enroll another ~30 fields into the program.

### Publications:

- E. Flint, M. Yost, B. Barker, and S. Ekadu (2024). *Ag Water Demonstration, Research, and Implementation Program (Ag-DRIP) 2023 Report.* Utah State University Extension, Logan, UT https://extension.usu.edu/ag-drip/files/ag-drip-2023-annual-report.pdf
- E. Flint, M. Yost, B. Barker, and S. Ekadu (2025). *Ag Water Demonstration, Research, and Implementation Program (Ag-DRIP) 2024 Report*. Utah State University Extension, Logan, UT

### Presentations:

- S. Ekadu, B. Barker, M. Yost, and E. Flint. *Leveraging Technology for Enhancing Irrigation Management in the Colorado River Basin of Utah for a Water-Secure Future*. ASABE Annual International Meeting, Toronto, ON. July 14-16, 2025.
- Numerous Extension presentations.

# Agricultural Irrigation Collaborative

## Research Summary:

We are leading a collaborative effort between several state agencies and other organizations listed above to coordinate messaging efforts regarding agricultural water use in Utah. We are building a dashboard with resources and information regarding irrigation water use, best practices, and agricultural water use messaging. The intent is that messaging will be consistent between organizations.

### Why this research?

Irrigation is by far the largest use of diverted water resources in Utah. In late 2025, USU Extension and several state agencies and other organizations met to discuss agricultural irrigation messaging needs. This collaboration was the result.


**Figure 1:** *Logo of the Agricultural Irrigation Collaborative.*

### Principal Investigators:

Burdette Barker (PI)
Matt Yost (PI)
Alfonso Torres (Co-PI)
Ryan Larsen (Co-PI)
Earl Creech (Co-PI)
Kelsey Hall (Co-PI)

### Research Collaborators:

Utah Department of Agriculture and Food, Utah Department of Natural Resources, Colorado River Authority of Utah, Office of the Commissioner of the Great Salt Lake, Utah Farm Bureau Federation

### Students:

Connor Hales (BS), Matthew Reyes (BS), Katelyn Parker (MS, Anticipatory Intelligence), Mia Nielsen (BS), Brianna Enright (BS)

### Funding Source:

USU Extension

### Geographic Areas:

Study Areas: Utah

Areas Benefited: Utah and similar regions

Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

## Utah impact

State agencies and other organizations are often queried about information relating to irrigation water use, irrigation practices, and efforts that the agricultural sector is making to optimize use of water resources.

## What we did

We hired five student interns to coordinate messaging efforts between the partner organizations, identify frequently asked questions, and develop an information dashboard.

## What we found

Information has been gathered and many FAQs answered. A draft dashboard has been constructed and will eventually be housed on the website: https://irrigation.usu.edu.

## Work plan FY 25–26

The website and information summaries will be published in the coming fiscal year.

# Agricultural Optimization Depletion Quantification Framework and Report

## Research Summary:

This report details the recommendations for quantifying differences in depleted water (depletion) from changing agricultural irrigation practices. We developed practical definitions of depletion for irrigated fields and conveyance systems, along with a practical definition of change in depletion. The report also recommends methods to use to quantify components of depletion.

### Why this research?

The Utah Division of Water Rights desired documented best practices recommendations for quantifying irrigation water depletion to help them fulfill their mandate of quantifying depletion changes in change applications. Depletion is not a quantity that can be directly measured; it must be quantified indirectly, often involving modeling.

### Utah impact

The Utah legislature provided a statutory pathway for water users to lease or otherwise transfer changes in water depletion (for example, to benefit the Great Salt Lake). The Division of Water Rights needs consistent and accurate methods for estimating depletion.

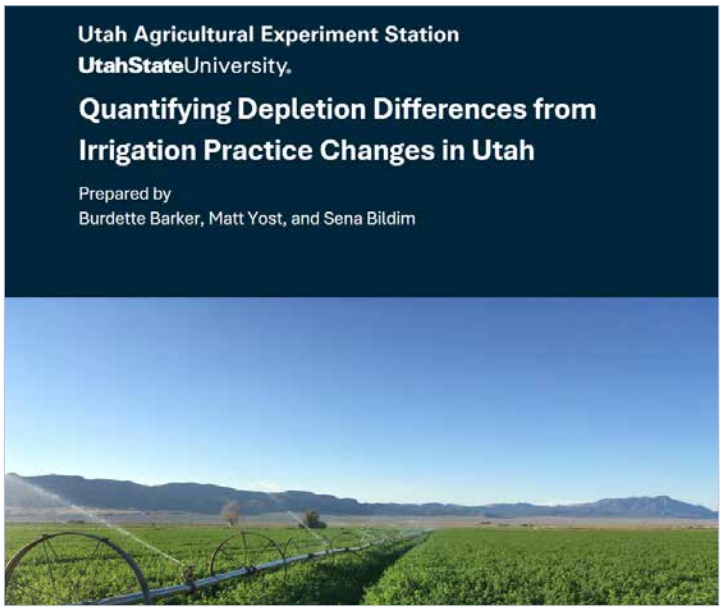



**Figure 1:** *Report Prepared for the Utah Division of Water Rights.*

### Principal Investigators:

Burdette Barker (PI)
Matt Yost (Co-PI)

### Student:

Sena Bildim (MS)

### Funding Source:

Utah Division of Water Rights

### Geographic Areas:

Study Areas: Utah

Areas Benefited: Utah and beyond

### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

## Publication:

B. Barker, M. Yost, and S. Bildim (2025). *Quantifying Depletion Changes from Irrigation Optimization in Utah*. Report Prepared for the Utah Division of Water Rights. Utah State University, Logan, UT. https://extension.usu.edu//irrigation/files/QuantifyingDepletionIrrigation_FINAL_Barker_Yost_Bildim_UAES.pdf

## Presentations:

Several presentations to state groups and Extension audiences.

### What we did

We collaborated with Water Rights engineers to define depletion from a quantification standpoint. We then collaboratively developed a set of recommended quantification methods.

### What we found

We published a report that is now being used by Water Rights and other organizations for selecting depletion quantification methods.

### Work plan FY 25–26

This project is complete.

# Development of Biosolids Beneficial Use Operator Certification Training Program

## Research Summary:

Biosolids training materials were developed to assist Utah municipal wastewater treatment operators, landowners, public health officials and state environmental regulators to implement the federal regulations that currently govern the recycling or beneficial use of biosolids.

### Why this research?

This research filled an important educational and training gap that has gone unaddressed by environmental engineering and technology programs across Utah colleges and universities. In 1993, the US Clean Water Act was amended to specify how municipal wastewater sludges could be beneficially used or recycled into the environment. The new rule, Title 40 of the Code of Federal Regulations Part 503 describes how sewage sludge can be technically transformed into a high-quality product known as "biosolids," which is the only solid material generated at municipal wastewater treatment plants that can be legally recycled.

### Utah impact

Many Utah farmers, ranchers and other large landowners can benefit financially by recycling biosolids to their land to increase vegetative growth (higher product yield) and improve soil quality (increase in soil conditioning). Concurrently, municipal wastewater treatment plants can recycle a material that would otherwise have to be disposed of in landfills or incinerated, both of which are financially expensive and inefficient disposal options.

*sewage sludge can be technically transformed into a high-quality product known as "biosolids,"*

Principal Investigator:
Michael J. McFarland (PI)

Research Collaborators:
State: Water Environment Association of Utah
National: US Environmental Protection Agency

Geographic Areas:
Study Areas: Northern Utah
Areas Benefited: Entire State of Utah and the western region

Contacts:
**Michael J. McFarland**
435.994.0905
farlandm1@outlook.com

**James Goldhart**
801.305.4231
james@chcwater.com

Publications:

- M.J. McFarland (2025) *Biosolids Land Applier Lecture Guidebook (Second Edition)*. Firetrail Publishing, NY, ISBN-13 979-830834816-0
- M.J. McFarland (2025) *Biosolids Quality Protection and Surface Disposal Training Workbook: (Second Edition).* Firetrail Publishing, NY, ISBN-13 979-834897-9

## What we did

The PI received a number of suggestions and requests from municipal wastewater operators as well as private consultants to establish a course that met the needs of statewide sewage sludge/biosolids stakeholders. The information that was received became the framework for a series of biosolids beneficial use technical manuals used throughout the state of Utah.

