Message from the Director

David G. Tarboton,
UWRL /UCWRR Director

The past few months have seen Utah battling unprecedented drought conditions. In July, the U.S. Drought Monitor showed nearly the entire State of Utah in extreme to exceptional drought. Early fall storms improved soil moisture, but our current limited snow reminds us that we are still in drought and emphasizes the importance of water and the research we do to understand and meet the challenges of living and thriving in one of the driest states in the US.

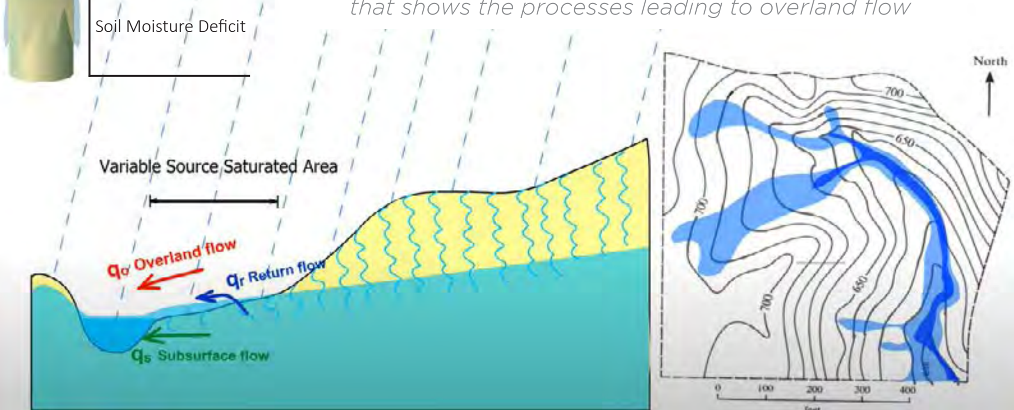
Much of Utah's water storage depends on runoff from winter snowpack. In this issue of the Water bLog, we highlight an innovative method for measuring snow depth in Utah's mountains that could greatly improve the accuracy of runoff estimates. Wheat is a major dry farming crop in Utah. A second project highlight takes a microscopic look at the effects of drought on wheat roots to better understand the mechanisms that could help these essential crops adapt to dry conditions.

Other stories give a brief introduction to two interactive educational tools. The first is HydroLearn, a collaborative effort that helps instructors develop active-learning resources for teaching hydrology and water resources that will help train the next generation of water professionals. The second is an interactive Lake Powell/Lake Mead flex-accounting model that gives managers the chance to test the consequences of various Colorado River water management choices. We hope you enjoy these overviews of some of the research at the lab and welcome any thoughts you may have on this work.

David Tarboton, UWRL/UCWRR Director

The projects highlighted in this issue of the Water bLog represent only a fraction of the active research in which the faculty experts at the UWRL/UCWRR are engaged as they continue to generate the knowledge needed to solve water-related natural resources problems throughout Utah, the nation, and the world.

This graphic is from a HydroLearn module on rainfall-runoff that shows the processes leading to overland flow



Welcome!

The Water bLog is the semi-annual newsletter of the Utah Center for Water Resources Research, housed at the Utah Water Research Laboratory (UWRL).

The Center supports the development of applied research related to water resources problems in Utah and promotes instructional programs that will further the training of water resource scientists and engineers.

Each issue of The Water bLog reports on a small selection of current or recently completed research projects conducted at the center. More information is available online at:

https://uwrl.usu.edu/research/ucwrr

INSIDE

UtahStateUniversity.

Snow & Synergy:

combining citizen science and lidar to improve snow depth estimates

Seasonal snowpack is a critical water resource. Snow supplies the majority of freshwater for more than a billion people globally and for more than 95% of the water in the state of Utah. We rely on yearly snowpack for the runoff that translates into drinking water, agricultural irrigation, municipal and industrial water supply, and ecological flow in rivers and streams throughout drier seasons.

As climate projections increasingly forecast a greater portion of precipitation falling as rain rather than snow, accurate snowpack and runoff data are more important than ever to support the predictive tools that make effective and sustainable water resources planning and management possible.

More than 200 SNOTEL monitoring sites in Utah already provide valuable information for Utah water managers. Remote sensing technologies have added another source of information, but both SNOTEL sites and continuous remote sensing are expensive and are not feasible everywhere, leaving many Utah watersheds unrepresented. Furthermore, methods for estimating snow-water equivalent (SWE) based on these data can lead to runoff forecasting errors of 40% or more.

Dr. Carlos Oroza (University of Utah) and Dr. Bethany Neilson (UWRL/USU) have been researching ways to create better snow estimates in Utah. Over the past year they have joined forces with two separate projects funded through the USGS 104b program to leverage and extend their snow-related work supported through the National Science Foundation and the Logan River Observatory (LRO).

