



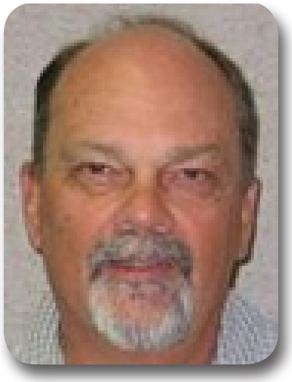

Utah Water Research Laboratory

2012-2013 ANNUAL REPORT

UtahStateUniversity

Message from the Director

INSIDE



Mac McKee
UWRL Director

Next year we will celebrate the 50-year anniversary of the Utah Water Research Laboratory building dedication. Anticipating that milestone has led us to look back and remember those visionaries, such as Dean F. Peterson, (former dean of the College of Engineering and Vice President of Research at Utah State University) who worked so hard to make this building a reality.

But of course, the lab is much more than the building. This was first in Dean Peterson's mind. The lab is a concept, a group of researchers and resources that allows Utah State University and the College of Engineering to do amazing things in water resources management. It represents what those in the old days thought would be a critical mass of people and resources to struggle with what we don't know about our water resources problems.

And now here we are, almost 50 years later, looking back at those amazing things that we have learned and accomplished. And just as our predecessors did, we are looking to the future at the things we still don't know about water resources problems and bringing together the people and resources to meet those challenges.

This report is only a brief snapshot of the wide range of research ongoing at the UWRL. For more information, please visit our website at:

http://uwrl.usu.edu/

Dean F. Peterson

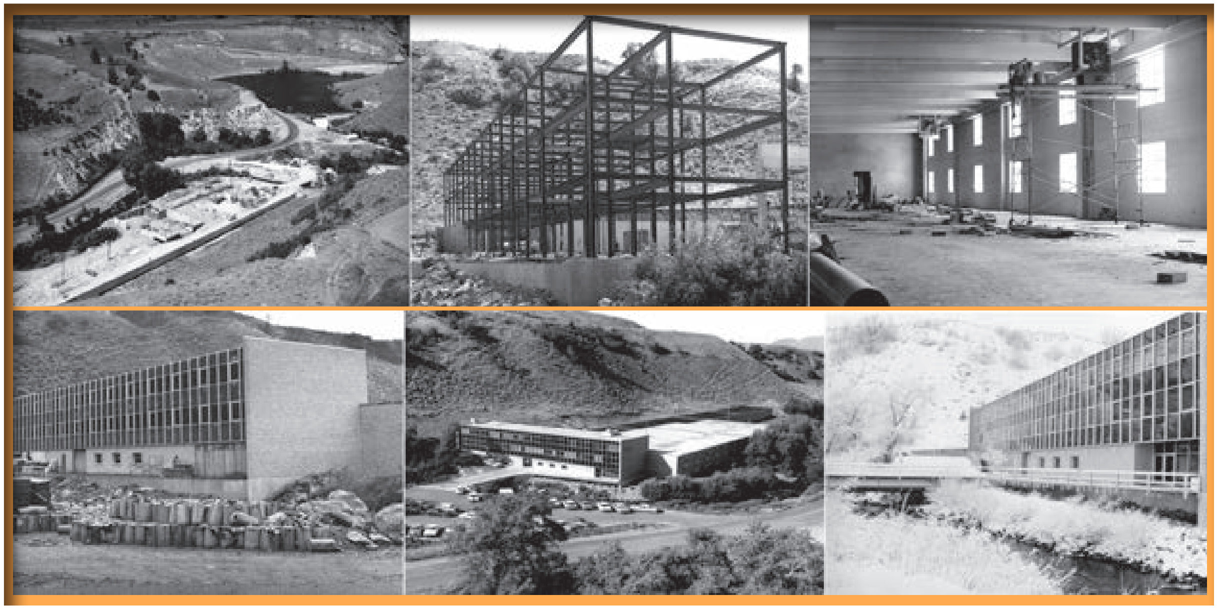
The Utah Water Research Laboratory (UWRL) was born of an idea, and that idea was put in motion by visionary leaders such as Dr. Dean F. Peterson (1913-1989).

Dr. Peterson, a native of Delta, Utah, studied structural and irrigation engineering at the Utah State Agricultural College (now USU) and had a wide ranging career as an engineer and an educator before returning to USU in 1957 to serve as dean of the College of Engineering.

At that time, Dr. Peterson foresaw the need for a water research facility at USU. He initiated some of the first water experiments at the present UWRL site with hopes that continuing research would increase the chances of developing a permanent water research facility at USU. Dr. Peterson presented a proposal to the USDA for a federal water research laboratory to be located in Cache Valley, and they put an irrigation hydraulics laboratory on their list of desired facilities.

In 1959, through the efforts of Dr. Peterson, Dr. Vaughn E. Hansen, and then Governor George Dewey Clyde, along with many others, the Utah legislature authorized the funding for construction of a water resources research laboratory at USU and initiated architectural planning. Ground was broken for the facility in 1963, and the building was dedicated in 1965.

In 1964 the US Water Resources Research Act was signed, authorizing water research centers in each state and territory. Consequently, the UWRL is the oldest and one of the largest water research facilities in the United States, and is considered one of the most well-respected such facilities in the world.



