### Tuesday, February 23

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<th>Time</th>
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<tr>
<td>8:30-12:00</td>
<td>Crystal B</td>
<td>Underground Injection Control Training</td>
<td>Abstract 1&lt;br&gt;Injection Well Cementing Practices&lt;br&gt;Instructor – Talib Syed</td>
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<td>12:00-1:30</td>
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<td>LUNCH ON YOUR OWN</td>
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<td>1:30-5:00</td>
<td>Crystal C</td>
<td>Underground Injection Control Training</td>
<td>Abstract 2&lt;br&gt;Class II Disposal Well&lt;br&gt;Best Management Practices&lt;br&gt;Instructor – Tom Tomastik, ALL Consulting</td>
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<td>5:15-7:30</td>
<td>Crestone Ballroom</td>
<td>The 21st Annual GWPC UIC Conference Reception</td>
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## The 21st Annual GWPC UIC Conference: Aquifer Management & Underground Injection

**Matt Lepore** - Colorado Oil & Gas Conservation Commission  
Overview of UIC and Oil & Natural Gas Program in Colorado  
-- Bios listed in Abstract 50  
Crystal Ballroom B,C

### Beneficial Use of Produced Water from the Oil and Natural Gas Industry

**John Veil**, Veil Environmental  
-- Bios listed in Abstract 50  
Crystal Ballroom B,C

## Break

### Stakeholder panel and open discussion: Water Associated with Oil & Gas Development and Long Term Water Sustainability Strategies

**Moderator:** **Mike Paque**, Ground Water Protection Council  
Panel: State, Federal, Industry, Environmental and Local Perspectives  
- **Peter Grevatt**, Director, USEPA Office of Groundwater and Drinking Water  
- **Holly Pearen**, Sr. Attorney, Environmental Defense Fund  
- **Ben Binder**, President, Digital Design Group (Colorado Citizen)  
- **Q&A**  
- **Michael Teague**, Secretary of Energy and Environment at the Oklahoma Office of Energy & Environment  
- **Jill Cooper**, HSE Manager Reporting & Advocacy, Anadarko Petroleum Corporation and Chair, Energy Water Initiative  
- **Mike Hightower**, Distinguished Member of Technical Staff, Sandia National Laboratory  
- **Q&A**  
**Special thanks to** **Linda Capuano**, Fellow in Energy Technology at the Baker Institute Center for Energy Studies  
Crystal Ballroom B,C

## GWPC UIC Conference Luncheon: Aquifer Management & Underground Injection

**Leslie Savage** – GWPC President & Railroad Commission of Texas  
Charge to Participants: Produced water is available in large volume, often in some of the most arid parts of the United States. It represents a valuable water resource. With suitable treatment, some produced water may be beneficially reused to support various end uses. At this conference we will further identify some of the current limitations, and discuss case examples that will lead decision makers to consider the best water management decisions within each unique situation. Also, with the understanding of the current limitations, begin to narrow down the most achievable changes that could potentially result in a significant opportunity to use more produced water for beneficial purposes.  
-- Bios listed in Abstract 50  
Crestone Ballroom

**Keynote Address:** **Peter Grevatt** - Director USEPA Office of Groundwater & Drinking Water
### Potential Concerns Associated with Management and Reuse of Oil & Natural Gas Produced Water

**Facilitator:** John Veil, Veil Environmental  
*In this session, we will discuss potential risks and opportunities associated with reuse of produced water as well as policy, regulatory and operational enhancements in play or to be considered.*

**Abstract 5:** New API Industry Standards for Shale Development – Roland Goodman, American Petroleum Institute  
**Abstract 42:** Treating Produced Water for Beneficial Use – Current Challenges and Potential Future Advances - Rick C. McCurdy, Chesapeake Energy  
**Abstract 7:** Flowback Operations Innovation – Reducing EHS Risk through Design and Planning - David Stewart, Bonanza Creek Energy Inc.  
**Abstract 48:** Opportunities and Challenges for Beneficial Use of Produced Water - Erik Anglund, Anadarko Petroleum Corporation

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### Examples of Beneficial Use of Oil & Natural Gas Produced Water

**Facilitator:** John Veil, Veil Environmental  

**Abstract 32:** Devon Energy’s 2015 Delaware Basin Water Management Program – Jeff Sawyer and Ken Nichols, Devon Energy  
**Abstract 33:** Agricultural Reuse of Treated Produced Water – Katie Lewis, Texas A&M AgriLife Research  
**Abstract 34:** Irrigation with Produced Water in Texas – Beneficial Use Case Study – Lloyd H. Hetrick, Newfield Exploration Company  
**Abstract 43:** Treatment of Hydraulic Fracturing Wastewaters through a Hybrid Coagulation-Nanoporous Membrane Filtration-Biological Treatment Process - Richard D. Noble, James Rosenblum, Sarah Dischinger, Douglas Gin, Karl Linden, U. of Colorado  
**Abstract 37:** Water Exchange for the Energy Ecosystem - Domenic Corso, Sourcewater

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### Class V UIC Well Session

