THE AQUAHOMAN

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The newsletter of the
OKLAHOMA WATER RESOURCES CENTER

Inside this issue:

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Oklahoma Water Resources Center

From the Director's Desk (by Garey Fox)

Just last month Leslie Elmore and I had the pleasure of attending the National Institutes for Water Resources (NIWR) meeting in Washington, D.C.

I had the pleasure of presenting the unique student education and research opportunities offered by the Oklahoma Water Resources Center. I discussed this summer's Research Experience for Undergraduates (REU) on stream restoration and our Student Water Conference happening later this month (March 24-25). (More on page 5.)

This year's Student Conference includes a Water Career Fair in which representatives from agencies/companies share current or future job opportunities and **discuss their path to their current position** with the students. We would love to include more water entities. If you are interested in participating, contact us immediately.

The NIWR conference also offers an opportunity to visit our congressional delegation and staffers to discuss the importance of water research in Oklahoma. We update them on our recent and upcoming activities and newly selected USGS 104b grants through the Water Resources Research Act.

We appreciate our congressional delegation's support of the Water Center. They were very impressed that our grant program is aimed at explicitly addressing major water issues in Oklahoma.

In 2016, the major water issues are **irrigation and drought, water reuse, and produced water recycling.** For more on the 2016 projects, see page 4.

One major issue in Oklahoma remains produced water (see page 2). Governor Fallin recently created a Produced Water Working Group to examine recycling produced water. We applaud the group for including representation from our academic institutions!

Faculty affiliated with the Oklahoma Water Resources Center also recently developed a major grant proposal in collaboration with the University of Arkansas and Kansas State University aimed at examining the potential for recycling produced water and treated municipal wastewater as part of a new funding emphasis on the Food-Energy-Water Nexus. If funded, this core group of engineers, scientists, and sociologists will be able to carry out the research I expect will align with key recommendations from the Governor's Produced Water Working Group.

Salts, Seismicity, and the Search for a Solution

(by Chad Penn, Associate Professor and Soil and Environmental Chemist)

Oil and gas (O&G) production are critical to the economy of Oklahoma, and our region. In Oklahoma, employment in the O&G sector has more than doubled since 2001, now representing 5% of the state's work force. According to the Oklahoma Energy Resource Board (OERB), this industry accounted for 27.1 billion dollars in gross state product in 2013 and supported 15.5 billion dollars in earnings.

Much of this recent economic success has occurred due to new technologies such as horizontal drilling and hydro-fracturing, allowing O&G companies to extract greater volumes of oil and gas compared to previous decades. However, one consequence of O&G exploration is management and proper disposal of various waste products: drilling mud, produced water, and flow-back water—the latter two being most abundant.

Extremely high volumes of water, mixed with salts and compounds, are used during the hydro-fracturing process. Additionally, the hydro-fracturing process can release geologic water from deep below the normal drinking water aquifers. These deep geologic waters, known as "produced water", are essentially ancient oceans, and therefore can be extremely saline and sodic. When some of this produced water flows up to the surface with the original water used for hydro-fracturing, this is known as "flow-back".

Both flow-back and produced water must be disposed of safely and economically. While some of these waters are of sufficient quality to be used in stream and pond augmentation or irrigation, much of it is too salty. Because of the excessive salinity and volume of water in need of disposal, the most economical option for disposal has historically been deep-well injection.

Deep-well injection involves pumping the saline water into geologic formations that are located deep below drinking water aquifers. The process of deep-well injection is heavily regulated by the EPA to protect drinking water resources.

While this form of disposal has been successful for decades, **the combination of increased injection volumes, rates and depths are leading to increased seismic activity**. In 2015 Oklahoma experienced 904 earthquakes with magnitude 3 or greater, which according to the Oklahoma State Geological Survey Director and Seismologist, was due to a perfect storm of conditions and excessive deep-well injection into the Arbuckle.

The Oklahoma Corporation Commission (regulating body for the O&G industry) has reacted to this problem by limiting the depth and volume of deep-well injection into the Arbuckle; however, the problem still persists. While some have suggested solving the problem by moving the injection wells into formations other than the Arbuckle, this is impractical and would essentially cripple the O&G industry. No other formations have the ability to accept such large volumes of water. Therefore, alternatives to deep-well injection must be developed.