WORLD renowned expert.
Kind and gentle **MENTOR**.
GIANT with humble bearing.
Knowledgeable **LEADER**.
HUMBLE family man.
Lasting **LEGACY**.
DECADES before his time.
Pushing for **PROGRESS**,
his **VISION** became our

HISTORY.

Alfonso F. Torres-Rua is a Research Engineer at the Utah Water Research Laboratory specializing in scientific and practical development and evaluation of data mining applications for local and spatial environments in water resources, agriculture, evapotranspiration, soil moisture, and environmental phenomena. He has been granted NASA-USGS privileged access to Landsat servers for his research. He uses high-resolution UAV and satellite imagery in monitoring, forecasting, and optimization studies for farms, irrigation systems, and hydrological basins. (**alfonso.torres@usu.edu**).

Alfonso Torres holding an AggieAir "Minion" unmanned aerial vehicle designed to collect multispectral imagery for use in agricultural and other scientific applications

Advances in Remote Sensing for Precision Agriculture

Remote sensing can be a powerful tool for many agricultural applications to estimate variables such as crop yield, nitrogen deficiencies, crop types, disease, and general health relative to applying herbicides and pesticides. Despite some success in agricultural applications, conventional sources of multispectral imagery (e.g. manned aircraft and satellite) tend to be costly and have coarse spatial and temporal resolution and long processing times.

Research

Utah Water Research Laboratory (UWRL) researcher Dr. Alfonso F. Torres-Rua is using high resolution (15 cm resolution) visual, near-infrared, and thermal-infrared imagery from AggieAir, an unmanned aerial remote sensing platform developed at the UWRL, along with custom analytical tools—machine learning techniques that include modeling algorithms using artificial neural networks (ANN) and multivariate relevance vector machines (MVRVM) adapted for these applications—to provide near-realtime information to farmers and irrigation system managers so they can make better decisions concerning field operations, irrigation, and application of products for crop fertility, pests, and disease.

Dr. Torres-Rua and his team of graduate students are developing ways to provide, at the subfield level, very high-resolution estimates of:

- Plant nitrogen and chlorophyll.
- Evapotranspiration rates.
- Soil moisture.

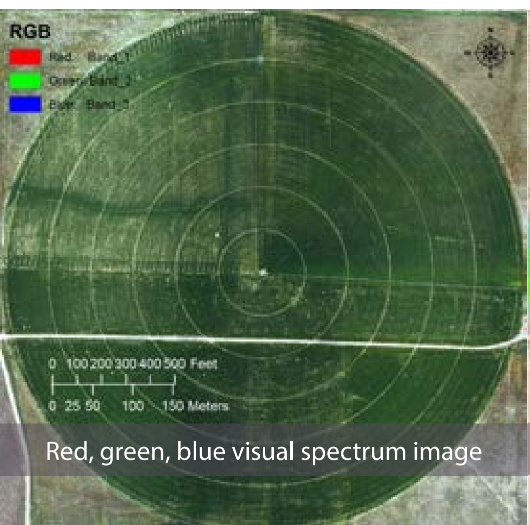
Results

Results so far have shown that machine learning regression models can be used to accurately estimate relationships between plant chlorophyll and nitrogen and the reflectance data in the multispectral AggieAir imagery, resulting in a very precise understanding of agriculturally important conditions within the field. The MVRVM model results are also accurately estimating evapotranspiration rates and soil moisture at much finer resolution, in both space and time, than conventional remote sensing technologies.

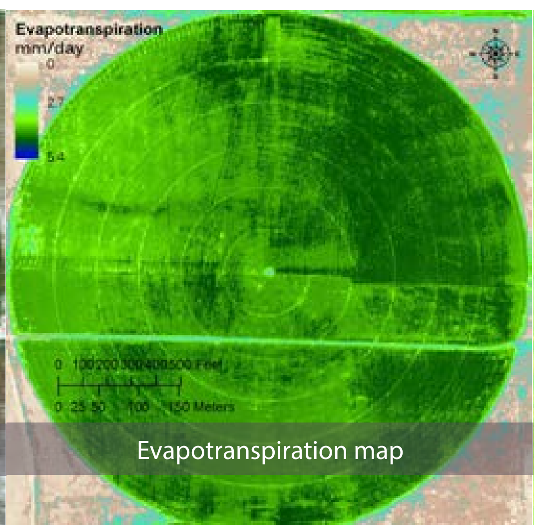
Looking to the Future

The ultimate goal is to facilitate precise application of pesticides, fertilizers, and irrigation water, which will lead to more sustainable practices and will beneficially impact crop production by addressing heterogeneity within the field.

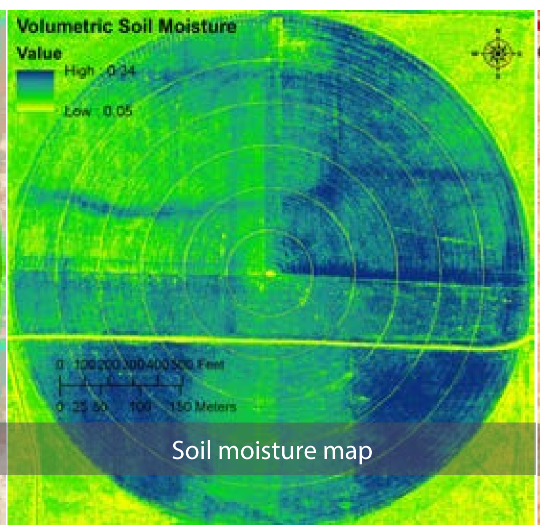
The UWRL is hoping to partner with major grape producers in California, vegetable growers in Texas, and potato growers in Utah to advance this research. If these combined technologies can be used affordably to provide actionable information for use in real-world precision agricultural ap-plications, that will take this technology one step closer to integration into commercial production.