## What we found

By developing a first of its kind technical training program, Utah municipal wastewater professionals, together with agricultural producers and public health officials, are addressing an important sewage sludge management issue using the same set of technical and regulatory facts. With the growing Utah population, biosolids beneficial use is becoming an increasingly important issue in land management planning

## Work plan FY 25–26

Training manuals will be updated with new regulatory and technical information pertaining to biosolids beneficial use practices.

*Utah farmers, ranchers and other large landowners can benefit financially by recycling biosolids to their land to increase vegetative growth and improve soil quality.*

# Development of an On-Site Demonstration Site at the Ash Creek Special Service District


## Research Summary:

An on-site wastewater (septic systems) demonstration site is being constructed at the Ash Creek Special Service District (Ash Creek) site in Hurricane, Utah. Ash Creek also has classroom facilities for on-site certification workshops that will utilize the demonstration site. This southern demonstration site at Ash Creek will facilitate instructors and regulatory staff from that area participating in State of Utah certification training program for on-site wastewater certification professionals. The site will also host tours and other educational activities concerning septic systems and non-point source pollution (NPS) to homeowners and users of septic systems, real estate developers, consulting engineers, students, and the public.


### Why this research?

The Huntsman On-Site Wastewater Treatment Training and Demonstration Site on the campus on Utah State University (USU) in northern Utah is used for State of Utah certification workshops for on-site wastewater professionals, as well as occasional tours for outside groups and for university classes. The site is an integral part of the USU On-Site Wastewater Treatment Training Program (https://uwrl.usu.edu/research/owt). However, because the USU demonstration site is located in northern Utah, a similar demonstration site is needed in the southern part of the state to serve on-site professionals in that area. Therefore, a second demonstration site is being constructed at the Ash Creek Special Service District (Ash Creek) site in Hurricane, Utah. Ash Creek also has classroom facilities for on-site certification workshops that will utilize the demonstration site. This southern demonstration site at Ash Creek will facilitate participation of instructors and regulatory staff from the area in the certification training program, as well as provide tours and other educational activities concerning septic systems and non-point source pollution (NPS) to homeowners and users of septic systems, real estate developers, consulting engineers, students, and the public.

### Utah impact

Continued population growth, along with associated housing developments, creates an increased need for accurate and thorough information regarding on-site wastewater treatment technologies. Enhanced educational opportunities available at the Ash Creek demonstration site will benefit Utah on-site professionals active in the oversight of septic system siting, design, inspection, and monitoring and maintenance, and especially those professionals located in central and southern Utah.


### Principal Investigator:

Judith L. Sims (PI)

### Student:

Isaac Smart (BS, Department of Biological Engineering)

### Research Collaborators:

Local: Mike Chandler, Ash Creek Special Service District

Utah's 13 Local Health Departments

State: Division of Water Quality, Utah Department of Environmental Quality

Utah On-Site Wastewater Association (UOWA)



### Funding Source:

Utah Division of Water Quality


### Geographic Areas:

Study Areas: Washington County, Utah

Areas Benefited: The development of the on-site wastewater demonstration site at Ash Creek Special Services District in Hurricane will be especially beneficial to persons in southern and central Utah, but use of the site will be open to all on-site professionals and other interested parties from all parts of Utah and the Intermountain West.

Contact:

**Judith L. Sims**
435.797.3230
judith.sims@usu.edu

Websites:

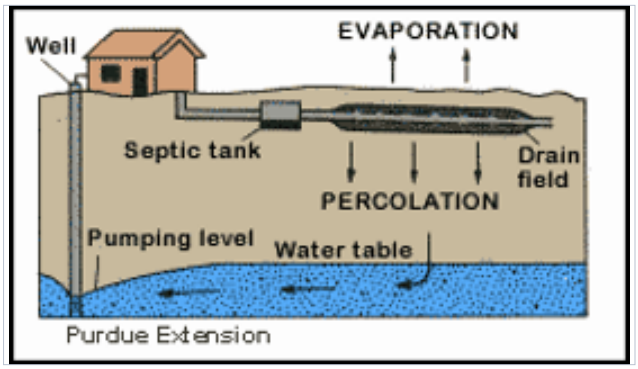
https://uwrl.usu.edu/research/owt/

## Work plan FY 25–26

We will finalize procurement of demonstration and other materials, complete displays, and finish installation of the educational models at the Ash Creek demonstration site. A grand opening celebration is planned for the summer of 2025, sponsored by USU's Utah On-Site Wastewater Treatment Training Program, the Utah Division of Water Quality, Utah Local Health Departments, and the Utah On-Site Wastewater Association.

## What we did

The approach to developing the project is design/build. Demonstration displays include: (a) septic tanks displays; (b) display showing distribution devices for septic tank effluents in absorption systems; (c) displays of absorption systems: standard trenches (pipe and gravel, chambers, bundled synthetic aggregates), deep wall trenches, pressurized drain fields, and absorption beds; (d) alternative systems: at-grade systems, mound systems, sand-lined trenches, and packed bed systems (including intermittent sand filter, recirculating sand and gravel filters, textile filter, peat filter, synthetic open cell foam media filter, and synthetic polystyrene media filter), and membrane bioreactors; (e) pump systems, tanks, and vaults; (f) control panels; (g) effluent filters for septic tanks; (h) valves for alternating drain fields; (i) dosing tanks; (j) drip irrigation systems, and (k) grease traps.




## What we found

During FY24–25 we continued to design and build various demonstration displays. We continued working on wording for signs and continued to edit and prepare videos illustrating percolation testing, soil texturing procedures, field soil pit evaluation techniques, conventional on-site wastewater treatment system design, and operation and maintenance (O&M) procedures for alternative on-site wastewater treatment systems. We also procured various technology components for display.


**Figure 1:** *The new demonstration site will be located at the Ash Creek Special Service District in Hurricane, Utah.*

# Immersive Modeling of a Cache Valley Water Bank to Shepherd Water to Great Salt Lake


## Research Summary:

The Great Salt Lake is vital to Utah's economy and environment. Our immersive online collaborative modeling of a water bank in South Cache Valley is provoking discussion on ways to conserve and shepherd water to Great Salt Lake (GSL). We have so far identified multiple ways to structure a water bank and two strategies to shepherd water past 100s of intermediary divertors (1) storing conserved water In one strategy, a user reduces their summertime use and the conserved water for winter release and combining small volumes of stored water into larger, short-duration pulse releases for measurable downstream delivery to GSL.


### Why this research?

Stabilizing and recovering Great Salt Lake will require agricultural and urban users to conserve 100,000s of acre-feet of water at their current point of diversion. Shepherding conserved water past 100s of intermediary river diversions to Great Salt Lake is an additional challenge. Thus, a need exists to identify new water banking and other strategies to promote water conservation and provide insights into why and how users make decisions to divert, conserve, lease, and purchase water.

### Utah impact

This research is (1) filling a gap between State of Utah goals to conserve water and shepherd water to the Great Salt Lake and actually getting water to the lake, (2) engaging diverse Utah users who have different and sometimes conflicting interests related to managing water for Great Salt Lake, and (3) helping fulfill the work plan of the newly created Office of the Great Salt Lake Commissioner.