Because the greatest volumes of water in need of disposal tend to be extremely saline, disposal options are limited. Such water is not suitable for traditional irrigation. One acre of cropland could only handle about 45 barrels once every several years--a single well located in the Mississippian formation would require about 4 acres/day for disposal.

Others have proposed reusing the produced water for algal fuel production, hydro-fracturing, and cooling water. However, such secondary uses do not result in true disposal or elimination of the biggest contaminant of concern: salt. As a result, many sophisticated treatment technologies have been developed for removing salt from produced waters, resulting in water that can be used for drinking, irrigation, or stream augmentation. The problem with most of these technologies is that they require high amounts of energy and capital, often uneconomical for highly saline waters. Even if an energy-efficient technology was developed to remove the salt from the water, there still remains the need to dispose of the separated solid salt in a safe manner.

In order to eliminate the earthquakes, an economical alternative to deep-well injection must be developed. Ultimately, this means finding a use for enormous amounts of salt or salt water. The search continues for a solution to keep the ground below us *and* our economy stable.

Read the full article and find additional resources on our Energy Development page at http://water.okstate.edu/strengths/industry/energy-development.

BRACE FOR IMPACTS: Streamside Aquifers Blur the Boundaries between Groundwater and Surface Water

(by Joshua Cross, OWRC staff writer, and Leslie Elmore, Program Coordinator)

Surface water and groundwater are critical resources in Oklahoma and the surrounding southern Great Plains, especially in light of recent droughts. While these water resources are naturally connected, water policy does not always recognize the extent of this connection. Water agencies must understand the interconnection of these waters, especially as groundwater demand continues to increase in the southern Great Plains.

Since 1965, the Oklahoma Water Resources Center has provided seed money in the form of U.S. Geological Survey (USGS) 104(b) grants to help researchers address important water issues, such as the interaction between surface water and groundwater. In 2009, Dr. Garey Fox received one such USGS 104(b) grant to fund a project titled "Stream Depletion by Ground Water Pumping: An Improved Stream Depletion Factor for Oklahoma." Fox and his research team used this funding to study alluvial aquifers in central Oklahoma and provide more precise data on alluvial well depletion.

Alluvial aquifers are formed when sand or gravel ("alluvium") is deposited by rivers or streams. As these deposits build up over time, rainfall and water from the nearby waterbody continually seep into the pores between the sand and gravel, forming an underground storage area for water (i.e., an aquifer). Alluvial wells are drilled into these areas adjacent to streams. As these wells draw water from the aquifer, they can also remove water directly from the stream or limit water recharging the stream from the aquifer—a situation known as alluvial well depletion. The amount of stream depletion depends on how connected the stream is to the alluvial aquifer.

Oklahoma water law does not currently consider the effects of alluvial well depletion on streamflow, so Fox's team sought to develop a method to estimate alluvial well depletion. "In the last several years, research has improved hydrologists' capability to analyze interactions between streams and aquifers during alluvial well depletion," Fox said. "These improvements have come primarily through the development of mathematical solutions; however, they are complex."

To overcome this complexity, Fox's team developed a simple tool in Excel, called the Oklahoma Stream Depletion Factor (OSDF), which calculates the stream depletion due to an alluvial well based on the stream and aquifer properties. The team also worked with databases developed by the Oklahoma Water Resources Board to characterize the aquifers. The research team set up field sites with alluvial groundwater wells next to the North Canadian and Washita Rivers, two of Oklahoma's major alluvial river systems, and monitored groundwater levels between the well and rivers during pumping.

"The Oklahoma Stream Depletion Factor worksheet has been requested and used worldwide by universities, consulting firms, and government agencies," Fox said. "While tested using field data collected in Oklahoma, this worksheet has been used by water agencies in Missouri, Montana, Minnesota, Washington, New Hampshire, and even as far away as Scotland."

In addition to the OSDF worksheet, the researchers published a peer-reviewed paper from this important research of stream-aquifer interactions. This publication highlights how to use the OSDF and conduct stream-aquifer analysis tests.

This USGS 104(b) grant also advanced the careers of the Oklahoma State University research team: an undergraduate research assistant went on to obtain an advanced degree in engineering, while Dr. Derek Heeren, the Ph.D. student who headed up the project, is now a professor at the University of Nebraska-Lincoln.

