As the director of the Nevada Water Resources Research Institute (NWRRI) program, I’m proud of the wide range of projects that we have supported over the years and this year is no exception. Our newest projects cover important hydrologic issues related to southern Nevada, as well as community and environmental health issues that can be applied nationwide.

- “Strain-Specific Monitoring of SARS-CoV-2 in Rural Wastewater Systems”: As the COVID-19 pandemic progressed, wastewater surveillance proved to be a valuable tool for detecting and tracking community viral spread. Desert Research Institute and the University of Nevada, Las Vegas, developed a pilot study using Coronavirus Aid, Relief, and Economic Security (CARES) Act funding to quantify and track community spread of the virus. This project will build on that work by identifying wastewater treatment steps to remove the virus and tracking viral abundance in a remote location (Death Valley National Park) to help the National Park Service manage public health policies. The researchers will also document the predicted eventual decline of the pandemic at a single location.

- “Trace Element Compositions in Spring Waters in Southern Nevada: An avenue to train young hydrologists in Nevada”: The researchers will generate the first complete suite of metal element compositions from a set of springs in Moapa Valley and the upgradient valleys in southern Nevada. They will then test existing flow models to determine the sources and pathways of spring waters. A key component of this project will be providing master’s, undergraduate, and high school students with the opportunity to get hands-on experience using geochemical tracers and state-of-the-art analytical methods.

- “Long-term Effects of Beaver-related Stream Restoration on Fluvial Sediment Transport”: This project will evaluate the possible benefits of reintroducing beavers as a means of environmental restoration for streams and stream systems. Beaver-related restoration (BRR) is a low-cost and relatively...
simple alternative to engineered restoration practices. The researchers will numerically model sediment transport through simulated networks of dams to determine best practices and how to use BRR for future restoration projects.

- “Sensitivity of Mountain Hydrology to Changing Climate: Exploring source mixing and residence time distributions in basin outflows”: This project will use local remote sensing data and advanced numerical tools to assess the hydrologic vulnerability of Lake Tahoe headwater basins to changes in the timing and intensity of snowfall, snowmelt, and rainfall. The results of this project will help land and water managers plan for a more sustainable future under climate change.

I look forward to sharing the innovations of our NWRRI projects as we continue to search for new ways to preserve Nevada’s water resources under the pressures of climate change, as well as the health of our environment and community.

Sincerely,

Chuck Russell

Events List

Please keep an eye on the event websites for changes in conference schedules.

Water Rights in Nevada Class
September 14, 2021
Winnemucca, NV
www.nwwra.org/2021-sept-water-rights-class

Nevada Gold Mines Tour
September 14-15, 2021
Winnemucca, NV
www.nwwra.org/2021-nevada-gold-mines-tour

Advanced Water Rights in Nevada Class
September 15, 2021
Winnemucca, NV
www.nwwra.org/2021-sept-advanced-water-rights-class

AGU-SEG Workshop
September 21-November 2, 2021
Online
www.agu.org/seg

GSA Annual Meeting
October 10-13, 2021
Portland, OR
community.geosociety.org/gsa2021/home

2021 Minerals & Mine Water Management Symposium
October 12-13, 2021
Sparks, NV
www.nwwra.org/2021-symposium

2021 Amargosa Valley Tour
November 3 & 4, 2021
Las Vegas, NV
www.nwwra.org/2021-amargosa-valley-tour

2021 ASA, CSSA, SSSA International Annual Meeting:
A Creative Economy for Sustainable Development
November 7-10, 2021
Salt Lake City, UT
www.acsmeetings.org

(Continued on page 6)
Baseflow Age Distributions and Depth of Active Groundwater Flow in a Snow-dominated Mountain Headwater Basin

This project is funded through the National Institutes for Water Resources (NIWR) 104(b) grant.