**Moderator:** Marty Link, Nebraska DEQ  

**Abstract 23:** Class I Injection Wells: Technological Opportunities for Improved Performance – Robert G. Maliva and Wm. Scott Manahan, Schlumberger Water Services  
**Abstract 35:** Recent Legislative Changes Affecting the Texas Class V Injection Well Program – Don Redmond, Texas Commission on Environmental Quality, Environmental Law Division  
**Abstract 40:** Water Treatment and Car Washes - Craig Boomgaard, USEPA Region 8  
**Abstract 39:** Rethinking Class V Wells: Improving Efficiency and Effectiveness - Candace C. Cady, and Brianna Ariotti, Utah Department of Environmental Quality  
**Abstract 47:** Well-Specific Class V Data: 200,000 Wells and Counting - Keara Moore, USEPA OGWDW

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### Aquifer Storage and Recovery

**Moderator:** Marty Link, Nebraska DEQ  

**Abstract 19:** Aquifer Storage and Recovery: A Management Tool for Upstream Operators - Lindsay Atkinson, CH2M Hill  
**Abstract 41:** Aquifer Storage and Recovery in Region 8 - Craig Boomgaard, USEPA Region 8

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### Class V UIC Open Forum

Facilitators: Lorrie Council, TCEQ and Candace Cady, UT UIC  
**Abstract 49:** Agenda

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**Frac Focus**

*Chemical Disclosure Registry*

*Find A Well Near You!*  
www.fracfocus.org
**Thursday, February 25**

**Induced Seismicity by Underground Injection**

Moderator: **Rex Buchanan**, Kansas Geological Survey

**Abstract 36**: Variations of Seismicity Parameters in Oklahoma and Their Spatial-temporal Correlation with M>4 Earthquake Occurrences - **Robin K. McGuire** and Arash Zandieh - Engineers with Lettis Consultants International


**Abstract 22**: Rapid Response, Monitoring, and Mitigation of Induced Seismicity Near Greeley, Colorado - **Jenny Nakai**, Department of Geological Sciences, University of Colorado Boulder and Cooperative Institute for Research in Environmental Sciences

**Abstract 30**: Injection-Induced Seismicity in Central Utah - **Megan R. M. Brown**, University of Colorado and Mian Liu, University of Missouri

**Abstract 18**: Regulatory Actions to Reduce Risks from Wastewater Injection Induced Seismicity - **Kathryn Mutz**, Glaser, University of Colorado

**Abstract 17**: Regulatory Considerations for Evaluating the Potential for Induced Seismicity of a Class I Non-Hazardous Waste Disposal Well - **Chad Milligan**


**Abstract 24**: A Proactive Approach to Addressing Annular Pressure Issues and Stray Gas Migration in the Unconventional Shale Plays - **J. Daniel Arthur**, **Tom Tomastik**, Kris Anderson, and Will Green, ALL Consulting

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**Oil and Natural Gas Environmental Initiative**

8:00-10:20

Moderator: **Stuart Ellsworth**, CO DNR


**Abstract 31**: Water-use Requirements Associated with Hydraulic Fracturing within the Williston Basin – **Kyle Blasch**, USGS Idaho Water Science Center and **Joanna Thamke**, USGS Wyoming-Montana Water Science Center

**Abstract 12**: Advancing Technology in Well Completions and Stimulations - **Megan Starr-Powell**, Anadarko Petroleum Corporation

**Abstract 10**: Sources of Variability in Dissolved Methane Concentrations at Residential Water Wells - **Stephen D. Richardson**, GSI Environmental, Inc.

**Abstract 13**: The Occurrence of Surface Casing Pressure in the Denver-Julesburg Basin and Implications for Stray Gas Migration - **Greg Lackey**, Harihar Rajaram, Owen A. Sherwood, Troy L. Burke and Joseph N. Ryan, University of Colorado

**Abstract 24**: A Proactive Approach to Addressing Annular Pressure Issues and Stray Gas Migration in the Unconventional Shale Plays - **J. Daniel Arthur**, **Tom Tomastik**, Kris Anderson, and Will Green, ALL Consulting

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**Class I UIC Well Session**

10:40-12:40

Moderator: **Bob VanVoorhees**, Underground Injection Technology Council

**Abstract 9**: Everything You Always Wanted to Know About Class I Injection Wells in Texas - **Lorrie Council**, Texas Commission on Environmental Quality and Shelly Bergel, Mickey Leland Environmental Internship


**Abstract 16**: Application and Analysis of Step-Rate Testing to Determine Fracture Pressure in Injection Wells - **Lewis Wandke** and Ken Cooper, Petrotek Engineering Corporation

**Abstract 6**: Innovative Methods in Nutrient Reduction by Use of Deep Well Injection, Virginia Key, Miami-Dade County, Florida - **Virginia Walsh**, and **Edward Rectenwald** Miami-Dade Water and Sewer Department


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**Class I UIC Open Forum**

Facilitator: **Lindsay Talianferro**, Ohio EPA

**Abstract 46**: Agenda
80 min.

Lunch on your own

2:00-3:40

**Oil and Natural Gas Environmental Initiative**

Moderator: **Mark Watson**, Wyoming Oil & Gas Conservation Commission

*Abstract 14*: Occurrence of BTEX from Oil- and Gas-Related Incidents in Groundwater above the Denver-Julesburg Basin - **Katherine J. Armstrong**, University of Colorado


*Abstract 20*: An Assessment of the Risk of Migration of Fracturing Fluids or Hydrocarbons into Fresh Water Aquifers in Colorado - **William Fleckenstein**, A.W. Eustes; C.H. Stone; P. Howell, CO School of Mines