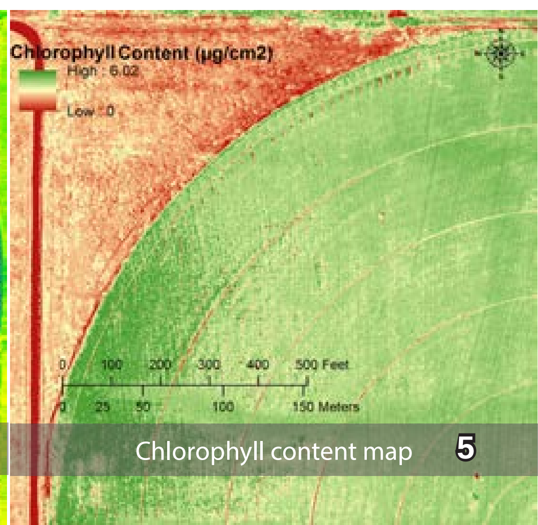
Red, green, blue visual spectrum image



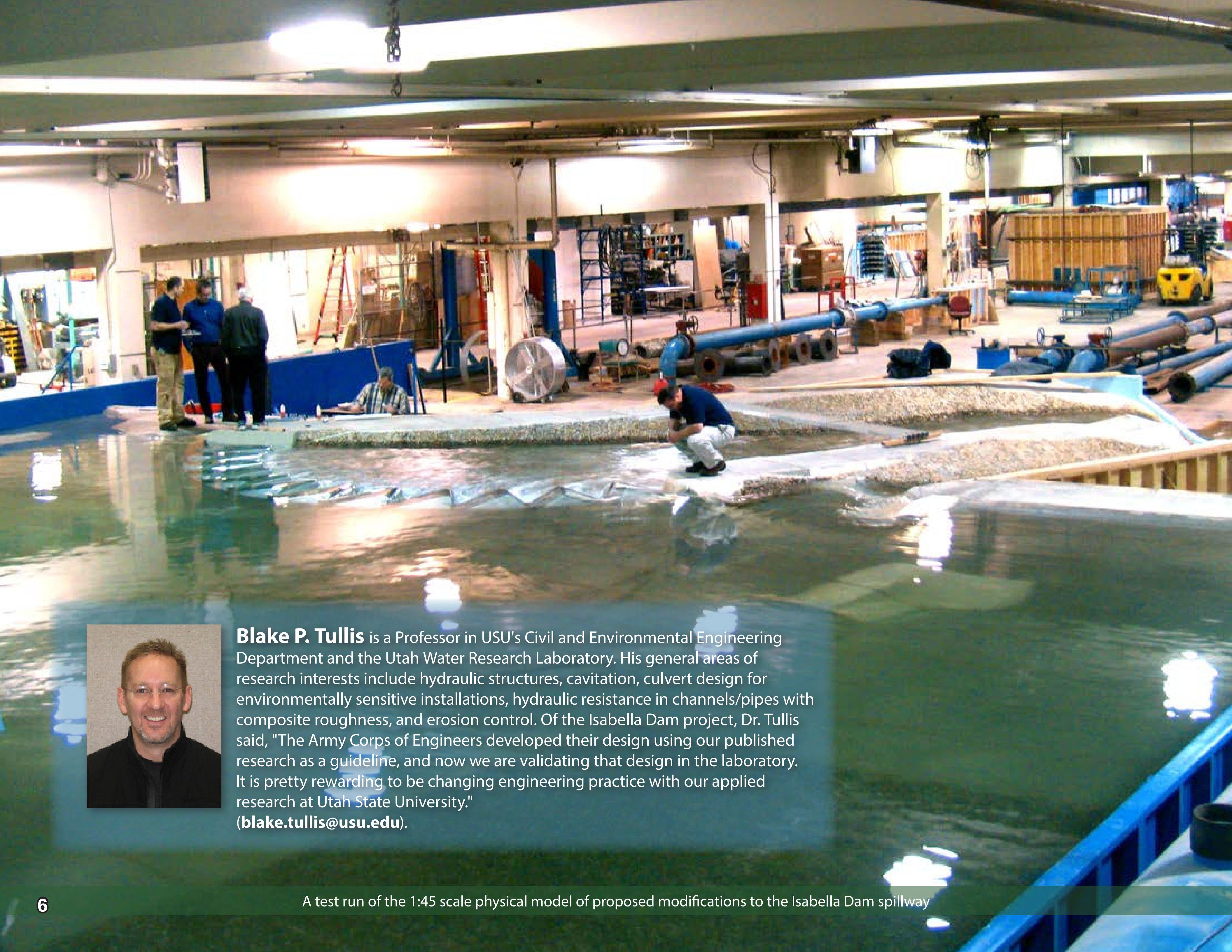
Evapotranspiration map



Soil moisture map



Chlorophyll content map



Blake P. Tullis is a Professor in USU's Civil and Environmental Engineering Department and the Utah Water Research Laboratory. His general areas of research interests include hydraulic structures, cavitation, culvert design for environmentally sensitive installations, hydraulic resistance in channels/pipes with composite roughness, and erosion control. Of the Isabella Dam project, Dr. Tullis said, "The Army Corps of Engineers developed their design using our published research as a guideline, and now we are validating that design in the laboratory. It is pretty rewarding to be changing engineering practice with our applied research at Utah State University."
(**blake.tullis@usu.edu**).