Synergy of Citizen Science

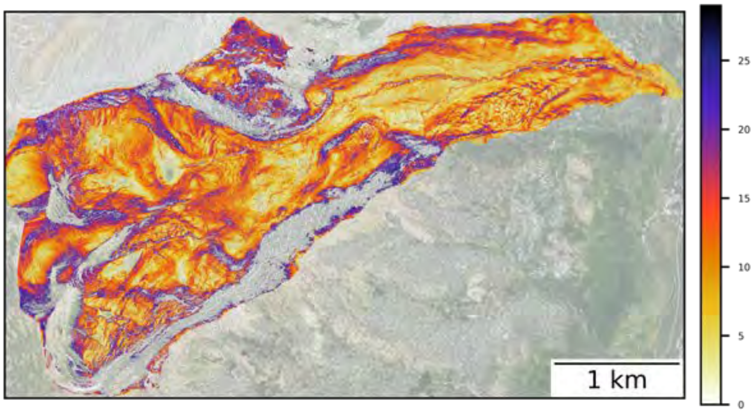
Dr. Oroza and PhD student Dane Liljestrand are combining citizen science with lidar terrain features to investigate the feasibility of generating continuously updated, high-resolution snowpack data. This synergistic approach to snow estimation could better quantify snow pack throughout the season, which in turn can lead to more accurate water supply forecasts and management.

This project enlists the efforts of volunteer citizen scientists and backcountry recreationalists to collect on-ground snow depth measurements via a mobile app platform (details at communitysnowobs.org/). These observations are used to train a computer algorithm to accurately estimate snow-depth across a region. Constraints are applied to the algorithm to protect citizen scientists such that they will not be required to traverse in avalanche terrain.

The team conducted a field campaign in Franklin Basin in Northern Utah in March to collect snow depth measurements and aerial lidar data. They have traversed throughout


Dane Liljestrand collecting snow measurements at Franklin Basin, UT.

Story photos courtesey Dane Liljestrand



(Left banner) Franklin Basin, Utah; (Banner inset) March 28, 2021 snow depth in Franklin Basin from aerial flown lidar; (Above) Slope degree map of field campaign region produced by the algorithm. Non-colored areas signify avalance risk and are excluded to limit citizen scientist exposure when collecting data.

the basin on skis and with standard backcountry equipment to collect the snow measurements. The collected data are then combined with lidar data collected during both snow-off (also called "bare earth") and snow-on conditions to create larger-scale estimates of spatial snowpack variability.

Leveraging LiDAR

Dr. Neilson and her team have coordinated the lidar flights over the mountainous portion of the Logan River watershed during fall 2020. This dataset provides the detailed bare earth topography information necessary for Oroza's citizen science work and is complementary to other LRO research focused on the development and testing of predictive hydrologic tools.

LRO faculty, staff, and students worked with their University of Utah collaborators to identify, install, and survey control points that align the bare earth lidar data and the snow-on lidar data collected early in 2021. Lidar data are also essential for identifying key areas of recharge in the Logan River basin.

Looking to the Future

“There is a clear need for better data regarding snow distributions and for support of predictive tools that give us insight about watershed response to shifting patterns of temperature and precipitation,” Neilson commented. “At the same time, we need to be creative in how we collect data from remote locations. Engaging stakeholders that spend significant time in these areas and that deeply value these resources provides a perfect collaboration.”

“This work will potentially transform how spatial snow depth is estimated," added Oroza. "By integrating existing LIDAR terrain attributes with citizen-science snow-depth data, we can produce highly resolved measures of snow depth at watershed scale. Our approach that combines current lidar terrain data and volunteer citizen science significantly reduces the cost and increases the frequency of basin-scale snow-depth estimates. Beyond the data, we hope this research engages and encourages backcountry recreationalists to take a direct role in the way we monitor and measure our snowpack and help to improve local snow models." ■

PI: Carlos Oroza
Assistant Professor, Civil & Environmental Engineering, U of U
carlos.oroza@utah.edu

PI: Bethany Neilson
Professor, Civil & Environmental Engineering, USU
bethany.neilson@usu.edu

Other Researchers/Collaborators:
Dane Liljistrand (PhD student, U of U)
Patrick Strong (Research engineer, USU)
Coleman Worthen (American Avalanche Institute, safety guide)
Mason Decker & Aerographics team (lidar)
Michael Jarzin (student, U of U)

The Utah Center for Water Resources Research (UCWRR), housed within the Utah Water Research Laboratory, is one of 54 state water institutes authorized by Congress in 1964. The UCWRR supports water research projects each year on topics relevant to the needs of the State of Utah with funding administered through the USGS 104b program.