It is critically important that the state of Oklahoma have the best available science to support sound policy. This and other studies funded by the Oklahoma Water Resources Center have provided science for the past 50 years.

To learn more about alluvial well depletion and to access the OSDF worksheet, please visit Dr. Fox's site on Stream Aquifer Interactions. More information about USGS 104(b) grant projects is on the Oklahoma Water Resources Center's website, http://water.okstate.edu/funded-projects.

Recipients Selected for the 2016 Oklahoma Competitive Research Grants

Our Water Research Advisory Board met January 7th. Following proposal presentations, Board representatives selected three projects that best suited the state's needs for 2016 funding through the 104(b) Oklahoma Competitive Research Grants Program.

Algal Remediation of Waste Water Produced during Hydraulic Fracturing

(Nurhan Dunford)

Microalgae are ubiquitous photosynthetic microorganisms that are found both in marine and freshwater environments with a great potential to produce not only biomass as feedstock for renewable fuels, high-value natural products, food, and feed applications but also to provide a valid solution to the problem of environmental pollution. In particular, they are able to grow using different nutrients (mainly N and P), heavy metals and other contaminants from different wastewaters such as agricultural and animal, municipal, as well as industrial. In addition, they can thrive using the CO2 emitted for instance by coal fired power plants thereby reducing greenhouse gas level in the atmosphere.

Western Oklahoma Irrigation Water and Energy Audits: Findings, Recommendations and Educational Materials

Scott Frazier, Saleh Taghvaeian, Jason Warren, Don Sternitzke, Cameron Murley)

Western Oklahoma is a semi-arid region that is very susceptible to drought and utilizes considerable amounts of irrigation water. Most of this irrigation is pumped ground water. Some of the irrigation is also shallow well or surface water. With water resources being consumed at higher rates for agricultural irrigation, farmers need to be as efficient as possible with the extraction and application of this resource. With increasing competition between rural and urban water needs, it will be necessary to document how well agricultural systems are utilizing water resources in order to maintain access.

Evaluating the Reuse of Swine Lagoon Effluent and Recycled Municipal Water for Agricultural Production

(Hailin Zhang, Doug Hamilton, Saleh Taghvaeian, Scott Carter)

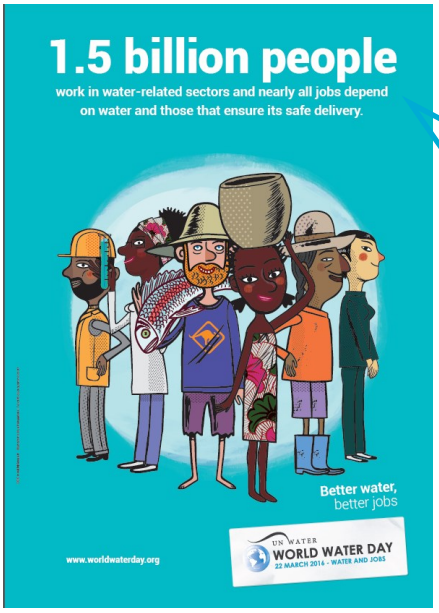
Significant amount of water in Oklahoma is used for crop irrigation. Water shortage in Oklahoma and the Southern Great Plains has become a major limitation for crop production and other uses, which will have a major impact on local economy. Therefore, alternative sources of irrigation water need to be explored. Treated municipal wastewater (TWW) is one of the most readily available alternative water sources, although infrastructures to use TWW for crop irrigation are lacking in most places and public acceptance is probably low because of the lack of field evaluations in the state. Currently, most TWW in the state is directly discharged to streams and rivers rather than recycled for crop production.

Student Section:

2016 OkState Water Week

The Oklahoma Water Resources Center hosts Ok-State Water Week March 21-26 on the campus of Oklahoma State University in Stillwater. The event follows the United Nations World Water Day on March 22nd themed "Water and Jobs."

See the **full line-up** at http://water.okstate.edu/activities/okstate-water-week.



1.5 billion people work in water-related sectors and nearly all jobs depend on water and those that ensure its safe delivery.

Job openings are listed on page 8.

Visit our Job Board at water. okstate.edu for the most current listings.