A test run of the 1:45 scale physical model of proposed modifications to the Isabella Dam spillway

Research Highlight

Beneficial Results from Labyrinth Weir Modeling Research

Labyrinth weirs are becoming the design of choice for dam spillway rehabilitation because they can increase the spillway capacity over linear weirs without increasing the width of the spillway chute.

It's hard to imagine that, as recently as 2008, very limited design and evaluation data were available for a variety of labyrinth weir design possibilities.

Research

At that time, the UWRL made a significant investment into labyrinth weir research by funding an ongoing study, led by Dr. Blake P. Tullis, to evaluate both channel and reservoir applications of labyrinth and piano key weirs in order to:

- Improve the design and analyses of labyrinth weir spillways by consolidating available data sets and information.
- Assimilate and expand current design methodologies.
- Utilize physical models to investigate areas in need of research.

This years-long study evaluated more than 40 different laboratory scale physical models of traditional, arced, and staged/notched labyrinth weirs and various piano key and oblique weir geometries for discharge coefficients, nappe stability and aeration characteristics, and local submergence effects and is continuing to study a variety of characteristics of labyrinth weirs.

Results

As a result of that initial funding, Dr. Tullis has become known internationally for his expertise with labyrinth weirs. The following are only a few of the beneficial results from that initial investment:

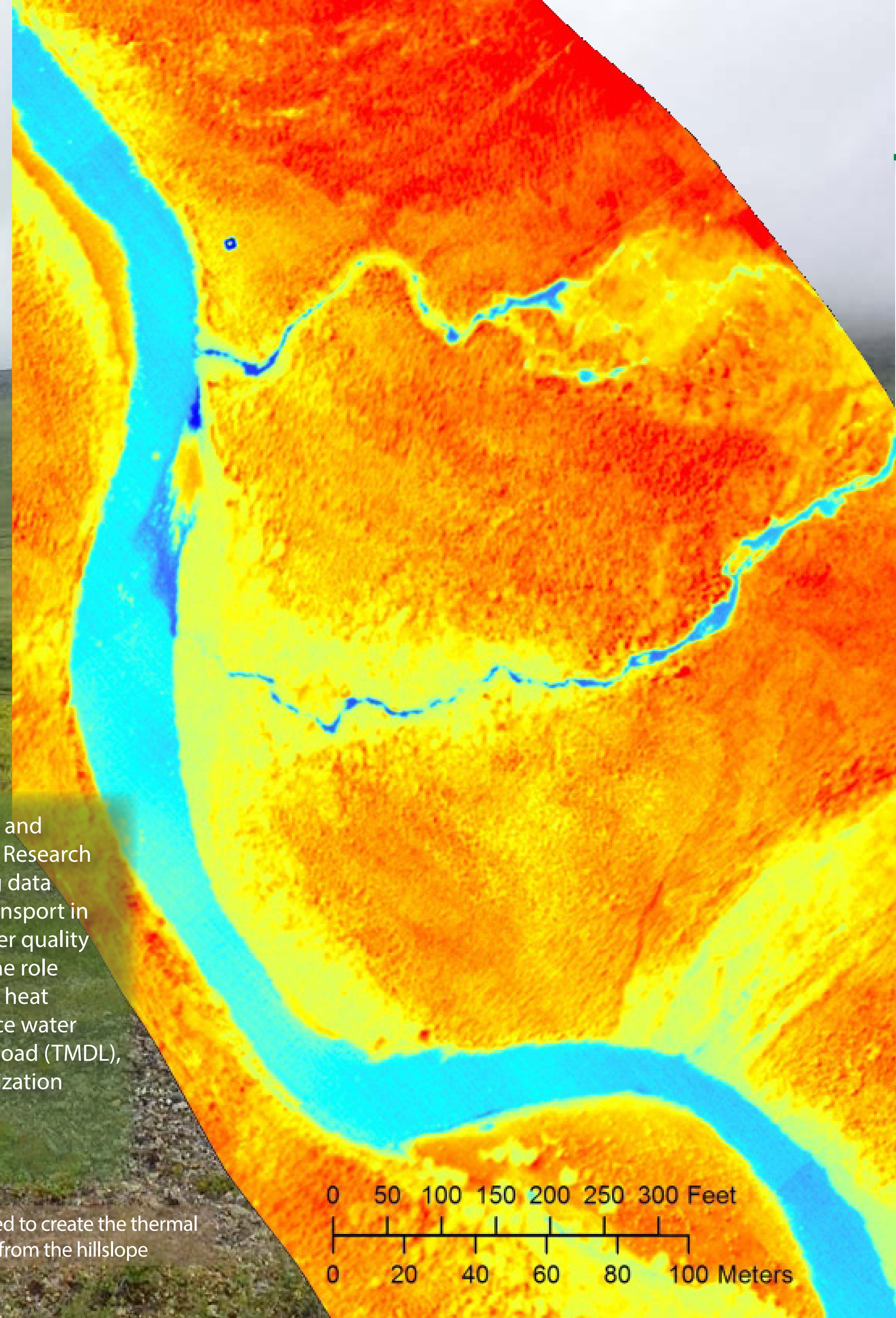
- The design methodology developed as part of this study is being increasingly integrated into standard practice.
- In 2012, the State of Utah designed an arced labyrinth weir for Millsite Reservoir based on this research.
- More than 60% of the presentations at the 2013 International Workshop on Labyrinth and Piano Key Weirs in Paris, France cited the work of Dr. Tullis and his students.
- The US Army Corps of Engineers commissioned the UWRL to construct and test a large physical scale model of the Isabella Lake dam spillway design based on the research published by Dr. Tullis and his students.