2020-21 USGS 104b Projects *(G16AP00086)*:

- Improving the hydraulics of urban flooding *(Z. Sharp)*
- Dynamic, adaptive management of the Colorado River to enhance water supply and river ecosystem outcomes *(D. Rosenberg, J. Wang, J. Schmidt)*
- Leveraging LIDAR and citizen-science for low-cost, high-resolution snow-depth estimation *(C. Oroza, D. Liljestrand)*
- Obtaining LIDAR data to support research in the Logan River Watershed *(B. Neilson)*

2021-22 USGS 104b Projects Now Underway *(G21AP10623)*:

- Real-time generation of multispectral and thermal aerial maps for immediate Utah water decision-making activities in urban, agricultural and natural environments *(S. Petruzza, C. Coopmans, A. Torres-Rua)*
- Quantifying the impact of reservoir sedimentation on water security in the Weber River watershed *(Patrick Belmont, Justin Stout, Ian Gowing, Alfonso Torres-Rua)*
- Assessing the sources, transport, and fate of microplastic in the Logan River watershed *(K. Moor, J. Brahney, B. Neilson)*
- Public views on water strategies for protecting the Great Salt Lake and its wetlands *(J. Endter-Wada, L. Welsh, K. Kettenring)*

Read more about the UCWRR at: **https://uwrl.usu.edu/research/ucwrr/**

The Root of the Problem:
understanding drought-driven changes to winter wheat root exudation

In late 2020, more than 80% of Utah entered a state of extreme drought for the first time since 2003. By July 2021 the drought had intensified and nearly 70% of the state was experiencing an exceptional drought, a condition not observed in Utah since the US Drought Monitor was established in 1999. All 29 Utah counties received USDA disaster designations and many dryland wheat fields suffered a complete loss.

Drought-related agricultural losses such as these are expected to continue in the face of climate change, so farmers need new strategies to increase crop resilience. One strategy being tested at the UWRL and by researchers nationwide involves the application of nanoparticle (NP) micronutrients to soil.

In order to fully understand the mechanisms by which micronutrient NPs may enhance drought tolerance in plants, UWRL researchers Joan McLean and Joshua Hortin are collaborating with other researchers in USU's Departments of Biological Engineering and Plants, Soils, and Climate to study the exudation patterns of winter wheat that may fortify the plant against drought stress. Their goal in investigating these mechanisms is to find ways for these essential crops to adapt to dry conditions.

Plant Root Exudation

"Plants acquire micronutrients through specific organic acids emitted through their roots. These exudates also help to stop harmful microbes and attract beneficial root-colonizing bacteria," say McLean and Hortin.

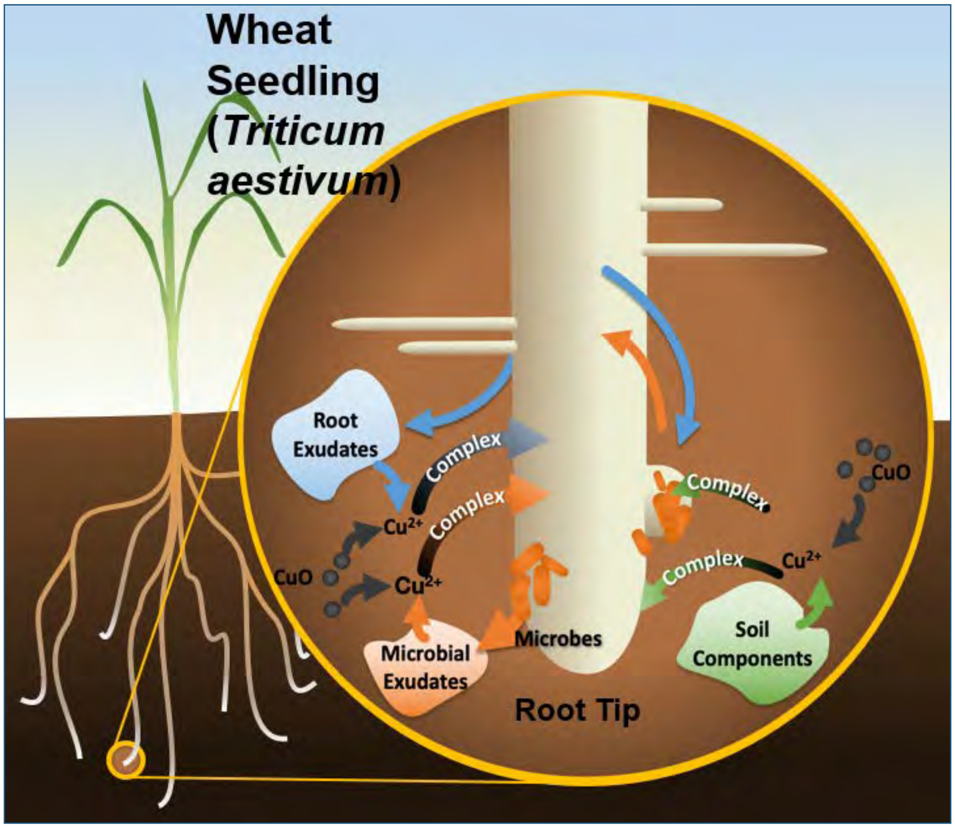
They further explain that plants may suffer from nutrient stress as well as water stress in dry soils as roots and shoots become less able to take up nutrients. Exudates change with drought stress to aid the plant and its associated bacteria to cope. The addition of NP micronutrients may aid in this strategy by increasing the bioavailability of these nutrients.