### What we did

We constructed online collaborative model environments that use web spreadsheets during in-person or video sessions. So far, 9 modeling sessions have been held with 29 collaborators (1 to 5 collaborators per session). During a 2-hour session, each collaborator chose, immersed in, and personified a water user. Users represented one of three agricultural users (representing different geographical groupings of canal companies), an urban user, an ecosystem user, and the water bank. Collaborators then chose the available water for the year. This available water was split among the users. Each user then made decisions to divert, conserve, lease, or sell water to the bank and decided the price to lease or buy water. Banked water was held in a reservoir. Users then proceeded


### Principal Investigator:

David E. Rosenberg (PI)

### Student:

Hadia Akbar (PhD)

### Research Collaborators:

State/Local: Participants from the Office of the Great Salt Lake, Utah water conservancy districts, state agencies, lawyers, canal company managers, farmers, ranchers, cities, academics

### Geographic Areas:

Study Areas: Cache and Box Elder counties in Utah

Areas Benefited: Cache and Box Elder counties, other cities and counties within the Great Salt Lake basin

### Contact:

**David E. Rosenberg**
435.797.8689
david.rosenberg@usu.edu


### Report:

H. Akbar, D.E. Rosenberg (2025). *2-page summary and full paper: Immersive modeling of water banking generates novel strategies to get more water to Great Salt Lake*. Utah State University Digital Commons. https://digitalcommons.usu.edu/cee_stures/17/

### Presentation:

H. Akbar, D. Rosenberg (2024). *Why Use Online Collaborative Modeling for a Water Bank in Cache Valley, UT?* Utah Water Users Association Conference, St. George, Utah

### Model Code:

H. Akbar, D.E. Rosenberg (2024). Collaborative Model for Water Bank in Cache Valley, UT, HydroShare, http://www.hydroshare.org/resource/c9614e389e324b7ba92d5c33247504a1

### Outreach:

- 9 collaborative modeling sessions with 20 collaborators from the list of collaborators
- Field trip to Cutler Reservoir to discuss challenges and opportunities to get more water to Great Salt Lake. May 2025.

### Media Coverage:

News article: https://www.fox13now.com/news/great-salt-lake-collaborative/usu-research-could-yield-solutions-for-getting-water-to-the-great-salt-lake. Fox 13 News, May 6, 2025.

to the next year, where they again chose a new inflow. At the end of each session, we asked collaborators why they made decisions to divert, conserve, lease, or buy water, what new insights they took away from the model session, and how we can improve the model to better represent the actual water system.

## What we found

**Box 1.**
**Ways to Structure a Water Bank**

| |
|---|
| The bank leases or sells water at a fixed price |
| The bank sells water at a price higher than they purchase |
| Users set their own prices |
| Users trade outside the bank |
| The bank can only lease water to keep in-stream |

(1) Collaborators found the immersive modeling "fun." Yes Fun!! Collaborators pursued different strategies, such as optimizing returns from cropped areas. Other collaborators leased water to keep it in-stream. Discussion during the model sessions elicited several ways to structure a water bank (Box 1). We heard repeatedly that setting the price to lease or buy water is very difficult. The sale price also depended on the subsequent use. For example, a user may sell at a lower price if they were guaranteed that water will stay in-stream or make it to GSL. (2) Water banking generated WIN-WIN outcomes where agricultural users retained their water rights, generated income, continued farming, and supported environmental needs such as deliveries to GSL. (3) Collaborators who personified agricultural users demonstrated diverse strategies. They balanced profits, land productivity, historical legacies, and long-term sustainability. (4) Water pricing was challenging. Agricultural users had a wide variability in pricing. Alfalfa was also the most chosen crop. (5) Some collaborator statements during model sessions included: "A Model like this can shows the potential of water [banking]—can help people understand the possibilities," "It was good to do a low-risk scenario planning. I think it can be a good tool for everyone," and "For a bank to be successful, some water has to be delivered to GSL otherwise there is not enough demand to pay the prices we set. No one would pay (price too high), GSL might."

## Work plan FY 25–26

In the next fiscal year, we plan to (1) seek funding to set up a Cache Water Bank and lease water for agriculture trades (keep water in agriculture), and delivery of water to GSL; (2) Engage future bank participants in immersive modeling to explore possibilities; (3) Scale up immersive modeling to the Bear River Basin, which has the increased complexity of interstate management and potentially allows for more water delivered to GSL.

# Increasing the Impact of Utah State University's Extension Water Check Program with 5-Second Metering

## Research Summary:

Outdoor water use is the largest component of residential use with the largest opportunity to reduce use This project aims to increase the volume of water saved by the Utah State University (USU) Extension Water Check program by using 5-second water use data to identify how residential water users changed their landscape irrigation behaviors after a Water Check.

### Why this research?

Since 1999, the Water Check program has visited thousands of households across Utah, measured landscape features, tested irrigation system performance, and recommended efficiency improvements and irrigation schedules to reduce landscape water use. We are now using Flume Inc. Smart Home Water Monitor devices to collect 5-second water use data to answer 4 research questions:

- How much water did households save?
- Which Water Check recommendations did participants implement?
- Why did participants implement some recommendations and not others?
- How can water use be further reduced?

### Utah impact

This project is helping Utah's Water Check program become more effective. The project can help Utah residents achieve statewide and regional conservation goals. This project can also help answer questions and meet recommendations of the Utah Governor's Recommended State Water Strategy such as the role water conservation plays, identifying conservation potential, quantifying water savings, adapting to changing weather, and the role of science, technology, and innovation in management. Additionally, the project can position Utah as a leader in collecting and disaggregating high- frequency (5-second) water use data into end-uses and targeting conservation messages to household motivations and specific end-use behaviors.


**Figure 1:** *Flume, Inc. Smart Home Water Monitoring device (grey) strapped around a water meter.*


### Principal Investigators:

David E. Rosenberg (PI)
Jeffery S. Horsburgh (Co-PI)
Belize Lane (Co-PI)
Kelly Kopp (Co-PI)

### Students:

Mahmuder Aveek (PhD)
Camilo Bastidas (Post-doc)

### Research Collaborators:

Local: Hyde Park, Logan City
Commercial: Flume, Inc. (San Luis Obispo, CA); WaterDM (Boulder, CO)

### Geographic Areas:

Study Areas: Cities of Logan and Hyde Park, Utah and counties throughout Utah

Areas Benefited: Municipal water providers and residential users statewide in all counties

### Contact:

**David E. Rosenberg**
435.797.8689
david.rosenberg@usu.edu

### Datasets/Code:

https://www.hydroshare.org/resource/fe0377e960b741c4a52dc6ea49db7d80/

### Report:

M. Aveek, D.E. Rosenberg, C. Bastidas, J.S. Horsburgh, B.A. Lane, K. Kopp (2025). *Evaluating the Impact of Residential Landscape Audits Using 5-second water use data."* Submitted to the Journal of American Water Resources Association.

### Work plan FY 25–26

We will resubmit the peer reviewed journal article in response to reviewer feedback.

**Box 1.**
Recommendations to improve Water Check Program

| |
|---|
| Include follow-up visit. |
| Assess drip irrigation zones. |
| Work with homeowner associations |
| Add a 1-pg summary to report |
| Share example water-wise landscapes |
| Share contact information for landscape contractors |
| Connect participants to city staff |

### What we did

In Summer 2022, We Installed 78 Flume devices and completed 74 Water Checks. We collected 2+ weeks of data for 59 households and conducted 9 follow-up interviews to learn why participants signed up for a Water Check and how they implemented Water Check recommendations. We compared water use before and after the water check and to a landscape water budget. This year we organized the data, models, code, and directions to use in a repository. We also drafted a manuscript to submit to a peer-reviewed journal.

### What we found

We found that 59 households collectively reduced water use by 100,300 gallons (0.3 acre-feet) per week, or 1,700 gallons per household per week, resulting in a payback period of 8 to 25 weeks per household. These reductions were significantly different than no savings with 99.998% confidence (Figure 2). Participants reduced their use by:

- **Reducing** water application to more closely match their landscape water budget.
- **Reducing** the duration of irrigation events and number of irrigation events per day.
- **Increasing** days between irrigation events.

The Water Check program implemented seven suggestions to improve the Water Check program (Box 1).