*Abstract 21*: Prioritizing Well Inspections in Colorado: A Risk-Based Approach - **Chris Eisinger**, GSI, and Ken Robertson, & Mike Leonard, Colorado Oil & Gas Conservation Commission

*Abstract 28*: A Look at Underground Natural Gas Storage Operation and Regulation in the United States - **Nathan Alleman**, Regulatory Specialist; J. Daniel Arthur, P.E., SPEC, President; Thomas E. Tomastik, Geologist; and Kris Andersen, Senior Environmental Manager; ALL Consulting

Class III UIC Well Session

Moderator: **Dale Kohler**, TCEQ

*Abstract 26*: Comparison of Pre-Mining and Post-Mining Groundwater Quality at Texas *In Situ* Uranium Mining Sites - **David Murry**, TCEQ

*Abstract 29*: ISR Project Vicinity Well Sampling in Response to EPA’s Proposed Amendment to the 40CFR192 Rule – **Mark S. Pelizza**, Pelizza & Associates

Class III UIC Open Forum

Abstract 45: Agenda

20 min.

Break

Class II UIC Open Forum

Abstract 44: **Mark Bohrer**, North Dakota Industrial Commission, Moderator

4:00-5:00

Rosen Shingle Creek Hotel
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Injection Well Cementing Practices
Instructor – Talib Syed

Designing and obtaining a good primary cement job is a critical phase in well construction and maintaining the integrity of a well throughout its life cycle. Ensuring zonal isolation and the integrity of the cement sheath are also critical components in casing and cement design. This workshop will cover the fundamentals of cementing practices and a state of the art review of cement evaluation techniques – including cement bond logs such as CBL/USIT/CAST-V/SBT/Isolation Scanner etc. Types of wells will include oil and gas production and injection/disposal wells and shale, HPHT wells.

TOPICS TO INCLUDE:
- Wellbore Integrity – Barrier Elements and Philosophy
  - Cement as Hydrostatic Barrier/Cement Wellbore Barriers
  - Annular Casing Pressure – SCP (API RP-90)
- Cementing Fundamentals
  - Casing Accessories
- Cementing Failures
  - Execution
  - Incomplete Mud Removal
  - Flow After Placement
  - Inappropriate Design
- Squeeze/Remedial Cementing Methods
- Evaluation of Cement Job/Quality/Bond Logs
  - Indirect Methods
  - Cement Bond Log – Variable Density Log
  - Current CBL Techniques/USIT/CAST-V/SBT/Isolation Scanner
  - Zonal Isolation, TOC and Casing Shoe Isolation
- Horizontal Shale Cementing Best Practices
- Cementing challenges in deep water/HPHT reservoirs
- Summary and Wrap-up – Q&As

Talib Syed, P.E. holds a B-Tech (Chemical Engineering – Univ. of Madras, India) and an M.S. in Petroleum Engineering (Univ. of Oklahoma) and is a Registered Professional Petroleum Engineer in CO and WY and a member of SPE (since 1977). He has more than 38 years of domestic and international experience in oil and gas production operations (both offshore and onshore) and in well integrity projects in some of the largest oilfields in the world (Saudi Arabia – Ghawar/Safaniya and Alaskan North Slope). His current areas of interest include well integrity projects including in HPHT reservoirs, underground injection/disposal, CO2 – EOR and CO2-GS, slurry fracture injection, and hydraulic fracturing of tight oil and gas reservoirs (drilling and completion).

Class II Disposal Well Best Management Practices Workshop
Instructor – Tom Tomastik, ALL Consulting

This course will focus on understanding all aspects of Class II injection well disposal and address the challenges facing not only the Class II injection well industry, but the oil and gas industry as a whole. Class II saltwater disposal wells are an essential component of unconventional oil and gas development in the United States. For the last several years, public attention has been focused on hydraulic fracturing, but now that attention has focused on Class II injection wells as issues such as ground water protection, potential injection-related induced seismicity, waste water radioactivity, and truck traffic have become more publicized. The Underground Injection Control Program is well regulated, but the use of best management practices (BMPs) can help to
reduce public and media concerns and ensure protection of underground sources of drinking water. This workshop will address BMPs related to a number of issues, including:

**TOPICS TO INCLUDE:**

- History of the Class II Program
- Well Siting Considerations – Leasing, Mineral Rights Issues, Geologic Evaluation, Transportation Options and Site Access
- Area of Review, ZEI, and Corrective Action
- Well Construction and Facility Design – “Best in Class”
- Well Drilling and Completion Practices – Cementing, Completion Methods, and Stimulation
- Injection Well Testing Requirements
- Operational Considerations – Environmental Compliance, Formation Damage, SPCC, Emergency Response Plans, Spill and Clean-up Remediation, Routine and Preventative Maintenance, Chemical Treatment and Filtering of Injectate
- Well Integrity and Well Workovers
- Financial Assurance
- Risk Considerations - Induced Seismicity and Seismic Monitoring, Accidents and Litigation, Public Opposition and Environmental Activism
- NORM/TENORM Issues – Solid Waste Disposal
- Well Closure – Plugging and Abandonment
- Questions and Answers
- Summary and Wrap-Up

This workshop is intended to be a comprehensive review of all key aspects of Class II disposal wells and to provide the attendees with a strong and clear understanding of Class II disposal wells and their role in the development of our oil and natural gas resources.