A Growing Understanding

In this research, drought-tolerant hard red winter wheat seeds from a common variety of wheat grown in Utah were planted in sand. Seeds were inoculated with a bacterium called Psedomonas chlororaphis (Pc06), which was originally isolated from the roots of a Cache Valley dryland wheat farm. At 7 days old, half of the pots had their water content reduced to simulate drought conditions, and all pots grew another 7 days.

As expected, the droughted plants exhibited decreased shoot and root mass, and shoot water content. Other findings included the following:

- PcO6 root colonization was not impaired by drought conditions.
- PcO6 metabolizes many root exudates under watered conditions.
- Under drought, more organic and amino acids were detected even in



Schematic of some chemistry in the rooting zone when CuO nanoparticles are present (graphic created by Jessica Cooper and Dakota Sparks).

the presence of PcO6, suggesting that the plants produce more root exudates under stress. Some of these exudates aid the plant against stress and others serve to increase the bioavailability of nutrients.

McLean and Hortin also observed an interesting shift in glycine betaine, a root exudate that is known to play a key role in drought tolerance. Glycine betaine was 15 times higher in concentration under drought conditions compared to watered conditions, even when PcO6 was present. Preliminary evidence from the biological engineering team indicates that winter wheat recovers more strongly following a drought period when glycine betaine is present in the rooting zone. Thus, the increase in root exudates could be beneficial for crop recovery.

Nanoparticles, Microbiome Enhancement, & Wheat Seeds

Increasingly, the literature suggests that application of metal and metal oxide NPs may be able to mitigate some of these drought-induced challenges.

In related research also conducted under this collaboration, varying doses of the NPs CuO, ZnO, and SiO2 (at fertilizer levels) were applied to drought-tolerant hard red winter wheat, inoculated with PcO6, and grown in sand. All of the wheat seeds were grown for 14 days, and then an 8-day drought was imposed on the test group, whereas the control group was watered as usual throughout the experiment. At the end of the experiment, the plants were evaluated to see whether any of the nanoparticle applications had an effect on root exudates, mitigating drought stress.

Under conditions that provided adequate mineral nutrition and a beneficial microbiome, nanoparticle fertilization did not further improve the drought tolerance of the wheat seedlings. These findings suggest that specific environmental conditions may be needed to realize any potential benefits of NPs in promoting plant drought tolerance.

Looking to the Future

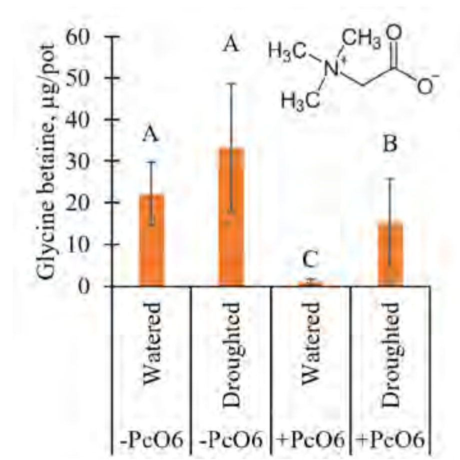
"Despite about ten years of NP agricultural research, NPs are not yet being used in commercial agriculture outside of a handful of field trials. This is because, out of an abundance of caution, we need to fully demonstrate that there will be minimal unexpected adverse consequences to human applicators, the soil microbiome, and the plant roots, which may already be under stress" Hortin stated. "Understanding how root exudation patterns change under different conditions such as drought will help solve a piece of this puzzle and advance the technology."