Snow-dominated, mountainous watersheds provide 60 percent to 90 percent of the fresh water worldwide (Viviroli and Weingartner, 2008). However, the effects of snow processes on groundwater flow paths in these watersheds and their sensitivity to climate or land-use changes were not well understood. The focus of the study “Baseflow Age Distributions and Depth of Active Groundwater Flow in a Snow-dominated Mountain Headwater Basin” was to improve on an existing hydrologic model using stream water gas tracers to measure baseflow age in a mountainous watershed. “Baseflow represents both shallow and deep subsurface flow paths that sustain late summer streamflow after precipitation and snowmelt cease, and it accounts for more than 30 percent of the annual stream water budget in many mountain systems,” says Dr. Rosemary Carroll of Desert Research Institute in Nevada, the principal investigator of this project who worked with key collaborators Andrew H. Manning of the USGS in Denver, Colorado; Richard Niswonger of the USGS in Menlo Park, California; David Marchetti of Western Colorado University in Gunnison, Colorado; and Kenneth H. Williams of Lawrence Berkeley National Laboratory in Berkley, California.

Scientists are beginning to recognize that deeper flow paths in mountain watersheds may have a greater influence on streamflow generation than previously understood, but there is a significant lack of data about the bedrock properties that affect these flow paths. The purpose of this project was to understand the influence that these deeper flows have on surface water, as well as how reduced snowpack and a warmer climate could affect that flow. The study area selected for this project was a watershed at the headwaters of the Colorado River: Copper Creek, Colorado. Copper Creek is a principal tributary of the East River, the home of the Watershed Function Science Focus Area headed by Lawrence Berkeley National Laboratory.

The East River Watershed and its tributary Copper Creek are representative of mountain systems around the world in which snowmelt is the primary source of fresh water. Understanding the effects of climate and land-use changes on groundwater in these systems is critical for estimating the vulnerability of water resources (photo by Rosemary Carroll).

"The gas tracer experimental procedure is relatively convenient and cost-effective because it only takes one day to perform and doesn’t require expensive drilling, which is often impossible in mountainous watersheds because of the steep topography and deep snowpack, and, as in the case of our study area, a wilderness designation.”

- Rosemary Carroll
For the gas tracer analysis, the researchers collected nitrogen, argon, sulfur hexafluoride, and trichlorotrifluoroethane concentrations from stream water samples over a 12-hour period. “The method’s effectiveness for describing a unique streamflow age distribution had been demonstrated in low-to-moderate-gradient streams but had never been applied to a high-gradient system where it could be hampered by fast gas exchange velocities to the atmosphere,” Carroll explains. “The gas tracer experimental procedure is relatively convenient and cost-effective because it only takes one day to perform and doesn’t require expensive drilling, which is often impossible in mountainous watersheds because of the steep topography and deep snowpack, and, as in the case of our study area, a wilderness designation.”

Stream water is a mix of different water ages and sources. Therefore, the researchers first needed to accurately define the age distribution of the baseflow to understand the length and depth of the groundwater flow paths. Because of the fast gas exchanges velocities in a mountain stream, they developed an iterative method that incorporated particle tracking through a sophisticated hydrogeologic model. “The originally published integrated hydrologic model of Copper Creek generated shallow groundwater flow moving predominantly through the alluvium situated on much less conductive bedrock.” Carroll says. “For the late summer conditions when the tracer experiment was conducted, the baseflow median age was estimated very young at 1.5 years, but to match the sulfur hexafluoride concentrations we collected, the hydraulic properties of the granodiorite bedrock needed to be adjusted and groundwater flow through the upper portions of Copper Creek needed to be deepened, which increased the groundwater age to 12.2 years.”

The adjustment that had to be made to account for those concentrations was a surprise to the research team. “We had to include significantly deeper groundwater contributions to stream water, with the median depth of maximum groundwater flow reaching 100 meters,” Carroll adds. “We also initially assumed that high recharge conditions in the watershed and low-permeability bedrock would largely maintain a topographically controlled groundwater system dominated by localized flow paths. Instead, we estimated this headwater basin is functioning much closer to a precipitation threshold, with drying predicted to significantly increase flow path depth and age.” These results are important because the time water spends underground affects biogeochemical processes that control mineral weathering and carbon dynamics, and therefore reflects the watershed’s sensitivity to climate change and land use, as well as potential contamination persistence.

The researchers then tested the sensitivity of groundwater flow paths to climate and land-use changes based on the ratio of recharge to hydraulic conductivity. The original
Western Colorado University undergraduate Manya Ruckhaus helps with streamflow sampling from the upper reaches of Copper Creek (photo by David Marchetti).