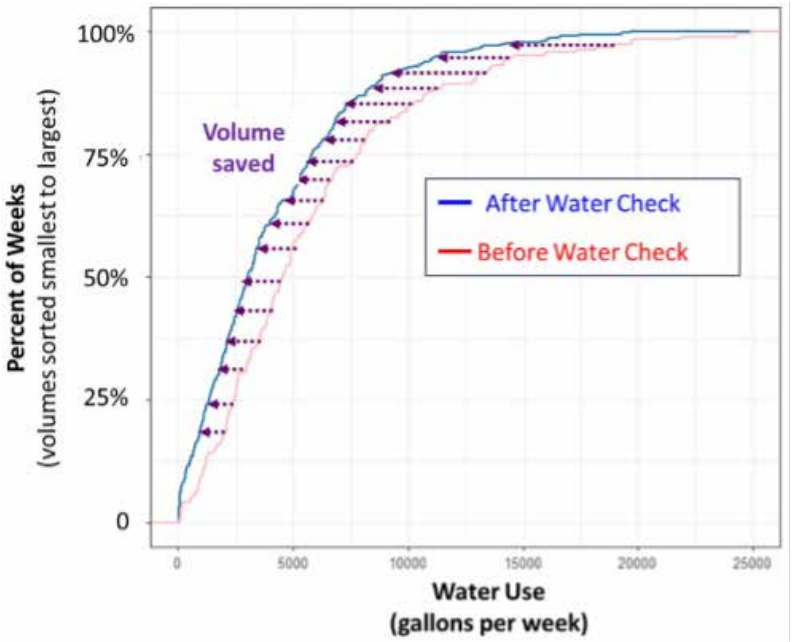



Figure 2. *Weekly water uses before (red curve) and after (blue curve) a Water Check are sorted by volume smallest to largest. The blue curve shifted left to lower weekly water volumes relative to the red curve (purple dotted arrows). The shift left indicates 100,300 gallons per week collectively saved by the 59 households that had 2 or more weeks of data before and after the Water Check. The water volume saved is greater than zero with 99.998% confidence.*

# Logan City Renewable Energy and Sustainability Advisory Board (RESAB)

## Research Summary:

The Logan City Renewable Energy and Sustainability Advisory Board (RESAB) provides advice and technical assistance regarding the conservation and efficient use of resources to assist the City of Logan in transitioning toward a renewable energy portfolio that is secure, diverse, and cost effective; promoting security of the environment; and addressing climate change action.

### Why this research?

The mission of the Logan City Renewable Energy and Sustainability Advisory Board (RESAB) is to provide advice and technical assistance related to the conservation and efficient use of resources, to assist the City of Logan in transitioning toward a secure, diverse, and cost-effective renewable energy portfolio, promoting environmental security, and addressing climate change action.

RECAB's goals include the following:

1. Reduce residential energy consumption (per capita) over the next 10 years.
2. Improve energy efficiency of commercial and public customers.
3. Implement demand-side management (DSM) programs with residential, commercial, and public customers.
4. Identify and research potential sources of renewable energy for Logan City.
5. Identify and promote green building standards.
6. Identify and promote alternative forms of public transportation.
7. Promote public education on issues of energy supply security, energy cost security, and environmental security.
8. Reduce carbon emissions and assist Logan City with a carbon emission study.

### Utah impact

The RESAB provides Logan City with technical expertise and experience on the potential of new renewable energy sources, carbon emission estimates, carbon emission reductions, and public education. The PI attends monthly meetings of the Logan RESAB, provides comments and input on renewable energy and waste management issues that arise, and has responded to special requests from RESAB regarding technical issues related to alternative renewable

Principal Investigator:

R. Ryan Dupont (PI)

Research Collaborators:

Local: Emily Malik, Logan City Environmental Department

Amy Anderson, Holly Daines, Tom Jensen, Logan City Council

Geographic Areas:

Study Areas: Logan City and Cache County

Areas Benefited: Logan City and Cache County

Contact:

**R. Ryan Dupont**
435.797.3227
ryan.dupont@usu.edu

Website:

https://www.loganutah.org/government/departments/light_and_power/energy_conservation_solar/recab.php

## Work plan FY 25–26

Involvement of the PI with the Logan RESAB will continue, as will his response to special project requests as they arise, to support Logan City RESAB's mission and goals. Planning for future renewable energy options, enhancement of Logan City's EV charging network, growth of community education efforts, review of county solar project proposals, review of residential and commercial energy reduction incentive programs, and updates to the city's PPA are the main activities planned for FY 25-26.

energy sources and Logan City's greenhouse gas emission inventory. The PI is a member of the Community Solar subcommittee of RECAB, which is evaluating program options for increasing participation in the existing Logan City solar farm and considering options for expansion of the current program and facilities to include a commercial customer base. The Sustainability name change occurred in February 2021 to reflect the expanded membership and mission of the Board regarding climate change concerns, the City's greenhouse gas emission inventory, and steps necessary for greenhouse gas emission reductions to address climate change.

## What we did

The PI attended all regularly scheduled remote RESAB meetings throughout FY24–25 and provided review and comment on all RESAB items relevant to his area of expertise. Topics included the following:

1. Review and update of the 50% renewables goal for Logan City's power portfolio by 2030.
2. Input on the long-term renewable energy Road Map and review of the 50% renewable resolution for Logan City that was passed by the Logan City Council in 2018.
3. Review of progress of the Integrated Resource Plan being developed for Logan City to guide its planning of future energy investments.
4. Input on EV charging station expansion within Logan City and city electrification program.

Figure 1: *Community solar array installed adjacent to the Logan City Wastewater Treatment Lagoons*

# Management and Technical Consulting for Agricultural Resiliency and Demand Management Pilot Program

## Research Summary:

We are providing technical expertise for the Colorado River Authority of Utah's Demand Management Pilot Program, which pays farmers for conserved water. As subject matter experts on quantifying water depletion (i.e., irrigation water that is consumed by a crop or evaporated), we are supporting Jacobs Engineering Group in providing the Colorado River Authority with information essential to operating and determining the impacts of the program.

### Why this research?

As Utah and other Colorado River Basin states currently renegotiate operating rules for the Colorado River, Utah needs to have programs in place for water conservation. These programs demonstrate Utah's good faith effort as the basin faces significant water shortages.

### Utah impact

For conserved water to "count" in Colorado River management, it must be a reduction in depletion—the net water diverted from a water source that does not return to that source, typically because it has been evaporated or transpired by a plant. This net value is difficult to quantify.

Figure 1: *The Green River, near Green River, UT.*


### Principal Investigators:

Burdette Barker (PI)
Matt Yost (Co-PI)

### Research Collaborators:

Jacobs Group
Precision Water Resources



### Funding Source:

Colorado River Authority of Utah


### Geographic Areas:

Study Areas: Utah portion of the Upper Colorado River Basin

Areas Benefited: Utah and Upper Colorado River Basin


### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

### Media Coverage:

Example News Article by B. Winslow. Fox 13 News: https://www.fox13now.com/news/colorado-river-collaborative/plan-to-pay-farmers-not-to-grow-crops-could-help-the-colorado-river-and-utah-politically#google_vignette. We are providing technical support for the program that was reported on. April 23, 2025

## What we did

We provided expertise to the Jacobs' team as they estimated depletion for the first cycle of the program (2025). We also provided input regarding program development.

## What we found

More participants than expected applied for some of the program opportunities. However, one program area (irrigation system conversion) had no viable applicants.

## Work plan FY 25–26

Management support will continue for the second cycle of the program.

# Opportunities and Costs for Agricultural Water Optimization and Leasing

## Research Summary:

We are providing the Utah Division of Water Resources with estimates of depletion (net evaporation and transpiration from irrigation water) for the Great Salt Lake Integrated Plan, presently under development. Quantifying the agricultural depletion in the Great Salt Lake Basin is important for the State in deciding management practices for the Lake and the impacts of those practices on land use in the Basin.

### Why this research?

The impacts from declining Great Salt Lake water levels are of paramount concern to many in Utah. As agricultural irrigation accounts for the largest portion of water use in the Basin, a good understanding of irrigation depletion in the Basin is essential for the development of the Great Salt Lake Integrated Plan.