McLean and her team plan to continue investigating the roles and importance of other specific root exudate shifts observed under drought conditions to help dryland farmers develop strategies to reduce crop losses in drought-affected areas in Utah and around the globe. ■

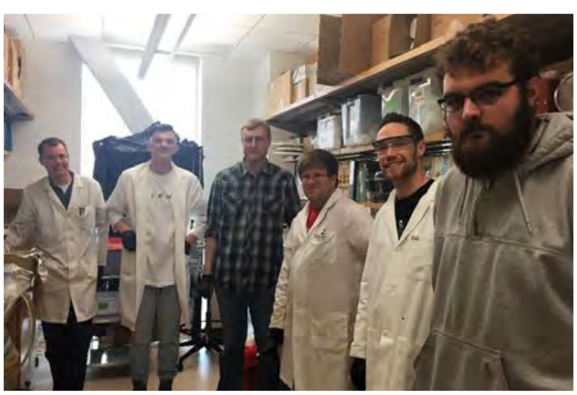
PI: Joan McLean
Research Professor, Civil and Environmental Engineering and Utah Water Research Laboratory, USU, (435) 797-3199, joan.mclean@usu.edu

PI: Joshua Hortin
Researcher II, Utah Water Research Laboratory, joshua.hortin@usu.edu

Other Researchers/Collaborators:
Anne Anderson (Biology), David Britt (Biological Engineering), and Astrid Jacobson (Plants, Soils, & Climate); MS students Dakota Sparks (UWRL), Justin Dearkin (PSC), and Matthew Potter (BE), PhD student Anthony Cartwrights (BE)



Concentration of glycine betaine (mg) per pot under 4 treatments, watered or droughted and with or without the bacterium PcO6 present (above). The structure of the glycine betaine molecule structure is shown in the inset. While glycine betaine did not increase under drought when PcO6 was absent (shown by the matching letters over the bars), it did increase under drought when PcO6 was present (graph by Joshua Hortin).



Read More

"Absence of nanoparticle-induced drought tolerance in nutrient sufficient wheat seedlings." 2021. Environ. Sci. Tech., doi.org/10.1021/acs.est.1c00453

The interdepartmental student and staff research team (left), A visual comparison of 8-day watered wheat (center) and droughted wheat (right). Plants grown by Justin Deakin. (photos by Dr. Astrid Jacobson)

HydroLearn: a collaborative, active-learning resource for teaching hydrology and water resources engineering

In the hydrologic sciences, some of the best learning happens when students are able to apply principles to actual water problems and real-world design scenarios. Creating that kind of research based, innovative learning environment requires significant time, effort, and technology—resources that are often in limited supply. Individually, educators can accomplish only so much, but combining those individual efforts into a community resource could go a long way toward making research-based, proven learning innovations available, scalable, and sustainable.

Inspired by the need to address these recognized challenges inherent in educational innovations, UWRL researchers, collaborating with researchers at three other US universities, have developed a learning platform called HydroLearn. This collaborative partnership funded by the National Science Foundation, is led by Emad Habib at the University of Louisiana at Lafayette and connects the expertise of teams at the U. of Louisiana at Lafayette, Utah State University (led by David Tarboton), Brigham Young University, and University of Houston. The project promotes the collaborative development and adoption of active-learning resources in hydrology and water resources engineering.

HydroLearn

The HydroLearn platform was created using the well-established EdX open-source technology platform (used by Harvard and MIT among others) with two main goals in mind:

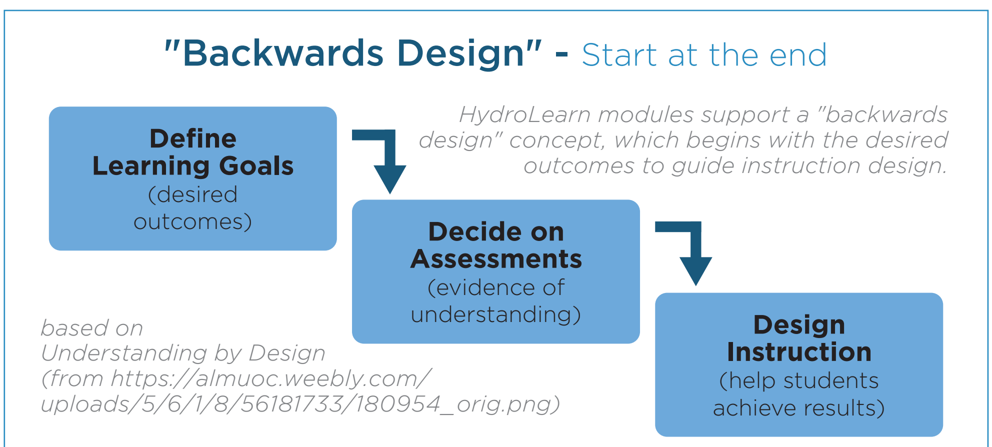
- Enable instructors to collaboratively develop and share active-learning resources, and
- Enhance student learning in fundamental and emerging topics in the field.