Looking to the Future

See USACE video and Bakersfield Californian newspaper story on the Isabella Lake Dam scale model project at the Utah Water Research Laboratory at:

http://www.youtube.com/watch?feature=playerdetailpage&v=wXTvvKkSxpo

Construction and testing of the new 3150-ft long, 30-ft tall arced labyrinth weir emergency spillway (1:45 scale) for Isabella Dam



Bethany Neilson is an Associate Professor in Civil and Environmental Engineering at USU and the Utah Water Research Laboratory. Her research expertise includes developing data collection strategies for quantifying solute and heat transport in streams and rivers; developing and testing surface water quality models based on detailed process data; determining the role of groundwater/surface water interactions in mass and heat transport in rivers and streams; data analysis and surface water quality modeling approaches for total maximum daily load (TMDL), wasteload allocation (WLA), and nutrient criteria development; and optimization procedures for parameter estimation in surface water quality models.
(bethany.neilson@usu.edu)

A site near the Kuparuk River in Alaska. AggieAir UAV multispectral imagery was used to create the thermal image overlay of the same location highlighting in dark blue the cold inflows from the hillslope

Quantifying Dominant Heat Fluxes in Arctic Streams

The Arctic is experiencing unprecedented environmental impacts as climate change influences the hydrologic cycle. Increasing air temperatures and changes in precipitation patterns have biological, ecological, and land stability implications. Shifts in vegetation due to climate change also have the potential to alter the surface energy balance and snowmelt patterns, leading to changes in the Arctic permafrost, which in turn affect stream flows and water quality.

A holistic understanding based on process specific data collection and modeling efforts is needed to increase the accuracy of predictions of climate change impacts.

Research

UWRL researcher Dr. Bethany Neilson is studying the linkages between Arctic landscape processes and the surface water response, particularly the influences of climate variability on instream temperature regimes. Dr. Neilson is quantifying individual heat fluxes in the higher order Kuparuk River and lower order Imnavait Creek. These data collection and modeling efforts are identifying heat fluxes at the reach and basin scale and comparing them to heat flux distributions found in temperate climate literature.

Results

The key heat fluxes in the Arctic are similar to those in temperate climates; however, the relative magnitude of the heat fluxes differ.

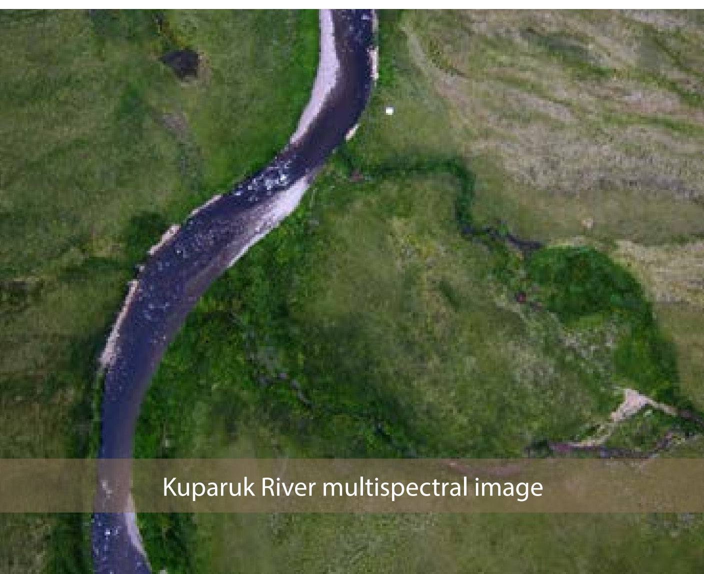
Initial study results indicate that:

- Quantification of lateral inflows from the hillslope is key to understanding surface water thermal regimes.
- Lower order river sections require a detailed spatial understanding of channel geometry.
- Higher order river sections require minimal information to predict relatively accurate instream temperatures.

Point measurements (temperature sensors) and spatially distributed measurements (longitudinal and sediment profiles, thermal imagery) have been collected to illustrate the significant spatial and temporal variability in even the simplest of streams.