**Tom Tomastik** received his BS and MS degrees in geology from Ohio University in 1979 and 1981. From 1982 to 1988, Mr. Tomastik was employed as a consulting geologist involved in oil and gas exploration and development in southeastern Ohio. From December of 1988 until August of 2014, Tom was employed by the Ohio Department of Natural Resources, Division of Oil and Gas Resources Management, UIC Section. Tom retired from the Division in August of 2014. He was responsible for all of the Underground Injection Control (UIC) duties, which include performing independent reviews of applications for Class II saltwater injection, secondary and enhanced recovery projects, and Class III salt-solution mining wells in Ohio. Tom also planned and implemented highly complex groundwater conflict investigations involving oil and gas investigations. He provided technical expertise to the general public, oil and gas industry, governmental agencies and officials regarding Federal and State regulations, oil and gas and injection well construction, well operations, and groundwater contamination and stray gas investigations. He has authored or co-authored articles on various aspects of Ohio’s oil and gas industry, groundwater investigations, injection wells, solution mining, and geology. Tom is currently employed as a Senior Geologist and Regulatory Specialist with ALL Consulting of Tulsa, Oklahoma and is involved in injection well evaluation, permitting, and oversight, stray gas investigations, groundwater complaint investigations, water sourcing, induced seismicity and seismicity monitoring.

**Abstract 3**

**Guidance in Mitigating Risks of Induced Seismic Events**

Overview of the State’s First document “Potential Injection-Induced Seismicity Associate with Oil & Gas Development: A primer on technical & regulatory considerations informing risk management & mitigation.

- **Rick Simmers**, Chief, Division of Oil & Gas Resources Management Ohio Department of Natural Resources
- **Rex Buchanan**, Interim Director, Kansas Geological Survey
- **Ivan Wong**, Principal Seismologist, AECOM
Thirteen states partnered through a multi-state initiative called StatesFirst this past year to share and summarize current knowledge related to earthquakes potentially caused by human activity, otherwise referred to as induced seismicity.

Recently the work group comprised of members of state oil and natural gas and geological agencies and other advisory experts from academia, industry, non-profit organizations and federal agencies released a Primer to provide a guide for regulatory agencies to evaluate and develop strategies to mitigate and manage risks of injection induced seismicity. The Primer also outlines how states can best provide information to the public in a transparent and effective manner.

Induced seismicity is a complex issue where the base of knowledge is changing rapidly. State regulatory agencies that deal with potential injection induced seismicity should be prepared to use tools, knowledge, and expertise, many of which are offered in this Primer, to prepare for and respond to potential occurrences of induced seismicity.

The primer primarily focuses on potential induced seismicity associated with Class II disposal wells. Injection wells are currently regulated under the Safe Drinking Water Act through the Underground Injection Control Program (UIC). The UIC program through primacy delegation by the U.S. EPA, is administered by certain states due to their in-depth knowledge of local industry operations and geology.

In its assessment, the work group observed that the majority of disposal wells in the United States do not pose a hazard for induced seismicity; however most cases of felt injection-induced earthquake activity has generally been associated with direct injection into basement rocks or injection into overlying formations with permeable avenues of communication with the basement rocks, and in proximity to faults of concern.

In areas where induced seismicity is thought to have occurred, the Primer also identifies the range of multi-disciplinary approaches states have used to manage and mitigate risks, discusses scientific methods for evaluating cause, identifies faults of concern, and distinguishes risks and hazards.

Overall the risk of induced seismicity for oil and gas operation is still low. It is clear that local factors in different parts of the country present different levels of risk. Because of this, risk management, mitigation, and response strategies are most effective when developed considering specific local geology, surface conditions as well as other local situations.

This session will provide a detailed overview of the recently released document entitled: “Potential Injection-Induced Seismicity Associate with Oil & Gas Development: A primer on technical & regulatory considerations informing risk management & mitigation” to inform regulators, Class II well operators and third party operators, researchers, and other stakeholders with interest in understanding the many complex details associated with induces seismicity and the developing suite of tools that can be utilized to minimize the risk of occurrence.

To download the Primer or to view an in-depth Webinar featuring commentary from key work group participants, visit www.statesfirstinitiative.org.

States First is a STATE led effort. Governors, regulators, and policy leaders from oil and gas producing states across the country have partnered with the Interstate Oil and Gas Compact Commission and Ground Water Protection Council in this endeavor.

The Interstate Oil and Gas Compact Commission is a multi-state government organization with a mission to conserve and maximize domestic oil and natural gas resources while protecting health, safety and the environment. The Ground Water Protection Council is a national association of state water-protection officials.
This joint initiative allows a unique mix of regulatory experts, state policy and technical staff from across the country to come together and to share the way they do business, review internal operations, react quickly to rapidly emerging technologies and opens up opportunities for extrapolating effective practices from one state to another.

**TOPICS TO INCLUDE:**
- Understanding Induced Seismicity
- Assessing Potentially Injected-Induced Seismicity
  - tools and technology that can be used
- Risk Management and Mitigation Strategies
  - tools uses to evaluate the geologic aspects before drilling any new wells
- Considerations for External Communication and Engagement
- Understanding Details Associated with State Regulations
- Understanding Details Associated with Industry Operators

**Abstract 4**

*Where should I put my disposal well? - An approach to siting optimization*

Jon Fennell, Integrated Sustainability Consultants Ltd.