Thus, the platform allows instructors to customize pre-developed learning modules to fit student needs and share components of their own learning resources with other interested users.

What can I do with HydroLearn?

Using the HydroLearn platform, instructors can:

- Adopt existing courses, case studies, and learning activities for use in their classes
- Customize existing courses and learning activities, or build new ones
- Share learning resources they have developed for others to use
- Learn to apply research based active learning methods in their courses



Who can use HydroLearn?

HydroLearn is freely accessible to everyone but is designed primarily for (1) instructors who want to develop, customize, and share innovative learning resources in hydrology and water resources engineering and (2) students who want to learn about fundamental and emerging topics in hydrology and water resources engineering using active learning approaches.

By contributing, customizing, and sharing educational content to the platform, the HydroLearn community of educators are helping to alleviate the barriers to development and adoption of active-learning innovations for themselves and other educators.

What courses are available?

HydroLearn modules currently comprise more than 40 courses developed by educators around the world. Initial models were developed by the HydroLearn team, but the majority of modules, covering a wide range of water resources topics, have been developed by HydroLearn Fellows, instructors who have participated in in-depth virtual workshops to learn the active-learning goal- and outcome-centered content design approach used in HydroLearn and to collaborate in the development of HydroLearn modules.

HydroLearn Fellowships

Three cohorts of HydroLearn faculty fellows (2019, 2020, and 2021) have developed online modules. The fellows workshops in 2020 and 2021 were held over compressed two-week periods, and while the online format was due to the pandemic, the online format proved to be beneficial as engagement could extend over a period longer than feasible in an in-person workshop. Although HydroLearn is targeted at the development of research-based active-learning content for both online and in-class instruction, the fellows showed an increased interest in online content.

Dr. Belize Lane (USU), who was in the 2019 cohort, developed modules for a Physical Hydrology course taught in civil and environmental engineering at USU. She later joined the HydroLearn team. Other USU HydroLearn modules include Flash Flood Protection, using Logan Dry Canyon as a case study, and a module on Remote Sensing in Hydrology by Dr. Alfonso Torres-Rua that is nearing completion. The Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI) has recognized the advantages of HydroLearn for promoting collaboration, sharing, and reuse of good learning material, and discussions are underway for CUAHSI to sustain HydroLearn as a community resource beyond the NSF grant. ■

PI: David Tarboton
Director, Utah Water Research Laboratory,
Professor, Dept. of Civil & Environmental Engineering, Utah State University
(435) 797-3172
david.tarboton@usu.edu

Other Collaborators/Students:
Belize Lane, Assistant Professor (USU), PhD students Irene Garousi (USU), Madeline Merck (USU), Emad Habib (U. of LA at Lafayette), Dan Ames (BYU), Melissa Gallagher (U. of Houston)

Explore HydroLearn at
https://hydrolearn.org

Example HydroLearn Modules

Flash Flood Protection: Logan Dry Canyon, UT

One of the first HydroLearn Modules. This module was developed by David Tarboton and UWRL graduate student Madeline Merck

PURPOSE:

This module gives students experience using engineering design processes to design a detention basin that will protect an urban development from flooding. The module sections follow the steps of a typical design process, including data gathering and analysis, design using hand calculations and computer software (HEC-HMS).

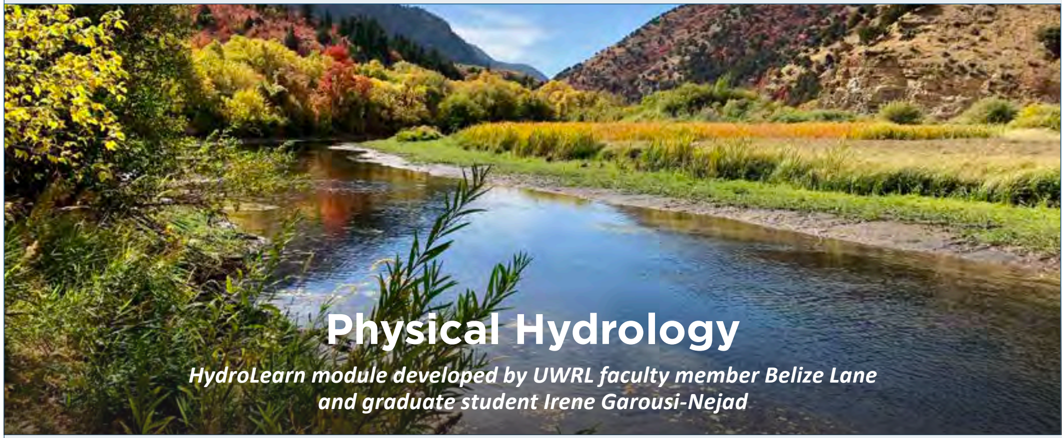
TOPICS:

- Watershed properties
- Precipitation analysis
- Runoff and infiltration
- Inflow and Outflow Hydrographs
- Reservoir design

TOOLS NEEDED:

Computer with internet access, Excel, and open-source HEC-HMS software.