### Utah impact

The declining lake presents significant potential economic, social, and health risks to the public, as well as significant potential economic, social, and health risks from some reductions to agricultural water. Utah policy makers may need to understand which agricultural practices are viable means of aiding the lake and the possible impacts to agriculture and society.

Figure 1: *A surface-irrigated corn field in the Great Salt Lake Basin. Surface irrigation typically has less evaporative losses than sprinkler irrigation.*

Principal Investigators:

Burdette Barker (Co-PI)
Matt Yost (PI)

Research Collaborators:

Jacobs Group
mCubed

Funding Source:

Utah Division of Water Resources

Geographic Areas:

Study Areas: Great Salt Lake Basin

Areas Benefited: Great Salt Lake Basin

Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

## What we did

We contracted with Jacobs Engineering Group and mCubed economic consultants to estimate depletion and economic impacts from several water use reduction scenarios.

## What we found

To achieve a 10% reduction in agricultural water depletion, 10% of the irrigated land in the basin could be not irrigated (this one is straight forward). Several partial-season leasing (fallowing) options could achieve similar levels of reduction. A suite of options for converting irrigation systems would be needed to achieve this level. None of the considered crop switching options would be sufficient.

## Work plan FY 25–26

Management support will continue for the second cycle of the program

# Planning for an Uncertain Future with Great Salt Lake

## Research Summary:

With the Great Salt Lake (GSL) at critically low levels threatening the economic, environmental and ecologic values derived from the lake, UWRL faculty members David Tarboton and Bethany Neilson participated in the GSL Strike Team convened to provide impartial, data-informed, solution-oriented policy recommendations for actions to restore the lake to more healthy conditions.

### Why this research?

The critically low level of Great Salt Lake threatens the economic, environmental and ecologic values derived from the lake. Research provides crucial perspective, understanding, information, and scenarios to help policy makers chart a path forward.

### Utah impact

Great Salt Lake (GSL) and the rivers that drain to the lake are important resources for Utah. Streamflow, which originates from snowfall and snowmelt in rivers draining to the lake, provides the majority of water used in the GSL basin and along the Wasatch Front. Infrastructure along the shore, brine shrimp and mineral industries, and important bird habitat support, all depend on GSL lake level.

### What we did

Water balance modeling based on analysis of historical streamflow and climate help us understand the inherent variability in GSL levels, as well as how depletion of streamflow, or conservation that adds to streamflow, shifts the expected ranges of variability for actions that change inflows or depletions. Historical streamflow, lake level, and climate data were used to produce 1,000 simulations of potential lake levels for the next 30 years. Annual inflow, precipitation, and evaporation values were randomly selected from the 2000 to 2024 historical inputs to represent hydrologic variability. The past 25 years were selected to represent the contemporary period with elevated temperatures and decreased inflow into GSL. Three scenarios were modeled:

- Baseline scenario assumes no additional inflows to GSL from conservation.
- A +250 KAF/year inflow scenario considers an additional 250 thousand acre-feet (KAF) of inflow each year to the lake from water conservation.
- A +770 KAF/year inflow scenario shows the expected inflow needed each year to reach a mean lake elevation of 4,198 feet by 2054.

### Principal Investigators:

David Tarboton (PI)
Bethany Neilson (Co-PI)

### Research Collaborators:

Academic: Janet Quinney Lawson Institute for Land, Water, and Air (USU); Kem C Gardner Policy Institute and Wilkes Center for Climate Science and Policy (U of U)

State: Department of Agriculture and Food, Department of Natural Resources, Department of Environmental Quality

### Geographic Areas:

Study Areas: The Great Salt Lake

Areas Benefited: The Great Salt Lake basin

### Contacts:

**David Tarboton**
435.797.3172
david.tarboton@usu.edu

**Bethany Neilson**
435.797.7369
bethany.neilson@usu.edu

### Publication:

W. Anderegg, C. Buttars, J. Ferry, K. Shelly, B. Steed, D. Tarboton, L. Ahmadi, E. Albers, B. Bingham, P. Brooks, J. Endter-Wada, C. Hasenyager, J. Lin, A. McEntire, B. Neilson, S. Null, K. Perry, B. Stireman, C. Strong, L. Vernon, K. Welch, M. Yost (2025). *Great Salt Lake Data and Insights Summary: A Synthesized*

*Resource Document for the 2025 General Legislative Session*. University of Utah, Kem C Gardner Policy Institute. https://gardner.utah.edu/great-salt-lake-strike-team/

### Presentation:

D. Tarboton, et al. and The Great Salt Lake Strike Team (2024). *Collaboration Between University and State Agency Researchers and Policy Experts has Synthesized Essential Data and Insights to Engage with Policy Makers in Evaluating Options for Restoring Great Salt Lake*. American Geophysical Union, Fall Meeting, Washington, DC, December 11, 2024. https://agu.confex.com/agu/agu24/meetingapp.cgi/Paper/1753262

### Media Coverage:

- KSL. https://www.ksl.com/article/51228236/heres-how-much-water-is-needed-to-get-the-great-salt-lake-back-to-healthy-by-2050s
- Utah News Dispatch. https://utahnewsdispatch.com/2025/01/15/great-salt-lake-report-meaningful-progress-getting-more-water/
- Deseret News. https://www.deseret.com/environment/2025/01/14/great-salt-lake-policy-water-levels-drought-restoration-environment-climate/
- Fox 13. https://www.fox13now.com/news/great-salt-lake-collaborative/new-report-says-great-salt-lake-still-at-risk-needs-long-term-support

## What we found

With no additional inflows to Great Salt Lake, the baseline scenario mean sustained level shows a 0.8-foot decline in lake levels over the next 30 years. 59% of simulations fall into elevations with "serious adverse effects." 28% of simulations result in "adverse effects," 12% result in the "transitionary zone," while only 1% result in "healthy lake levels."

With additional 250 KAF/year of inflow, the mean sustained level rises 1.9 feet by 2054, and the likelihood of elevations with "serious adverse effects" falls from 59% to 23%.

With an additional 770 KAF/year inflow, the mean sustained level rises 5.9 ft, leading to a 2054 elevation of 4,198.0 feet, which is the lower bound or the healthy level range determined by the Utah Division of Forest Fire and State Lands. In 46% of simulations, the lake reaches healthy elevations by 2054. Another 46% of simulations result in the lake reaching the "transitionary" zone between 4,194 and 4,198 feet.

Thus, while an additional 250 KAF/year would improve GSL conditions, an additional inflow of around 770 KAF/year is required for the lake to achieve consistent sustained levels in the healthy range.

## Work plan FY 25–26

The Great Salt Lake Strike Team is preparing an updated assessment and evaluation of potential solutions for the GSL to be presented to the legislature this year.

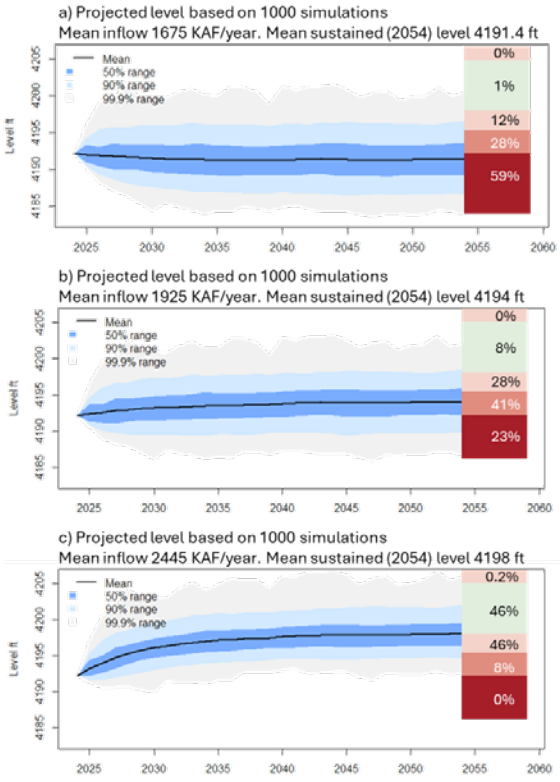



**Figure 1:** *GSL level ranges from Monte Carlo sampling of 2000 to 2024 inputs for (a) Base Case Scenario, (b) Additional 250 KAF/year inflow, (c) Additional 770 KAF/year inflow. Serious adverse effects (< 4192 ft), adverse effects (4192-4195 ft), transitionary (4195-4198 ft), healthy (4198-4205 ft) and adverse effects due to high lake (>4205 ft) from bottom to top respectively.*