Unconventional oil and gas development, whether it is oil sands or tight formations, requires the use of large amounts of water and also produces large amounts of liquid wastes. Although some of this waste is reused, much of it requires disposal. Over the past several decades, upwards of 23 billion m$^3$ (6.08 trillion US gallons) of liquid waste has been injected into more than 3,000 wells (mostly in Alberta). According to the EPA, over 140,000 Class II wells have been used in the United States to dispose of over 7.6 million m$^3$ (2 billion US gallons) each day, with upwards of 37.9 billion m$^3$ (10 trillion US gallons) disposed of to date.

Subsurface disposal is a regulated activity, and once approved a disposal scheme is restricted to certain injection pressures to maintain cap-rock and formation integrity, and isolation of the waste. In certain development areas, the presence of suitable disposal formations is scarce (e.g. Pennsylvania). In others, active disposal schemes are now experiencing cumulative build-up of formation pressures, induced seismicity, and associated constraints on development. To address this challenge, a study was launched in Alberta to assess disposal opportunities to address liquid wastes generated by the oil sands industry. Potential opportunities, as well as operational risks, were identified within a 152,000 km$^2$ area using a combination of multi-criteria analysis (MCA) and geomatics, leveraging publically available information and institutional knowledge. The result identified a number of high value formations, locations suitable for future consideration, and laid the foundation for development of a sustainable disposal strategy.

This presentation will highlight the development of a disposal well siting strategy, the risks and challenges identified, and highlight some of the opportunities for industry to address the challenge of disposal well siting.

**Dr. Fennell** is a Principal Hydrogeologist at Integrated Sustainability Consultants Ltd. with over 28 years consulting experience in the natural resource sector, 23 of which have been directly related to water and waste management in the conventional and unconventional oil and gas sectors. Jon received his B.Sc. in Geology from the University of Saskatchewan in 1985, M.Sc. in Hydrogeology from the University of Calgary in 1994, and a Ph.D. in Geochemistry from the University of Calgary in 2008. His areas of specialization include physical and chemical hydrogeology, environmental forensics, water supply and waste disposal strategies, risk assessment, and risk mitigation.
New API Industry Standards for Shale Development

Roland Goodman, American Petroleum Institute

New editions of API's hydraulic fracturing standards provide the latest technical direction for operators working to continuously improve well integrity, groundwater protection, and environmental safety. Last updated in 2011, API's standards for shale development have worked alongside robust state regulations to ensure safe and responsible energy development with hydraulic fracturing for over 65 years.

Dubbed ANSI/API RP 100-1 and 100-2, the two new standards provide detailed specifications for pressure containment and well integrity, as well as environmental safeguards, including groundwater protection, waste management, emissions reduction, site planning, and worker training. The release follows last year's publication of ANSI/API Bulletin 100-3, which outlines community engagement guidelines to help operators communicate effectively with local residents and pursue mutual goals for community growth.

The new standards will be accessible to the public on API's website and shared with regulators at every level of government. API's voluntary standards serve as an important source of information for state regulators, who finalized an estimated 82 groundwater-related rules for oil and gas production, including hundreds of discrete rule changes, from 2009 to 2013 alone. These efforts have allowed America’s energy sector to achieve a track record of proven safety while growing our economy and cutting U.S. carbon emissions to near 27-year lows.

API first began publishing standards in 1924 and currently has over 650 standards and technical publications. 130 of them have been incorporated into U.S. regulations with over 460 citations, and 216 of them have been cited over 4035 in state regulations. They are also the most widely-cited industry standards by international regulators. The program is accredited by the American National Standards Institute (ANSI), the same body that accredits programs at several national laboratories.

Roland Goodman is the Manager of Upstream standards for the American Petroleum Institute in Washington, D.C. Roland’s group is responsible for staffing 14 committees that maintain approximately 350 standards covering various types of exploration and production equipment and drilling and production operations. Roland has been with API for 21 years and has a Bachelor of Science degree in Industrial and Systems Engineering from the University of Southern California.

Innovative Methods in Nutrient Reduction by use of Deep Well Injection, Virginia Key, Miami-Dade County, Florida

Virginia Walsh, P.G., Ph.D., Miami-Dade Water and Sewer Department

Dr. Walsh has over 19 years of experience as a hydrogeologist in various hydrologic, geologic, and environmental investigations. She has been Chief of the Hydrogeology Section at MDWASD for over the past 7 years. Dr. Walsh received her Ph.D. in Geology from Florida International University in 2012. Dr. Walsh and her staff are responsible for all hydrogeologic investigations for MDWASD, and are involved in the design, operation and maintenance of water production wells and the deep injection well systems at MDWASD. She is also the Project Manager for the Aquifer Storage and Recovery cycle testing at MDWASD South and West wellfields.

Edward Rectenwald, P.G., MWH Americas, Inc.