LEARN MORE about this course OR
READ a related recent publication



Physical Hydrology

HydroLearn module developed by UWRL faculty member Belize Lane and graduate student Irene Garousi-Nejad

PURPOSE: This graduate level module gives students an intuitive and quantitative understanding of physical processes involved in the land phase of the hydrologic cycle and helps them use this knowledge to address engineering problems and participate in data-driven research based on physical understanding and parameterization of hydrologic processes.

TOPICS:

- Fundamentals of the hydrologic cycle and hydrologic processes
- Precipitation
- Runoff and infiltration
- Evapotranspiration
- Snowmelt

MODULE BASIS:

Integrates ESRI Story Maps, CUAHSI JupyterHub, HydroShare into learning

LEARN MORE about this course
READ a related recent publication

Story photos courtesy HydroLearn

A synchronous model
for a combined Lake Powell-Lake Mead system spurs Colorado River discussion

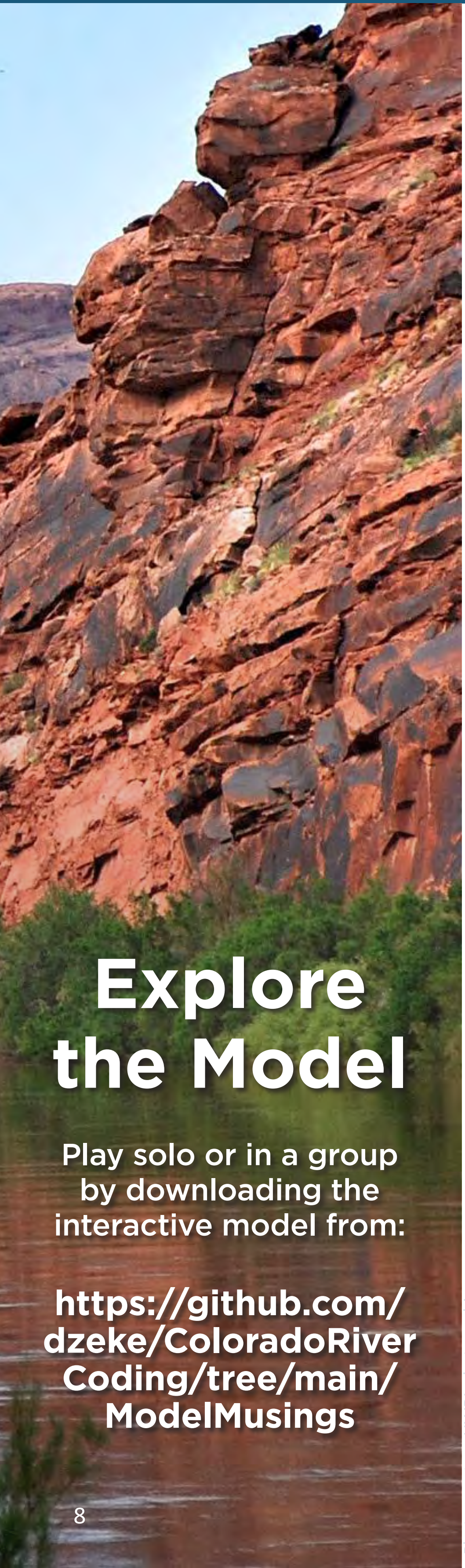


Photo courtesy UWRL photo archive

Explore the Model

Play solo or in a group by downloading the interactive model from:

https://github.com/dzeke/ColoradoRiverCoding/tree/main/ModelMusings

In the face of a persistent 20-year drought, Colorado River managers face a daunting task—meeting municipal, agricultural, and other water needs and goals, sustaining river ecosystems and endangered fish, and maintaining critical water storage in reservoirs such as Lake Mead and Lake Powell. In 2021, the reservoirs reached critically low levels, and the Bureau of Reclamation declared the first water shortage on the Colorado River in the 99 years on record.

Amid these increasing concerns, UWRL faculty member David Rosenberg built an interactive Google Sheet model for a combined Lake Powell-Lake Mead system and then shared and discussed it with 24 Colorado River managers, stakeholders, and basin experts. Those discussions led to 36 model improvements.