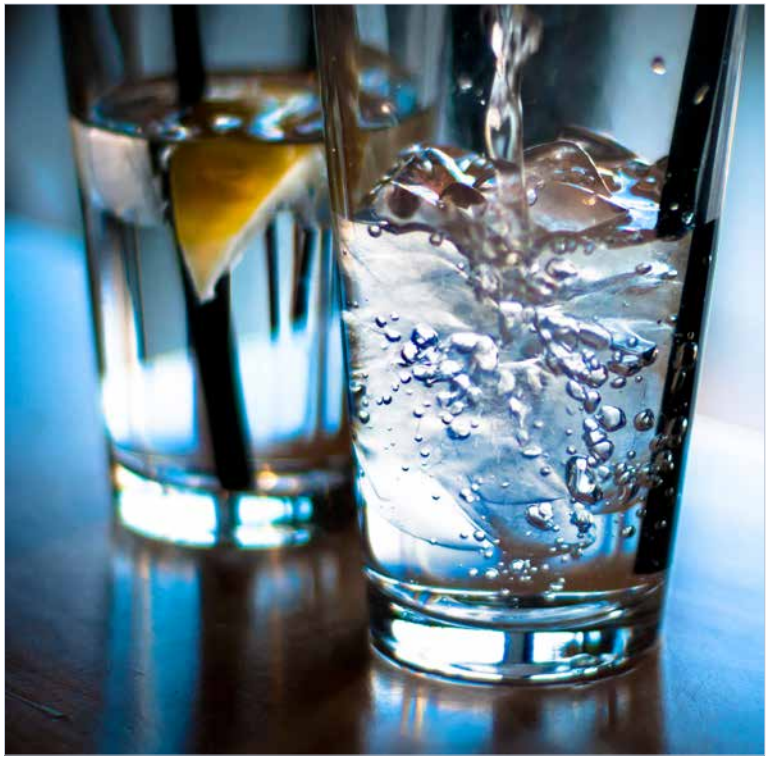
# State of Utah Drinking Water Board

## Research Summary:

The Utah Drinking Water Board, administered by Utah's Division of Drinking Water, adopts and enforces rules related to public drinking water systems. The PI attended yearly meetings of the Board held in Salt Lake City and provided comments and inputs policies and procedures in accordance with Federal and State drinking water laws.

### Why this research?

Under the Utah Drinking Water Act (the Act), responsibility for overseeing drinking water treatment and distribution rests with the Utah Department of Environmental Quality (DEQ) and the Utah Drinking Water Board (the Board). The Board has the authority to issue orders implementing the Act and to ensure compliance with the Act's provisions. Jurisdiction of the Board covers public and private community drinking water systems, including the various federal facilities. Utah Water Research Laboratory faculty member Dr. Blake Tullis has served on the State of Utah Drinking Water Board since 2020.



### Principal Investigator:

Blake Tullis (PI)

### Research Collaborator:

State: Nathan Lunstad, Director, Utah Division of Drinking Water

### Geographic Areas:

Study Areas: State of Utah

Areas Benefited: State of Utah

Contact:

**Blake Tullis**
435.797.3194
blake.tullis@usu.edu

Website:

https://deq.utah.gov/boards/utah-drinking-water-board

## Utah impact

Membership on the Drinking Water Board provides service to the citizens of the State of Utah, the Utah DEQ, and the regulated community by providing technical overview and expertise for drinking water management, as well as oversight of state and federal revolving loan funds, to the Division of Drinking Water in their rulemaking, facility inspections and reviews, policy implementation, and conflict resolution. Dr. Tullis attended approximately quarterly meetings of the Drinking Water Board held throughout the State or virtually and provided comments and input on drinking water treatment and distribution issues that arise during the course of the Division's implementation of federal and state drinking water laws.

## What we did

The PI attended regularly scheduled Drinking Water Board meetings and facility tours from July 1, 2024, to June 30, 2025, and provided review and comment on all Board items relevant to his area of expertise.

## Work plan FY 25–26

PI involvement on this board will continue through 2027.

# State of Utah Operators Certification Commission

## Research Summary:

The Operators Certification Commission established by the Utah Drinking Water Board manages training for water treatment plant operators. The PI attended yearly meetings of the Commission held in Salt Lake City and provided comments and inputs on policies and procedures regarding the certification of water treatment and distribution system operators in accordance with Federal and State drinking water laws.

### Why this research?

Under the Utah Drinking Water Act (the Act), responsibility for overseeing drinking water treatment and distribution rests with the Utah Department of Environmental Quality and the Utah Drinking Water Board (the Board). The Board has the authority to issue orders implementing the Act and to ensure compliance with the Act's provisions. Jurisdiction of the Board covers public and private community drinking water systems, including the various Federal facilities. The Board created the Water Treatment Operators Certification Commission in 1984, and Blake Tullis has been a member of the commission since 2024.

Figure 1: *Little Cottonwood treatment plant ponds.*

### Principal Investigator:

Blake Tullis (PI)

### Research Collaborators:

State: Ryan Dearing, Operator Certification Commission Chair, and Nathan Lunstad, Director, Division of Drinking Water

### Geographic Areas:

Study Areas: State of Utah

Areas Benefited: State of Utah

Contact:

**Blake Tullis**
435.797.3194
blake.tullis@usu.edu

Website:

https://deq.utah.gov/drinking-water/operator-certification

## Utah impact

Membership on the Operators Certification Commission provides service to the citizens of the State of Utah, the Utah DEQ, and the regulated community by managing training for water treatment plant operators. This includes setting policy, administering examinations, and making decisions on appeals. The PI attended yearly meetings of the Commission held in Salt Lake City and provided comments and inputs on policies and procedures regarding the certification of water treatment and distribution system operators in accordance with federal and state drinking water laws.

## What we did

The PI attended all scheduled Operators Certification Commission meetings July 1, 2024, to June 30, 2025, and provided review and comment on all Commission items relevant to his area of expertise.

## Work plan FY 25–26

The PI will continue to attend meetings and participate as a member of the commission through 2027.

# Utah Agricultural Water Teaching, Extension, and Research Network (Ag WaTER Net)

## Research Summary:

We are developing a long-term agricultural irrigation water balance monitoring network of fields in Utah that are instrumented to monitor the full water balance, meaning all of the inputs and outputs of water. The data will be made publicly available in real time, along with yield and agronomic inputs (fertilizers, etc.). For the pilot site, located in Cache Junction, Utah, students will be able to use the data to learn advanced irrigation management techniques. The network fields and data will also be used in Extension trainings, and the datasets will be available for researchers, state agencies, and others.

### Why this research?

Many climate observation networks monitor weather and precipitation throughout Utah. The Utah Flux Network, operated by the Utah Geological Survey, provides valuable evapotranspiration datasets. However, no monitoring network anywhere makes publicly available, in real time, all of the data necessary to quantify agricultural water depletions and the economics of irrigation water use.

### Utah impact

Important components of agricultural water use are not available in continuous, real time public datasets. These include applied irrigation, irrigation inefficiencies, drainage of water below the plant roots, etc.

**Figure 1:** *Monitoring sites in Uintah County part of a separate study on subsurface drip irrigation. The data from these sites is also being used to develop measurement standards for the Ag WaTER Net.*


### Principal Investigators:

Burdette Barker (PI)
Alfonso Torres-Rua (PI)

### Student:

Shreya Vaidyanathan (MS)



### Funding Source:

Utah Agricultural Experiment Station


### Geographic Areas:

Study Areas: Utah

Areas Benefited: Utah and Intermountain West


### Contacts:

**Alfonso Torres-Rua**
435.797.0397
alfonso.torres@usu.edu

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

These datasets will enable cutting edge educational resources for students and farmers and provide datasets for researchers and state agencies.