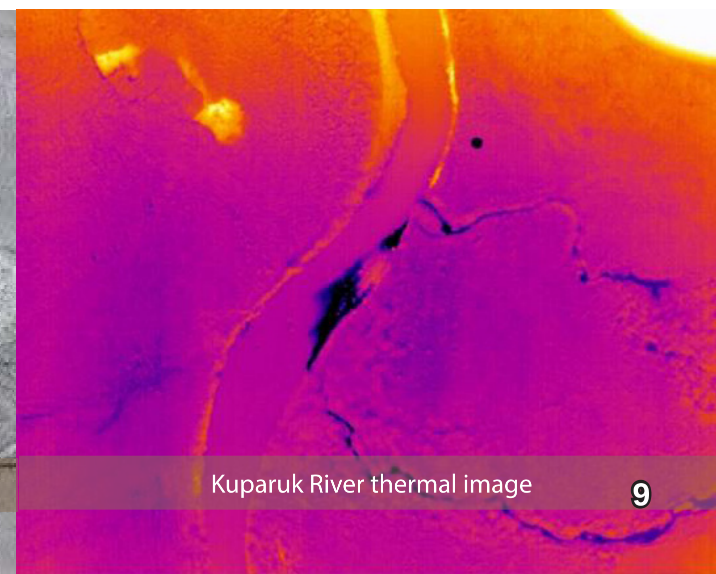
Looking to the Future

Data collected in the Kuparuk River in the summer of 2013 provided a preliminary understanding of processes controlling temperature regimes. The resulting process-based modeling tool and the associated predictive capabilities developed in this research will be applicable to any arctic area and can be integrated into other larger scale hydrologic modeling efforts. This effort is helping to determine how simultaneous changes in the identified sensitive variables will alter instream temperatures with anticipated changes in air temperature, weather patterns, and lateral inflows due to changing active layer thaw depths and hillslope hydrology.



Kuparuk River multispectral image

Kuparuk River near-infrared image



Kuparuk River thermal image

David E. Rosenberg is an Associate Professor in Civil and Environmental Engineering at USU and the Utah Water Research Laboratory. David's work uses systems analysis (optimization and simulation modeling and data management) for water and resources management, infrastructure expansions, demand management, and conservation at scales ranging from individual water users to regional systems. His work integrates engineering, economic, environmental, uncertainty, and when necessary, social and political considerations to plan, design, manage, operate, and re-operate water systems. Applications include optimization for environmental purposes, water conservation, computer support to facilitate conflict resolution, supply / demand modeling, and near optimal management for environmental and ecological purposes. He has worked in the Middle East, California, Maryland, and now Utah.
(david.rosenberg@usu.edu)

The paper published as a result of this research by Francisco J. Suero, Peter W. Mayer, and David E. Rosenberg received the Quentin Martin Best Practice Paper Award by the Journal of Water Resources Planning and Management for 2013.

Research Highlight

Estimating the Potential for Household Water Conservation

While urbanization and a growing population place ever increasing demands on scarce, limited municipal water supplies, residential water conservation can cost-effectively extend existing surface and groundwater supplies to accommodate rapid future population growth. Utah's arid climate makes water conservation an important part of drought planning strategies. The governor and state legislature recognize the importance of water conservation and have set ambitious targets to reduce average per-capita water use 25% by 2025.

Research

UWRL faculty member Dr. David Rosenberg recently collaborated on a research project to develop analytical, hybrid, and regression models to estimate the water saved when retrofitting indoor water appliances. These computer models identify the separate and combined effects of technological and behavioral factors and highlight ways US water utilities can target their efforts to households with the potential to save the most water.

Data from 96 single-family houses before and after each household was retrofitted with water efficient appliances were analyzed, including:

- Toilets.
- Showerheads.
- Clothes washers.
- Faucets.

The three different models addressed different aspects of the combined technological and behavioral factors involved in the use of each appliance.

Results

- The models all reasonably characterize distributions among households of water saved by retrofits.
- Ninety-six percent of the households saved water, showing that retrofits can be effective.
- Six homes had no water savings even after the retrofit.
- In some cases, households increased their water use after the retrofits as a consequence of behavioral changes that offset technological improvements.

Houses that saved more tended to have more residents, had less efficient appliances before the retrofit, and used appliances more frequently.

Looking to the Future

These tools can help utility companies improve conservation program effectiveness by targeting appliance retrofit programs to households with the highest potential to conserve water.

Further research is needed to identify behavioral indicators that utility companies can readily measure and reliably act upon to target these households.

Read more about this research here:

http://ascelibrary.org/doi/abs/10.1061/(ASCE)WR.1943-5452.0000182

In general, households reduced water use after they were retrofitted with new water-conserving appliances

This study used disaggregated end-use data for each water appliance

Flow rate most influenced the water saved by retrofitting faucets

Utah's UWRL

Park City, Utah

Park City is known for its ski resorts and for hosting the Sundance Film Festival. Lately, the city has also become known for its drinking water problems. Episodes of discolored water with high levels of arsenic, thallium, manganese, iron, and mercury have prompted city managers to seek ways to deal with these episodes and provide high quality water to their citizens.

UWRL researchers are working with the city and Confluence Engineering to assess the causes of these adverse water quality events and develop techniques to respond to changes in the water system.

Initial UWRL funding for this project has been leveraged into a $495,000 project sponsored by the Water Research Foundation (project lead, Confluence Engineering)

Shadow Lake, Salt Lake County, within the boundaries of Park City Mountain Resort

UTAH WATER RESEARCH

Research programs at the Utah Water Research Laboratory (UWRL) are recognized throughout the nation and around the world but also directly address Utah's current and future water resources needs in significant ways.