This year *Dr. Ty Ferre* will present the **Buchanan Lecture**. Dr. Ferre is the 2016 Darcy Lecturer and University of Arizona professor March 24th at 4 PM in French Lounge of Student Union. His talk will address improving our ability to make decisions about water under uncertain conditions. It will examine the role of science, through data collection and model development, in informing personal, economic, and policy decisions about water as a shared resource.

NSF-REU selections will be announced soon!

We are hosting our second NSF-REU (Research Experiences for Undergraduates) on Stream Restoration/Rehabilitation this summer in Stillwater, Oklahoma.

We had amazing interest: 107 applicants for 7 positions! The selection process of these motivated and qualified students will not be easy.

Faculty Spotlight: Saleh Taghvaeian

(by Saleh Taghvaeian, Biosystems and Agricultural Engineering Assistant Professor and Extension Specialist)

Dr. Saleh Taghvaeian

My research and extension activities are focused on improving irrigation sustainability and agricultural water management. The major threats to sustainability of irrigated agriculture in Oklahoma, which covers over half a million acres mainly in the western half of the state, are the decline of groundwater resources in the Panhandle, soil health degradation due to the high salinity of irrigation water in parts of southwest, and the occurrence of prolonged and severe droughts that can impact the entire state and region.

Since joining OSU in 2013 I have been involved in several main projects attempting to address these threats. Examples include the energy/water efficiency audit for sprinkler irrigation systems in the Panhandle, salt buildup simulation for subsurface drip irrigation systems in the southwest region, and setting up demonstration sites for improving irrigation scheduling in multiple locations across the state. I also collaborated with other OSU researchers and extension educators to initiate an annual Oklahoma Irrigation Conference to serve as a one-stop shop for any producer, crop consultant, state agency personnel, or policy maker wanting to learn more about aspects of irrigation.

Before joining OSU I was a postdoctoral fellow at Colorado State University, where I contributed to several research projects on deficit irrigation of corn and sunflower in east and southeast Colorado. I received my PhD in Irrigation Engineering from Utah State University and I have also worked on studying agricultural water balance and irrigation efficiency in southern California.

I love reading and hiking, but my number one hobby is traveling to new places. What I like most about traveling is the opportunity to experience new foods, cultures, and landscapes.

Oklahoma Irrigation Conference set for March 8 in Woodward

(Donald Stotts, Agricultural Communications Services)

Southern Plains agricultural producers looking to get the most out of their water-use investment should register now to attend the March 8 Oklahoma Irrigation Conference in Woodward.

The conference will take place from 9:45 a.m. to approximately 4:30 p.m. at the Woodward County Event Center and Fairgrounds, located at 105A Temple Houston Drive, south of State Highway 412 between 1st Street and Lakeview Drive.

"Registration is $15 per participant," Taghvaeian said. "We ask participants to pre-register **no later than March 1.** This greatly aids our planning and helps ensure we have sufficient lunches, refreshments and session materials on hand." Registration forms are available online at http://oces.okstate.edu/woodward/oklahoma-irrigation-conference and through all OSU Cooperative Extension county offices.

Conference sessions will include an irrigation water quality assessment, two presentations on different aspects of subsurface drip irrigation, maximizing the long-term value of groundwater resources, future challenges of increased irrigation production, plant water use and evapotranspiration, energy and water efficiency for center-pivot systems and sensors for irrigation management, among others.

[The full news release is available at water.okstate.edu.]

OSU Professor Awarded USDA Grant to Improve Oklahoma Agricultural Water Management

(by Joshua Cross, OWRC staff writer)

Recently, Dr. Saleh Taghvaeian, Assistant Professor of Biosystems and Agricultural Engineering at Oklahoma State University and State Extension Specialist in Water Resources, and his colleagues received a US Department of Agriculture Conservation Innovation Grant (CIG) for $772,029.that will improve conservation of land and water resources across Oklahoma and neighboring states.

Taghvaeian's project, titled "Promoting Sensor-Based Technology to Improve Land and Water Resources Conservation," aims to improve irrigation scheduling and agricultural water management, especially in regards to sensor-based technologies for water conservation. Dr. Taghvaeian is working with collaborators from Texas and Kansas on the project.

The CIG funding will help "create and disseminate educational material on different types of sensors for agricultural irrigation management through the network of county extension educators, conservation district personnel, NRCS personnel, crop consultants and producers," Taghvaeian said. These education materials will include fact sheets, video clips, podcasts, and other media.