Mr. Rectenwald is a Principal Hydrogeologist and Client Service Manager in south Florida with over 20 years of technical and management experience. His experience includes regional aquifer investigations, water use permitting, hydraulic modeling, design and testing of aquifer storage and recovery wells (ASR), injection wells, public and industrial supply reverse osmosis (RO) wells, irrigation wells, and monitor wells. Mr. Rectenwald has managed detailed geochemical investigations to better understand flow patterns of the Floridan Aquifer System using stable isotopes, carbon-14, and noble gases.
Miami-Dade Water and Sewer Department (WASD) investigated a number of innovative and cost effective methods to meet the State of Florida Ocean Outfall Legislation requirements at the Central District Wastewater Treatment Plant (CDWWTP) on Virginia Key, Miami-Dade County, Florida. The CDWWTP is permitted to treat an average daily flow (ADF) of 143 mgd, and historically treated an ADF of 114 mgd that is treated to secondary standards and a majority of the effluent is disposed of via an ocean outfall. Florida Statutes Chapter 403 Section 86(9)(b) require that the discharge of domestic wastewater through the ocean outfalls must meet advanced wastewater treatment (AWT) no later than December 31, 2018. This milestone requirement can be met by reducing the outfall baseline loadings of total nitrogen (TN) and total phosphorus (TP) which would be equivalent to that which would be achieved by the AWT requirements fully implemented beginning December 31, 2018, and continued through December 31, 2025.

One of the options that WASD is exploring is to dispose a portion of; or all of the secondary effluent below the Floridan Aquifer System (FAS) in permeable Cretaceous aged sediments as a potential significant cost savings option for their customers where AWT may not be required prior to disposal. A deep injection well (DIW) has been permitted as a Class V Exploratory well from the FDEP UIC and is currently in construction. The exploratory DIW is being used to evaluate the hydrogeologic characteristics of the Boulder Zone in the FAS which is the primary source of disposal via deep injection in south Florida, and alternative disposal options below the FAS to a depth of 10,000 feet within Cretaceous age formations. This presentation will provide the audience with design information regarding the DIW design, construction testing techniques used, and savings realized by WASD.

Abstract 7

Flowback Operations Innovation – Reducing EHS Risk through Design and Planning

David Stewart, Bonanza Creek Energy Inc.

David Stewart joined Bonanza Creek in 2014 as Vice President of Environmental, Health, Safety and Regulatory Compliance (EHS&RC) with 23 years of industrial EHS&RC experience. Prior to joining Bonanza Creek he served in environmental and safety positions of increasing responsibility with Encana and has worked in a variety of other consulting and industry roles. He holds a BA in History and Biology coursework from Coe College and a Masters of Applied Science degree in Environmental Policy and Management from the University of Denver.

Flowback operations pose an increased risk of environmental and safety impacts due to their temporary nature and variable flow rate conditions. Bonanza Creek energy operations teams developed an innovative approach to flowback that reduces risk of tank overflow incidents, and produced water/oil spills while achieving a dramatic decrease in air quality emissions releases and enhancement of site process safety. Bonanza Creek was awarded the Colorado Oil and Gas Conservation Commission 2014 Outstanding Oil and Gas Operations Award for this innovative approach to flowback operations. The key aspects of this innovation reside in the use of process safety management techniques that resulted in significant reductions in risk related to spills and air emissions. The technical innovations that made this successful were:

- closed top tanks with pressure relief systems,
- liquid and gaseous manifold systems to provide liquid/vapor balancing and capture,
- chemical and tear resistant liners under all flowback tanks and piping,
- routing closed top tank emissions to enclosed flares in lieu of venting or open flaring, and
- extensive bonding and grounding of equipment, piping and loadout.

The environmental and safety benefits were estimated and calculated using a risk reduction process and emissions calculations spreadsheet. The estimated benefits of implementing closed-loop flowback operations include:

- 80% reduction in risk of tank overflow,
- 80% reduction in spill impacts to pad site soils and/or offsite release,
- 95% reduction in volatile organic emissions, and
- 80% reduction in catastrophic explosion from static and sparks.

The closed-loop flowback operation does result in an increase in direct cost due to additional equipment needed and increased time/labor for set-up and dismantling. However, the decrease in potential indirect costs of an environmental release or explosion greatly exceeds the costs of incorporating strong process safety improvements into the operation.
Abstract 8