## What we did

We have been piloting data collection methods on two Uintah County production fields so that a standard can be adopted.

## What we found

Preliminary data from Uintah County have not yet been analyzed.

## Work plan FY 25–26

A pilot study in Cache County will be initiated. Data standards will be developed.

### Publications:

- E. Flint, M. Yost, B. Barker, and S. Ekadu (2024). *Ag Water Demonstration, Research, and Implementation Program (Ag-DRIP) 2023 Report.* Utah State University Extension, Logan, UT. https://extension.usu.edu/ag-drip/files/ag-drip-2023-annual-report.pdf
- E. Flint, M. Yost, B. Barker, and S. Ekadu (2025). *Ag Water Demonstration, Research, and Implementation Program (Ag-DRIP) 2024 Report*. Utah State University Extension, Logan, UT.

### Presentations:

- S. Ekadu, B. Barker, M. Yost, and E. Flint. *Leveraging Technology for Enhancing Irrigation Management in the Colorado River Basin of Utah for a Water-Secure Future*. ASABE Annual International Meeting, Toronto, ON. July 14-16, 2025.
- Many Extension presentations.

# Utah On-Site Wastewater Treatment Training Program

## Research Summary:

The Utah On-Site Wastewater Treatment Training Program, established in January 1998 in cooperation with the Utah Department of Environmental Quality (DEQ) and the thirteen Utah local health departments, provides classroom and field (hands-on) training in on-site wastewater treatment systems to Utah homeowners, regulators, designers, installers, pumpers, and other stakeholders in on-site wastewater treatment systems. The Training Program also provides the mandatory training required by the Utah Division of Water Quality for the certification of on-site wastewater professionals involved in siting, designing, operating, and maintaining both conventional and alternative on-site systems

### Why this research?

A state legislative initiative introduced and passed as House Bill 14s during the 2001 Legislative Session mandated a certification program for persons involved in siting, designing, operating, and maintaining both conventional and alternative on-site systems. The certification program, administered by the Division of Water Quality in the Utah DEQ, involves mandatory training provided by the Utah On-Site Wastewater Treatment Training Program.

Adequately protecting environmental health and enhancing user satisfaction are achieved through knowledgeable selection, competent design, correct installation, and proper operation of on-site systems. Applying the right technology in the right place requires accurate information and up-to-date training. Landowners, homeowners, developers, lenders, installers, regulators, planners, municipal authorities, and elected authorities are all stakeholders in Utah on-site issues and must have current information and training to address these matters responsibly.

### Utah impact

Utah continued growth is expanding housing developments into open spaces that may include sensitive areas such as groundwater recharge zones, shallow soils, or areas with shallow ground water. Current Utah regulations allow the use of conventional septic tank systems, as well as ten alternative treatment systems that may be installed in areas where soils are unsuitable for conventional systems. Ensuring that professionals are well-trained in the siting, installation, and maintenance of these systems is essential to protect water resources and maintain system performance.

**Principal Investigator:**
Judith L Sims (PI)

**Co-Researchers:**
Margaret Cashell
Brian Cowan
Richard Jex

**Program Support:**
Andrea Dolinsky-Webb

**Students:**
Jackson Storer and Isaac Smart (BS, Biological Engineering)

**Collaborators:**

Local: Utah's 13 Local Health Departments

State: Division of Water Quality, Utah Department of Environmental Quality

Council of Local Environmental Health Directors (CLEHA)

CLEHA Onsite Wastewater Partnership (COWP)

Utah On-Site Wastewater Association (UOWA)

**Funding Source:**
Utah Division of Water Quality, class registration fees, MLF

**Geographic Areas:**

Study Areas: Utah

Areas Benefited: The entire state of Utah (29 counties and 13 local health departments)

## Website:

https://uwrl.usu.edu/research/owt/

## Contacts:

**Judith L. Sims**
435.797.3230
judith.sims@usu.edu

**Andrea Dolinsky-Webb**
435-797-9617
onsitewastewater@usu.edu

## Publication:

J.L. Sims, M. Cashell, B. Cowan, and R. Jex (2024, 2025). *Course Manuals for Levels 1, 2, and 3 Original Certification and Recertification Workshops*. Utah Water Research Laboratory, Utah State University, Logan, UT

## Videos:

Percolation Test, Soil Characterization, and In Situ Soil Evaluation

- https://www.youtube.com/watch?v=YooMuqStE90
- https://www.youtube.com/watch?v=XTkS_uFt_tM
- https://www.youtube.com/watch?v=Y28W74IrdaI

Level 2 & 3 Tours—USU Demonstration Site

- https://www.youtube.com/watch?v=0fMxSxHegbk
- https://www.youtube.com/watch?v=XPbuayDNEzk

## Work plan FY 25–26

We will continue to provide workshops in support of the mandatory State of Utah certification program for on-site wastewater professionals through FY 2026.

## What we did

This state-mandated certification program includes three levels, each of which requires workshops and testing provided through the Utah Training Program: **Level 1**: Soil Evaluation and Percolation Testing; **Level 2**: Design, Inspection, and Maintenance of Conventional Systems; and **Level 3**: Design, Inspection, and Maintenance of Alternative Systems. Because Level 1, Level 2, and Level 3 certifications expire after three years, workshops are also provided for renewal of certifications.

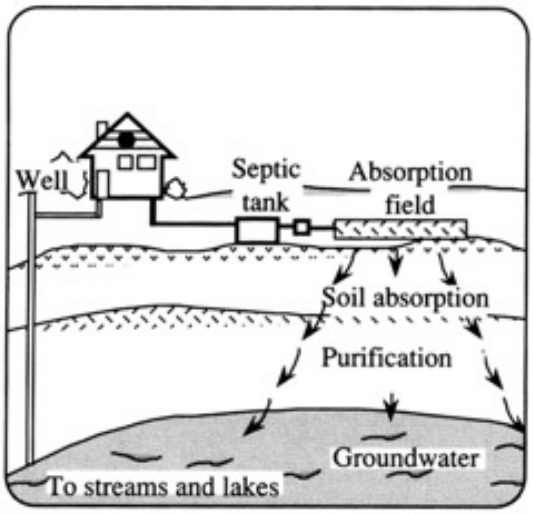
**Workshops held during FY 24–25:**

- **Level 1**: 3 workshops at Richfield, St. George, and Ogden, Utah, locations—72 total participants
- **Level 2**: 2 workshops at Logan, Utah location—41 total participants
- **Level 3**: 2 workshops at Logan, Utah location—38 total participants
- **Level 1 & 2 Renewal**: 4 workshops at Richfield, St. George, and Ogden, Utah, locations—104 total participants
- **Level 3 Renewal**: 4 workshops at Richfield, St. George, and Ogden, Utah, locations—61 participants

**FY 24–25 Total:** 316 participants

A re-test option at local health departments is an alternative to attending a Level 1 & 2 certification renewal classes. Professionals wishing to certify can waive attendance at Level 1 & 2 by taking these examinations.

- Level 1 & 2 re-testing: 1 test date in FY 24-25—2 total participants
- Level 1 & 2 classes waived: 1 waiver for Level 1 workshop for 1 licensed contractor




**Figures:** *Overview graphic of the importance of properly siting a septic system (above). Workshop participants in field and classroom training (right).*

# Wine Grape Irrigation Water Requirements in Utah

## Research Summary:

We are measuring crop water use for wine grapes in southwestern and northern Utah. Wine grapes are a relatively new crop in Utah, resulting in uncertainty regarding their water use and irrigation water requirements in different Utah climates. Wine grapes have been promoted by some as a low water use, high value alternative crop. We are seeking to provide farmers and the state with research-based information on wine grape irrigation requirements.

### Why this research?

Wine grapes are a relatively new crop in Utah, resulting in uncertainty regarding their crop water use and irrigation water requirements in different Utah climates. However, hard data is lacking regarding the actual water use of this crop in production settings in Utah.