Education

The UWRL is involved in university graduate and undergraduate education through hands-on projects, part-time employment, and research assistantships. Most projects involve graduate students and result in masters or doctoral degrees. As these students are hired by Utah employers, they become the means of technology transfer from the UWRL to Utah's water and environmental organizations.

Research at the UWRL contributes to a growing knowledge base and often helps to define current professional practice. For example, the new Millsite Dam spillway currently up for renovation in Ferron, Utah, was designed using results from UWRL research on labyrinth weirs.

Current Millsite Dam spillway

— Benefiting Utah

Training

UWRL faculty members and researchers provide training for a wide spectrum of water professionals, including those involved in protecting public health and the environment. They are also involved in technology and information transfer and public and professional education and service.

UWRL faculty members serve as advisors and members of State organizations including the Utah Drinking Water Board, the Statewide Nutrient Criteria Development Core Advisory Team, and State of Utah Solid and Hazardous Waste Control Board, among others.

Collaborations

The UWRL collaborates and partners with engineers, scientists, and managers from the Utah Departments of Natural Resources and Environmental Quality; the twelve Utah local health departments; and several large water user districts and associations.

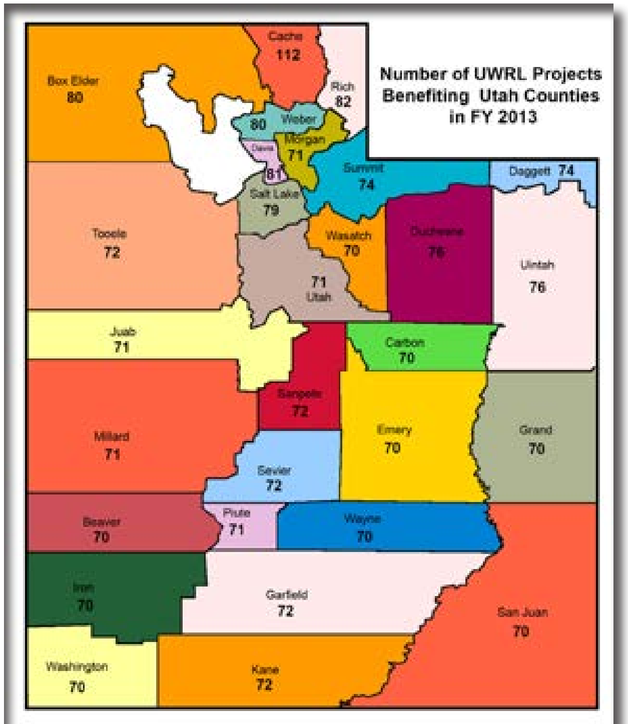
In one example, UWRL researchers are working with Park City and Confluence Engineering to assess the causes of adverse water quality events in the city's drinking water, develop techniques to respond to changes in the water system, and preserve a high-quality water supply for the the city's citizens and visitors (see inset, left).

Research

The UWRL's diverse research program benefits each of Utah's 29 counties (see map, right). Some projects involve interdisciplinary teams in collaboration with multiple agencies and the private sector, while others are relatively small.

One example is a project to assess and calibrate open channel and closed conduit flow measurement devices in the state for accuracy and provide direction for reducing any measurement errors. The flow measurement devices being calibrated include primarily weirs and Parshall flumes, as well as other types of in-pipe flow meters.

Improved accuracy of flow measurements throughout the State of Utah will ultimately improve the allocation of water rights. Small errors in flow measurement are known to add up to very large water volume errors over time. This multi-year project is generating a database of locations, measurement device types, accuracies, and specific problems that will assist the Utah Division of Water Rights in setting priorities for remediation, repair, or recalibration of flow measurement devices in the state.



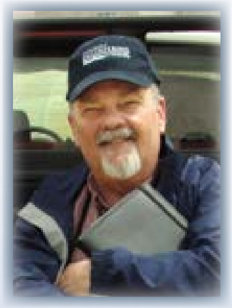

Foam swabs after passing through pipes in Park City, UT


Water samples from a cleaning trial in Park City, UT


The Crockett Avenue Parshall flume in Logan, UT

Outstanding Contributions

Governor's UAS Advisory Board Member



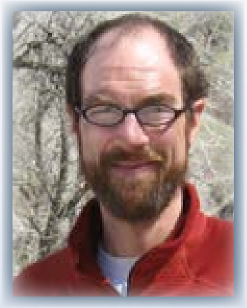
Mac McKee

UWRL Director Mac McKee has been appointed a member of the governor's Unmanned Aerial Systems (UAS) Test Site Advisory Board to represent higher education. The board also has members from a broad spectrum of agencies and industries in the state and seeks to support and foster development of UAS-related industries in Utah.

This burgeoning technology could represent a significant economic benefit in the state for a wide variety of public and private applications. Mac's experience in spearheading the development of AggieAir, a remote sensing unmanned aerial system for scientific applications, makes him a strong voice for helping to advance the industry in Utah.

http://aggieair.usu.edu

David Rosenberg TEDxUSU Presentation



David Rosenberg

UWRL faculty member and National Science Foundation CAREER award recipient Dr. David E. Rosenberg was a featured speaker at USU's TEDx event in November 2013. David's talk titled, "Near-Optimal to Survive and Thrive," describes the often unsatisfying nature of optimal solutions to many water management problems and how exploring near-optimal options can give water managers more flexibility to select solutions from among hundreds or thousands of very good strategies that address the political, social, and other factors of the problem at hand.