**Wastewater Disposal, Hydraulic Fracturing, and Seismicity in Southern Kansas**

Justin L. Rubinstein¹, Fabia Terra¹, William L. Ellsworth²

¹US Geological Survey, ²Stanford University

The concurrent appearance of seismicity with the expansion of oil and gas activities in southern Kansas since September 2012 suggests that industrial operations are inducing earthquakes. These earthquakes occur in a portion of the Mississippian Lime Play, an oil and gas field stretching from central Oklahoma to northwestern Kansas. As has been seen in other areas of high-rate wastewater injection, the seismicity appears to be driven by the disposal of produced water by injection into deep sedimentary formations. We focus on an 1800 km² area in Harper and Sumner counties where a temporary, 16-station seismic network deployed by the USGS monitors ongoing seismicity. Regional and national networks supplement the temporary network. Earthquake locations and magnitudes are reported on a daily basis and M≥1.5 earthquakes are included in the USGS Comprehensive Catalog (ComCat) with a magnitude of completeness of ~M2.0. The clusters of earthquakes are principally in the crystalline basement, some forming lineations extending up to 10 km. Focal mechanisms indicate normal faulting, consistent with the local tectonic stress field. While some of the clusters of seismicity are located close to high-rate injection wells, others are at least 10km from large injection wells. Additionally, high-rate wells do not always appear to be associated with seismicity. In response to the increased seismicity, on March 29, 2015 the Kansas Corporation Commission placed new limits on the rate of wastewater disposal in 5 areas in southern Kansas. Additionally, many wells were required to be plugged back, such that no fluids were injected into the crystalline basement. Since this regulation has been in place, earthquake activity has decreased by 40-50%. The reduction in earthquake rate is limited to the zones where injection rates were lowered. The seismicity rate outside these zones has actually increased, but not enough to fully counterbalance the reduction in seismicity in the zones affected by the regulation. Throughout the study region, in the 87 days between January 1, 2015 and March 29, when the order was enacted, there were on average three M≥2 earthquakes and 0.3 M≥3 earthquakes per day in the study area. The earthquake rate in the 87 days following the change in regulations dropped to 1.8 M≥2 and 0.2 M≥3 earthquakes per day in the same region over the same amount of time. The two largest earthquakes (M4.1 and M4.0), however, occurred after the new regulation was put in place.

Abstract 9

**Everything You Always Wanted to Know About Class I Injection Wells in Texas**

Lorrie Council, P.G., Texas Commission on Environmental Quality, UIC Permits Section
Shelly Bergel, 2015 Mickey Leland Environmental Internship, UIC Intern

Lorrie Council serves as the UIC Permits Section Manager for the Texas Commission on Environmental Quality (TCEQ). She manages professional geologists and engineers who review applications and write permits and authorizations for Class I, III, IV, and V injection wells in Texas. Ms. Council has 21 years of environmental consulting experience in groundwater protection and restoration and 14 years of Texas state government experience covering UIC permitting, waste disposal, and coastal erosion response. Ms. Council earned a B.S. in Geology from the University of Oklahoma and is a licensed professional geologist in Texas and Arizona.

Shelly Bergel graduated with a B.S. in Environmental Science/Geology Focus from the University of Texas at Austin in May 2015. She worked as a UIC Intern at TCEQ under the Mickey Leland Environmental Internship Program during the summer of 2015. Ms. Bergel's primary project for the internship was to research and summarize current and historical Class I injection well operations in Texas.

The Texas Commission on Environmental Quality has primacy for the UIC Program which includes Class I injection wells. The state has one of the largest numbers of permitted Class I injection wells in the nation. During 2014, over 5.6 billion gallons of industrial and municipal waste were disposed via Class I wells into deep subsurface reservoirs. Between 1953, when agency records of wastewater disposal into Class I injection wells began in Texas and 2014, over 248 billion gallons of waste had been injected into Texas-permitted Class I wells. Almost half of the 165 active Class I permits in Texas allow hazardous waste disposal. The geology of Texas provides a favorable framework for deep wastewater disposal, with abundant receiving formations and confining units situated well below Underground Sources of Drinking Water. Challenges with aging wells, reservoir pressure build-up, coordination with oil and gas activities, permitting of new hazardous waste disposal wells, and streamlining of the permit process are discussed in this comprehensive summary of the Texas Class I injection well program.
Sources of Variability in Dissolved Methane Concentrations at Residential Water Wells

Stephen D. Richardson, Lisa J. Molofsky, Tom E. McHugh, Ann P. Smith, and John A. Connor; GSI Environmental, Inc. 
Anthony W. Gorody; Universal Geoscience Consulting, Inc. 
Fred Baldassare; Echelon Applied Geosciences

Concerns have been raised regarding the potential impact of shale oil and gas development on local drinking water sources such as residential water wells. However, determining whether changes in groundwater chemistry (methane, salts, etc.) are natural in origin or caused by nearby oil and gas operations can be challenging, particularly when i) different sampling and analytical methodologies are used to conduct baseline sampling programs and ii) water quality varies naturally over time due to various factors (e.g., residential water use, well construction, aquifer geochemistry, precipitation events, temperature). Understanding the sources of variability in concentrations of dissolved gases and other water quality parameters is critical to discerning natural changes in water quality from those associated with oil and gas activities.

This talk presents the findings of field studies conducted in Northeastern Pennsylvania that evaluate key sources of variability in residential water quality. Specifically, dissolved methane and ethane data derived from three common and commercially-available sampling methods are compared and baseline data from the Appalachian basin are evaluated to identify parameters representative of naturally-elevated methane concentrations. Study findings suggest that a “closed-system” sampling device (that eliminates loss of both exsolving and dissolved gases to the atmosphere) should be used when effervescence is observed or elevated methane concentrations are suspected. Under effervescing conditions, samples collected using common “open-system” methods (e.g., direct-fill and inverted bottle) are likely to be underestimated. In addition, several easily measured and commonly analyzed geochemical parameters strongly correlate with natural occurrence of methane in the Appalachian Basin. These simple geochemical relationships can serve as an additional line of evidence to distinguish natural methane variability from potential stray gas migration. Study findings culminate in a baseline sampling protocol aimed at improving sample collection procedures and data interpretation for groundwater sampling programs in areas of shale oil and gas development.