Copper Creek model established a very high recharge to hydraulic conductivity ratio in the upper portions of the basin. This produced a permeability-limited groundwater flow system with shallow water table elevations that lessened the effect of decreased recharge on baseflow ages. A high recharge to hydraulic conductivity ratio produces higher water table elevations and increases the influence of topographically controlled local flow paths on streamflow. If water table elevations are high enough to support perennial streams, then increases in recharge are unlikely to have a significant effect on groundwater flow paths and the median age of groundwater is stable.

However, watersheds with a lower recharge to hydraulic conductivity ratio have deeper water table elevations that are primarily controlled by the recharge rate. “Under these conditions, ephemeral streams emerge, flow paths are less constrained by local topography, and groundwater flow conditions become increasingly sensitive to changes in recharge,” Carroll says. The researchers achieved a lower recharge to hydraulic conductivity rate by recalibrating the model, which suggests that Copper Creek is closer to a recharge-controlled condition that deepens groundwater flow paths and increases groundwater ages even with relatively small reductions in precipitation. “Therefore, as the climate becomes drier, groundwater ages will become more sensitive to decreases in recharge,” Carroll adds.

The results of the project highlighted some important aspects of mountain watersheds that provide valuable information for water resources management. “We found that the deep groundwater is a potentially important component to streamflow and that these flow paths operate on decadal timescales, so their sensitivity to interannual climate is muted,” Carroll says. “However, because the basin is less permeability limited than we anticipated, groundwater flow paths are susceptible to becoming significantly deeper and older with small shifts in climate toward a drier equilibrium state—and the ability of forest management to buffer changes in deep groundwater is limited.” The results also emphasized the importance of including the deeper bedrock in hydrologic models of mountain watersheds and characterizing the hydraulic properties of the bedrock through indirect means, such as gas tracer
analysis, especially when borehole drilling isn’t an option. The final report with the results of this NWRRI project are available in *Water Resources Research* (Carroll et al., 2020).

**References:**
Carroll, R., A. Manning, R. Niswonger, D. Marchetti, and K.H. Williams, 2020. Baseflow Age Distributions and Depth of Active Groundwater Flow in a Snow-dominated Mountain Headwater Basin. *Water Resources Research*, 56, https://doi.org/10.1029/2020WR028161.

Sanford, W.E., G. Casile, and K.B. Haase, 2015. Dating Base Flow in Streams Using Dissolved Gases and Diurnal Temperature Changes. *Water Resources Research*, 51, pp. 9790–9803. https://doi.org/10.1002/2014WR016796.

Viviroli, D., and R. Weingartner, 2008. Water Towers: A global view of the hydrological importance of mountains. In E. Wiegandt (ed.), *Mountains: Sources of Water, Sources of Knowledge*, Advances in Global Change Research, Vol. 31, pp. 15–20. Dordrecht: Springer. https://doi.org/10.1007/978-1-4020-6748-8_2.

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### Events List Continued

| Event Title                                                                 | Date                          | Location   | URL                                                                 |
|---------------------------------------------------------------------------|-------------------------------|------------|----------------------------------------------------------------------|
| 2021 AWRA Annual Water Resources Conference                               | November 8-11, 2021           | Kissimmee, Fl | www.awra.org/Members/Events_and_Education/Events/2021_Annual_Conference/2021_Annual_Water_Resources_Conference.aspx |
| NGWA 2021 Groundwater Summit                                               | December 7-8, 2021            | Online     | pheedloop.com/Summit2021/site/                                      |
| AGU Fall Meeting                                                          | December 13-17, 2021          | Online and in New Orleans, LA | www.agu.org/Fall-Meeting                                           |
| Tour of the Nevada National Security Test Site                            | January 31, 2022              | Las Vegas, NV | www.nwra.org/2022-january-nnss-tour                                 |
| 2022 NWRA Annual Conference Week                                          | January 31, 2021-February 3, 2022 | Las Vegas, NV | www.nwra.org/2022-annual-conference-week                           |
| Ocean Sciences Meeting 2022                                                | February 27-March 4, 2022     | Honolulu, HI | www.aslo.org/osm2022/                                               |
| 118th Annual Meeting of the Cordilleran Section                           | March 15-17, 2022             | Las Vegas, NV | www.geosociety.org/GSA/Events/Section_Meetings/GSA/Sections/cd/2022mtg/home.aspx |
| 2022 AWRA Geospatial Water Technology Conference                          | March 21-23, 2022             | Austin, TX  | www.awra.org/Members/Events_and_Education/Events/2022_GIS_Conference/2022_GIS_Conference.aspx |
| 2022 AWRA Spring Conference                                               | April 24-27, 2022             | Tuscaloosa, AL | www.awra.org/Members/Events_and_Education/Events/2022_Spring_Conference/2022_Spring_Conference.aspx |
| 18th Annual Truckee River Field Study Course                              | May 5 & 6, 2022               | Reno, NV    | www.nwra.org/2022-truckee-river-tour                                |
| AbSciCon                                                                  | May 15-22, 2022               | Atlanta, GA | www.agu.org/abscicon                                               |
| Chapman Conference: Climate and Health                                    | June 7-10, 2022               | Washington, DC | www.agu.org/Plan-for-a-Meeting/AGUMeetings/Chapman-Conferences    |
| UCWOR/NIWR Annual Water Resources Conference                              | June 14-16, 2022              | Greenville, SC | ucwror.org/conference/                                             |
| Frontiers in Hydrology                                                    | June 19-24, 2022              | San Juan, Puerto Rico | www.agu.org/FHIM                                                  |
Postdoc Interview: Dr. Rubab Saher