View Dr. Rosenberg's TEDx talk at:

https://rgs.usu.edu/tedxusu/htm/tedx-usu-2013/david-rosenberg/

AGU Outstanding Student Paper Award

Noah Schmadel

CEE Graduate student Noah Schmadel recently received AGU's Outstanding Student Paper Award for his research presentation at the 2013 AGU Fall Meeting in San Francisco, CA.

Noah's research titled, "The role of spatially variable stream hydraulics in reach scale, one-dimensional solute predictions," focused on using remotely sensed, high-resolution imagery to estimate hydraulic parameters for use in a transient storage model in order to better understand key transport processes.

Only the top 3-5% of student presenters in each focus area are presented with this award. Noah is the second student from the Utah Water Research Laboratory in the past two years to receive this honor.

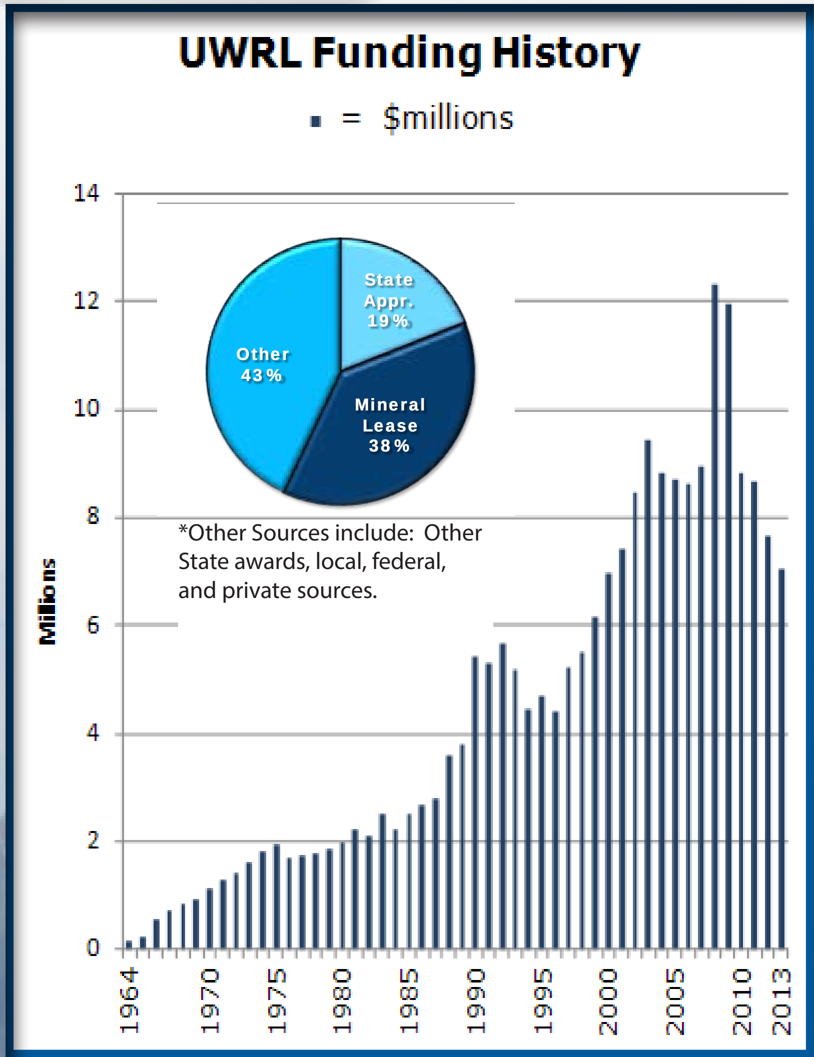
USU's AggieAir "Minion" in flight

David Rosenberg presenting at the TEDxUSU event in 2013

Installing monitoring equipment in a heavily managed stream

Financial / Academic Summary

Measures of academic research productivity continue to improve at the UWRL, even as research expenditures have suffered during the economic downturn. In FY 13 the number of scientific articles published by UWRL personnel remains high, more than triple the number of a decade ago. Both the number of active projects and the number of graduate assistants supported also remain at record levels. These accomplishments during difficult economic times reflect the hard work and commitment of UWRL faculty, students, and staff.



Products (FY 13)

Number of Active Projects	257
Dollar Value of Active Projects	$ 7,030,792
Scholarly Publications in Peer-Reviewed Journals	93
Scholarly Presentations at Professional Conferences	152

Outreach Products (FY 13)

Short Courses and Field Training	16

Academic Training Facilitated (FY 13)

Number of Graduate Research Assistantships Funded	72
Number of Undergraduate Students Supported	102

Degrees Granted (FY 13)

PhD	7
MS	30
ME	14

UtahStateUniversity

Utah Water Research Laboratory

8200 Old Main Hill, Logan, UT 84322-8200 • (435) 797-3155 • uwrl.receptionist@usu.edu • http://uwrl.usu.edu