The project also aims "to establish demonstration sites at several eligible producers' farms and hold field days to provide hands-on training for different aspects of sensor-based technologies – from site selection to proper installation and data interpretation."

This year, the USDA awarded $20.5 million in CIG to 45 projects aimed at advancing and developing natural resource conservation. "Forty-five projects were chosen out of about 400 submitted proposals," Taghvaeian said. "Our project was the only one funded under the Water Quantity category."

In addition to the CIG funds from the USDA's Natural Resources Conservation Service, Taghvaeian has also received a $104,000 grant from USDA Agricultural Research Service to conduct research in a similar field. These two external grants carry immense value for conducting research and extension activities, especially at a time when the state budget is declining.

A key factor in receiving the awards has been the seed grants from Cotton Inc. and the Oklahoma Water Resources Center (funding from OSU's Division of Agricultural Sciences and Natural Resources). "Smaller grants helped build the foundation to get these USDA grants," Taghvaeian said. The grant from the Water Resources Center provided the opportunity to hire a graduate research assistant and purchase sensors to study the effectiveness of sensor-based technologies for improving irrigation management in southwest Oklahoma. This was of great importance because some growers in that region only have access to low-quality (saline) water. Thus, **improving irrigation has a direct positive impact on both water conservation and soil health and quality**. "The Water Resources Center and DASNR administration recognize the increasing pressure on our fresh water resources and strongly support efforts towards adopting advanced technologies" Taghvaeian said.

The grant from Cotton Inc. (CI) State Support Program was also instrumental in providing funds to purchase additional sensors and for frequent travel to demonstration sites, developed in collaboration with cotton growers from Hydro, Martha, and Altus. "This funding was given to us at a time when financial resources of CI State Support Program have declined significantly due to severe drought in western Oklahoma over the last few years," Taghvaeian said. "Yet, CI board members valued the importance of conducting these projects and generously provided us with requested funding."

The research conducted with this initial funding led to the USDA grants that will help Taghvaeian and colleagues to improve Oklahoma's land and water resource conservation. "The CIG grants are very competitive," Taghvaeian said. "The funding we received from these initial seed grants helped to strengthen our proposal."

For more information on this project and additional funding opportunities, please see our website, http://water.okstate.edu.

New & Noteworthy

Funding (water.okstate.edu/faculty/funding)

- **DoE Regional and Global Climate Modeling and Integrated Assessment Research:** (pre-application due 3/7/16; full application due 4/18/16)
- **NSF/USDA: Innovations at the Nexus of Food, Energy and Water Systems** (due 3/22/2015)

Employment (http://water.okstate.edu/job-board)

- Two internships for OCC Water Quality stream (Bristow) and wetland (Oklahoma City) monitoring crews.
- NEW!! Two Wisconsin Water Fellowships (applications due March 11, 2016)
- Education Model Program on Water-Energy Research: graduate training program (open now)
- **Assistant Professor** in groundwater hydrology (UC, Riverside; open thru June 30, 2016)

Events (water.okstate.edu)

- **2016 No-Till Oklahoma Conference** (Norman, OK; 3/1-2)
- **Seminar**: Fluid Induced Earthquake Insights (OSU, Geology Room 106; 3/4 @ 4pm)
- **Great Plains LID Research and Innovation Symposium** (Omaha, NE; 3/7-9/2016)
- **Oklahoma Irrigation Conference** (3/8; Woodward County Event Center and Fairgrounds)
- **Great Plains LCC Science Webinar**: Groundwater pumping ... Great Plains fishes (3/9 @ 3pm)
- **Oklahoma Research Day** (3/11/2016; NE State Univ. Event Center. Abstracts due 1/29; register by 2/10)
- **OSU Water Week** (Stillwater, OK; 3/24-26)
- **OK Clean Lakes and Watershed Association Conference** (Stillwater, OK; 3/29-30/2016)

**Correction: Joshua Cross was the author of last issue's* Using Cosmic Rays to Measure Soil Moisture, *not Jonathan Anthony.*

WWWeb Updates

- ◊ New video playlists for Extension Demonstrations & Services and Water Education Resources are on our new Extension & Extension video page.
- ◊ New irrigation efficiency, flooded wells, and educational videos are in our library.
- ◊ Be the first to know about the latest additions! Subscribe to the RSS feed or connect with us on social media.

Connect

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