We asked postdoctoral fellow Dr. Rubab Saher about her current research and her continuing research plans. Here’s what she had to say:

1) What field are you currently studying and what sparked your interest in that field?

I am currently studying urban climates, specifically arid climates, using remote sensing algorithms. Growing up, I was fascinated by kaleidoscopes. As I grew older and studied the environments of urban areas, the 3D configuration of urban elements (the dimensions of buildings and the spaces between them, and the street widths and spacing) and the interaction of the built environment with sunlight reminded me of my kaleidoscope, which has been a constant source of fascination for me.

2) What kinds of research are you currently working on and what have you learned so far from this research?

I am working on urban irrigation models in arid regions. My goal is to introduce the microclimate effects in existing irrigation models. Our cities are inherently heterogeneous with discontinuous surfaces. However, the current irrigation models are oversimplified because they were initially created to optimize agricultural yield, not to maintain the landscapes. I am focused—my close friends would argue fixated—on improving the current evapotranspiration and irrigation models in urban areas. I am also interested in understanding the applications of remote sensing in environmental modeling.

3) What do you hope to learn more about from the research you are doing?

I hope to better my understanding of microclimates and develop an integrated model for urban irrigation estimation. I believe a significant portion of outdoor water can be saved if we improve our irrigation scheduling, which depends on the radiation processes of the land, buildings, plants, and atmosphere.

4) What do you find most interesting about water resources research, especially working in an arid/semiarid environment such as Nevada?

What interests me is the interwoven relationship between the five “spheres”: the hydrosphere, lithosphere, pedosphere, biosphere, and atmosphere, especially their responses in arid regions.

5) What are some of your other research interests? Do you have any goals for incorporating those interests into your work as you continue in your career?

My research interests are mainly in surface hydrology, but I have been reading about robotics and autonomous systems and their future impacts on urban ecosystems. In my future projects, I am planning to use these systems to improve the scale of our current datasets.

6) What is one of your favorite movies or books, and why?

My recent favorite book is Urban Climates by T.R. Oke, G. Mills, A. Christen, and J.A. Voogt. I had

“I believe a significant portion of outdoor water can be saved if we improve our irrigation scheduling, which depends on the radiation processes of the land, buildings, plants, and atmosphere.” – Rubab Saher
been shopping for a decent climate science book for quite a while and this book is it. It goes from telling the history of cities to understanding urban form and urban fiber and their effects on the atmosphere. I believe that improving something requires fully understanding the problem and I still don’t understand why our physical processes don’t conform to urban surface energy dynamics. I am hoping that this book will help me answer that question.

I’ve also started a TV series called One Strange Rock. I highly recommend it to anyone who wants to know about Earth’s origin and the interconnection between biological and geophysical processes.

7) If you could go on vacation anywhere in the world, where would you want to go, why would you want to go there, and what would you do there?