### Utah impact

Wine grapes have been promoted by some as a low-water-use, high-value alternative crop. Furthermore, current producers are unsure how

Figure 1: *Soil moisture measurement site in a Washington County vineyard.*


### Principal Investigators:

Burdette Barker (PI)
Michael Caron (Co-PI)
Michael Pace (Co-PI)

### Research Collaborators:

Farmers in Washington and Box Elder Counties, Utah

### Student:

Tarque Aziz (PhD)



### Funding Source:

Utah Department of Agriculture and Food, USU Extension, Utah Agricultural Experiment Station


### Geographic Areas:

Study Areas: Washington and Box Elder counties, Utah

Areas Benefited: Utah and Intermountain West


### Contact:

**Burdette Barker**
435.303.0311
burdette.barker@usu.edu

much water is sufficient and how much is an excess when irrigating this crop as limited local data currently exist on the subject.

## What we did

We measured irrigation water applied, precipitation, and soil moisture in five production vineyards between 2022 and 2025: four in Washington County and one in Box Elder. We are using a water balance approach to estimate crop water use and have done preliminary evapotranspiration modeling using satellite remote sensing.

## What we found

We are currently finalizing the results, but preliminary results seem to suggest that publicly available evapotranspiration products like OpenET may be accurate for this crop in Utah.

## Work plan FY 25–26

Most of the field data collection is complete. An eddy covariance evapotranspiration measurement system will be used in 2025 and 2026 in Box Elder County to validate the water balance results. Publication of research results in academic journals and Extension outlets is expected to begin in 2026.

### Presentations:

- T. Aziz, B. Barker, M. Caron, and M. Pace. *Enhancing Vineyard Water Management in Utah: A Water Balance Approach to Optimize Irrigation*. Northern Water Users and Spring Runoff Conference, Logan, UT. March 26, 2025.
- T. Aziz, B. Barker, M. Caron, and M. Pace. *A comprehensive study of evapotranspiration estimation in vineyards across Utah climate zones*. Fall Student Research Symposium, Utah State University, Logan, UT. December 5, 2024

Section 4

# Research Faculty, Professional and Support Staff

## Utah Water Research Laboratory

David G. Tarboton, Director July 2019 - July 2025
Steven L. Barfuss, Associate Director
Jeffery S. Horsburgh, Associate Director
Randal S. Martin, Head of Environmental Engineering Program
Bethany T. Neilson, Head of Water Engineering Program, Director July 2025 - Present
Cathi Allen, Business Services Office Manager
Carri Richards, Public Relations Specialist
Lacy Susman, Administrative Assistant & Building Manager

## Utah Water Research Laboratory Faculty

Steven L. Barfuss, MS, Associate Director, UWRL, Research Professor, CEE/UWRL
Burdette Barker, PhD, Assistant Professor, Extension Irrigation Specialist, Extension/CEE/UWRL
Cal Coopmans, PhD, Research Assistant Professor, AggieAir Director ECE/UWRL
Brian Crookston, PhD, Associate Professor, CEE/UWRL
R. Ryan Dupont, PhD, Cazier Endowed Professor, CEE/UWRL
Jeffery S. Horsburgh, PhD, Associate Director, UWRL, Associate Professor, CEE/UWRL
Joanna (Liyuan) Hou, PhD, Assistant Professor, CEE/UWRL
Michael C. Johnson, PhD, Research Professor, CEE/UWRL
Belize Lane, PhD, Associate Professor, CEE/UWRL
Randal S. Martin, PhD, Research Associate Professor, CEE/UWRL; Head of Environmental Engineering Program, CEE/UWRL
Michael J. McFarland, PhD, Associate Professor, CEE/UWRL
Joan E. McLean, MS, Research Professor, CEE/UWRL
Kyle Moor, PhD, Assistant Professor, CEE/UWRL
Bethany T. Neilson, PhD, Professor, CEE/UWRL, Head of Water Engineering Program
Colin Phillips, PhD, Assistant Professor, CEE/UWRL
David E. Rosenberg, Ph.D., Professor, CEE/UWRL
Zac Sharp, PhD, Research Assistant Professor, CEE/UWRL
Pin Shuai, PhD, Assistant Professor, CEE/UWRL
Ronald C. Sims, PhD, Professor, BE/UWRL
Yiming Su, PhD, Assistant Professor, CEE/UWRL
David G. Tarboton, PhD, Sant Endowed Professor of Water Resources Engineering, CEE/UWRL
Alfonso Torres-Rua, PhD, Assistant Professor, CEE/UWRL
Blake P. Tullis, PhD, Professor, CEE/UWRL, Associate Vice President of Research, USU
Sierra Young, PhD, Assistant Professor, CEE/UWRL

## Utah Water Research Laboratory Staff

Cathi Allen, BS, Business Services Office Manager Sr.
Tyler Blackham, BS, IT Technician
Tracy Brown, MS, Business Manager
Mark Cannon, BS, Research Engineer II
Andrea Carroll, Business Assistant III
Brittanie Carter, MS, Marketing and Public Relations Coordinator
Pabitra Dash, PhD, Programmer/Analyst Sr.
Ashton Decker, BS, Staff Assistant/Receptionist
Andrea Dolinsky-Webb, BS, Program Assistant
Maria Gates, BS, Business Manager
Ian Gowing, BS, Research Engineer III, AggieAir Service Center Manager
Larry Jacobsen, BS, Research Staff
Anzy Lee, PhD, Postdoctoral Scholar
Marissa Li, MS, Researcher II
Ken Lippold, MS, Research Engineer
Eileen Lukens, MS, Research Engineer
Ayman Nassar, PhD, Postdoctoral Scholar
Bryson Parker, BS, Maintenance Technician
Noelle Patterson, PhD, Postdoctoral Scholar
Ken Provard, BS, Research Engineer I
Maurier Ramirez, MS, Programmer/Analyst Sr.
Alyssa Regis, BA, Communications and Outreach Specialist
Katie Reynolds, MS, Business Assistant II
Carri Richards, BS, Public Relations Specialist
Homa Salehabadi, PhD, Postdoctoral Scholar
Judy Sims, MS, Coordinator, Utah On-Site Wastewater Treatment Training Program
Daniel Slaugh, BS, Software Engineer
Melissa Stamp, MS, Research Engineer
David Stevens, PhD, Project Administrator
Patrick Strong, BS, Research Engineer I
Jamie Stubbs, BS, Business Assistant III
Lacy Susman, Administrative Assistant & Building Manager
Vaishali Swaminathan, PhD, Postdoctoral Scholar
Shannon Syrstad, MS, Research Engineer II
Chad Taylor, Engineering Technician III
NeCole Walton, BS, Business Manager
Jian Wang, PhD, Postdoctoral Scholar

## Emeriti Faculty

Kurt Becker, PhD, Professor Emeritus, CEE/UWRL
A. Bruce Bishop, PhD, Professor Emeritus, CEE/UWRL
David S. Bowles, PhD, Professor Emeritus, CEE/UWRL
William J. Doucette, PhD, Professor Emeritus, CEE/UWRL
William J. Grenney, PhD, Professor Emeritus, CEE/UWRL
Eugene K. Israelsen, MS, Senior Research Engineer Emeritus, UWRL
Mac McKee, PhD, Professor Emeritus, CEE/UWRL
Richard Peralta, PhD, Professor Emeritus, CEE/UWRL
William J. Rahmeyer, PhD, Professor Emeritus, CEE/UWRL
Judy Sims, MS, Research Associate Professor Emeritus, BE/UWRL
Darwin L. Sorensen, PhD, Research Professor Emeritus, BE/CEE/UWRL
David K. Stevens, PhD, Professor, CEE/UWRL
J. Paul Tullis, PhD, Professor Emeritus, USU Foundation, CEE/UWRL

**Utah Water Research Laboratory**
**UtahState**University

1600 Canyon Road, Logan, UT 84322-8200 | 453.797.3550 | https://uwrl.usu.edu