The participants liked the whole-basin approach to management and appreciated the opportunity to see the consequences of choices. For example, how did storing water in Lake Powell vs. Lake Mead impact native endangered fish of the Grand Canyon? Several participants called the model experience fun and provocative, even though the model strayed from current river operations. Nearly all participants encouraged Rosenberg to continue to share the model.

"It was a fantastic experience to build a model and then share that model in real-time with the people who know the Colorado River basin best," Rosenberg said. "I learned about critical pieces in Colorado River management and how to better share my research."

In the model, up to five parties—Upper Basin, Lower Basin, Mexico, Colorado River Delta, First Nations—managed accounts in the combined Lake Powell – Lake Mead system. For each year, each party received a designated share of the natural inflow. Reservoir evaporation was subtracted in proportion to each party's account balance. Parties purchased water from or sold water to other parties and jointly managed withdrawals from a shared water reserve. The shared water reserve started with a combined volume of 11.6 million acre-feet, which corresponded to the volumes associated with the current Lake Powell and Lake Mead protection elevations of 3,525 and 1,020 feet. End-of-year account balances became the account balance and reservoir storage for the start of the next year.

To use the model, players connected to the Google Sheet, chose a party to role play, and defined their party's strategy over the next 1–5 years. Each player responded to the year's hydrology by making individual year-to-year water conservation, consumption, purchase, and sale decisions within their account balances, while also tracking other parties' choices and account balances and the combined reservoir storage. Players jointly agreed how to split the combined storage between Lake Powell and Lake Mead and tracked impacts to Grand Canyon fish. Then all players moved to the next year.

Rosenberg is documenting the lessons from his experiences. Now it's your turn to explore the model! ■

PI: David Rosenberg
Professor, Civil and Environmental Engineering and Utah Water Research Laboratory, USU
(435) 797-8689
david.rosenberg@usu.edu

Links to additional information on flex accounting:

READ» Invest in Farm Water Conservation to Curtail Buy and Dry

READ» Adapt Lake Mead Releases to Inflow to Give Managers More Flexibility to Slow Reservoir Draw Down

In the News:

Faculty & Student Achievements

USU faculty members David Tarboton, Jeff Horsburgh, and Courntey Flint recently became part of a large multi-disciplinary team collaborating within the University of Illinois Urbana-Champaign's newly formed Institute for Geospatial Understanding through an Integrative Discovery Environment (I-GUIDE), which will receive $15 million in funding over five years as part of the National Science Foundation's Harnessing the Data Revolution initiative. The USU team is creating tools to better understand the global impact of climate change and other disasters.

Read more

Caitlin Arnold and Emma Lyon, recent civil and environmental engineering graduate students at the UWRL working with Dr. Brian Crookston, presented their research at the September Association of State Dam Safety Officials Annual Meeting in Nashville, Tennessee. Caitlin's presentation was titled, "Using deep learning in ArcGIS Pro to locate low-head dams," and Lyon presented her research about what communities can do to prepare for hundred-year floods.

Read More

Other News

Three Faculty Positions Open

The UWRL and USU's Department of Civil and Environmental Engineering is reviewing applications for the following tenure-eligible faculty positions:

- Environmental Engineering
  Two openings with a preferred focus in microbiology or physical/chemical processes.
- Groundwater Engineering
  One opening in the broad topical area of groundwater engineering.

Accreditation granted

The UWRL hydraulics Laboratory is proud to have received ISO/IEC 17025 Certification through Perry Johnson Laboratory Accreditation, Inc. This certification is a distinction of excellence and quality in the laboratory testing industry.

Read more

Former Faculty Passings

We are deeply saddened at the loss of two former UWRL faculty members.

Roland Jeppson (1933-2021) was an honored faculty member at the UWRL and was well known for his work in pipe networks and his rigorous courses on numerical methods and hydraulics.

Duane Chadwick (1925-2021) joined the USU faculty in 1957 and the UWRL research staff when the lab opened in 1965. He holds 9 patents for his innovative energy- and weather-related research inventions.

Both will be greatly missed and fondly remembered by the UWRL and Aggie community.

Future Issues:

"Improving the Hydraulics of Urban Flooding"

(This research compares the results of 1D, 2D, and 3D modeling for a potential flooding event in Logan, Utah, to determine the likely flood boundaries and possible actions for flood prevention)

Contact:

Utah Water Research Laboratory
Utah State University
Logan, UT 84322-8200
(435) 797-3157

Director:
David Tarboton

Associate Directors:
Steven Barfuss
Jeffery Horsburgh

Publication Editor:
Carri Richards

uwrl.usu.edu/research/ucwrr/

Utah Water Research Laboratory
UtahStateUniversity.