I would go to Australia. I am an urban researcher by profession and a geology enthusiast at heart. The country is known for ~30,000-year-old sedimentary rocks such as Uluru and the Pinnacles. Uluru is actually a 550-million-year-old isolated rock and is sandstone. We rarely see sedimentary rocks this ancient. It is known to be 5 km to 6 km deep on the surface and its outer shell is orange red, probably because of the presence of aquatic life in the stone that has oxidized. I find rocks and trees interesting because each one has a history to share if we look carefully.

8) If you had six months with no obligations or financial constraints, what would you do with the time?

I would probably explore the geological wonders throughout the world. The first stop would be Australia, and then I’d go to Iceland, Peru, Indonesia, and the list goes on.

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Publications and Presentations of NWRRI Research

2020 and 2021

Peer-reviewed Publications

Ziedman, A., O.M. Rodríguez, J. Moon, and E.R. Bandala, 2020. Removal of Antibiotics in Aqueous Phase Using Silica-based Immobilized Nanomaterials: A review. *Environmental Technology & Innovation* 20, 101030.

Clurman, A.M., O.M. Rodríguez-Narvaez, A. Jayaratne, G. De Silva, M.I. Ranasinghe, A. Goonetilleke, and E.R. Bandala, 2020. Influence of Surface Hydrophobicity/Hydrophilicity of Biochar on the Removal of Emerging Contaminants. *Chemical Engineering Journal* 402, 126277.

Hong, N., A. Goonetilleke, E.R. Bandala, and A. Liu, 2020. Assessing the Effect of Surface Hydrophobicity/Hydrophilicity on Pollutant Leaching Potential of Biochar in Water Treatment. *Journal of Industrial and Engineering Chemistry* 89, 222-232.

Mortazavian, S., E.R. Bandala, J. Bae, D. Chun, and J. Moon, 2020. Assessment of P-nitroso Dimethylaniline (pNDA) Suitability as a Hydroxyl Radical probe: Investigating bleaching mechanism using immobilized zero-valent iron nanoparticles. *Chemical Engineering Journal* 385, 123748.

Lane, B., O.M. Rodríguez-Narvaez, B. Apambire, and E.R. Bandala, 2020. Water Dechlorination Using Sequentially Coupled Moringa Oleifera Seed Extract and Electrocoagulation. *Groundwater Monitoring & Remediation* 40(3), 67-74.

Zhang, L., F. Zeng, C. McKay, R. Navarro-Gonzalez, and H. Sun, 2021. Optimizing Chiral Selectivity in Practical Life-Detection Instruments. *Astrobiology* 21(5), 10.1089/ast.2020.2381.

Conference Presentations

Clurman, A., O. Rodriguez, and E.R. Bandala. Degradation of Antibiotics in Aqueous Phase Using PMS Catalytic Decomposition with Zero-Valent Iron Nanoparticles Immobilized in SBA-15. 2020 NWRA Annual Conference, Las Vegas, NV, February 11-13, 2020.

Ziedman, A., and E.R. Bandala. Application of Peroxymonosulfate Decomposition with Heat-Treated Biochar for the Removal of Acetaminophen. 2020 NWRA Annual Conference, Las Vegas, NV, February 11-13, 2020.

Notable Achievements and Awards

Abdhe Ziedman, 2nd Place in the 2020 NWRA Annual Conference, Graduate Student poster competition.

Adam Clurman, 2nd Place in the 2020 NWRA Annual Conference, Undergraduate Student poster competition.
Success and the dedication to quality research have established the Division of Hydrologic Sciences (DHS) as the Nevada Water Resources Research Institute (NWRRI) under the Water Resources Research Act of 1984 (as amended). As the NWRRI, the continuing goals of DHS are to develop the water sciences knowledge and expertise that support Nevada’s water needs, encourage our nation to manage water more responsibly, and train students to become productive professionals.

Desert Research Institute, the nonprofit research campus of the Nevada System of Higher Education, strives to be the world leader in environmental sciences through the application of knowledge and technologies to improve people’s lives throughout Nevada and the world.

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Page 1: Photo courtesy of Chuck Russell
Events list, page 2: First snow view of Reno by Chelsea Ontiveros
Page 3: East River Watershed by Rosemary Carroll
Page 5: Streamflow sampling at Copper Creek by David Marchetti
Page 7: Photo courtesy of Rubab Saher