Dr. Richardson is an Environmental Engineer with GSI with over thirteen years of experience in soil and groundwater remediation, environmental site investigation, engineering design, and research and development. Dr. Richardson is a Licensed Professional Engineer in Texas, Louisiana, North Carolina, and Alberta, Canada. He holds a doctoral degree in environmental engineering from the University of North Carolina, a master’s degree from Louisiana State University, and a bachelor’s degree from the University of Waterloo. Dr. Richardson serves as the technical lead for a DOE-funded research project examining the environmental effects of shale gas operations, specifically air emissions, stray gas events, and flowback/produced water.

Regulatory Considerations for Evaluating the Potential for Induced Seismicity of a Class I Non-Hazardous Waste Disposal Well

Chad Milligan PG, SCS Aquaterra 
Craig Pangburn PG, Underground Cavern Stabilization

Recent seismic activity in Oklahoma and south-central Kansas has heightened concerns that human activities might be causing felt earthquakes. “Induced seismicity in other states has been linked to reservoirs (lakes), geothermal development, and waste disposal (KCC1).” Therefore, Kansas Governor Sam Brownback established a task force in February 2014 to “study and develop a state action plan for induced seismic activity related to oil and gas activities in Kansas (KCC2).” Representatives from the Kansas Corporation Commission (KCC), Kansas Geological Survey (KGS), and the Kansas Department of Health and Environment (KDHE) comprise the State task force.

As stated with the development of the State task force, oil and gas production has oftentimes been the target for inducing seismic activity. A number of sources indicate that hydraulic fracturing, or fracking, may cause seismic events. However, these are low intensity, less than magnitude 1, and are too small
to be felt at the earth’s surface. A number of sources have reported that waste water injection has induced seismic activities in a number of states, including Oklahoma, Colorado, and Ohio.

The KDHE has recently required an evaluation of earthquake potential and the potential for induced seismic activity as part of the permit application process. Under a recent permit application, a Class I applicant evaluated the potential for induced seismic activity with respect to the KDHE’s Class I and Class V UIC injection wells, and the KCC’s Class II injection wells, as these wells potentially have similar construction and injection details and increased potential for inducing seismic activities, as has been demonstrated in other states.

Chad Milligan is a licensed professional geologist in the states of Kansas and Illinois. He has a Bachelor of Science degree in Environmental Chemistry from Emporia State University and a Master’s Degree in Environmental Science from Wichita State University. He has over 20 years of experience in the environmental field and has been responsible for permitting and regulatory compliance of Class I (non-hazardous), Class II, Class III, and Class V disposal and salt solution mining wells and LPG storage caverns in the states of Kansas, Illinois, and Colorado. He also has a broad range of experience in water resources and has authored and co-authored a number of published reports relating to surface water and groundwater quality in central Kansas.

Craig Pangburn is a licensed Professional Geologist in Kansas, Texas and Louisiana. He has a Bachelor of Science Degree in Geology from Fort Hays State University. He has over 29 years of experience in permitting, design, drilling, completion, testing, operation, maintenance and installation of Class II salt water disposal systems/wells, Class I, Class III, Class V wells and underground hydrocarbon storage cavern wells in Kansas, Oklahoma, Michigan, Texas and Iowa. He is also the Co-Owner and President of T&C MFG & Operating, Inc., a Co-Member of Underground Cavern Stabilization, LLC and was previously a Regional Field Manager for Rice Engineering Corp.


Abstract 12

Advancing Technology in Well Completions and Stimulations

Megan Starr-Powell, Anadarko Petroleum Corporation

Anadarko has long held safety and environmental protections as high priorities, and as the company continues to grow its operations in urban environments, it is continuously evolving its completion practices to minimize impacts through technology and innovation. Two completion technologies that Anadarko, in conjunction with Halliburton, enhanced in 2014 were the use of Stimulation, or Stim Centers, and hydraulic fracturing equipment that runs on natural gas along with diesel (dual-fuel). These techniques benefit the community by reducing noise, light and truck traffic, while preserving air quality and surface space. These technologies also enhance safety and environmental protection.

Stim Center Operations: In August 2013, Anadarko worked with Halliburton to develop a solution that would enable hydraulic fracturing equipment to be centralized on a remote pad at a distance from the pad being treated. The primary goals for centralizing the majority of the equipment was to reduce noise, light and truck traffic, while preserving air quality and surface space. This innovation resulted in reduced surface operational impacts within the community.

Safety: The lines Anadarko uses to transport completion fluid from the Stim Center to the wellhead have the same specification structural competency as the pipe used on the ocean floor in the Gulf of Mexico. Specialized high-integrity welds are used to connect the robust piping and to prevent leaks. The entire piping system must undergo and pass an eight-hour, 10,000-psi pressure test prior to being put into service. A 50-foot “Red Zone” restricts personnel from entering the area when the pipe is pressurized. Multiple cameras are installed along the pipe to monitor the lines and to ensure personnel are safely clear of the “Red Zone.” All high-pressure threaded pipe have pipe restraints as an additional safety provision.
Environmental Benefits: Noise and light reduction is achieved by strategically isolating the Stim Center in a less-populated area. While the individual wells being completed may be in a closer proximity to urban areas, the pumping operations and the associated lighting is moved to the Stim Center. Centralizing the frac equipment, in addition to Anadarko’s previous environmental conservation efforts like “Water on Demand,” has eliminated more than 21,000 truck trips from the roadways since 2013. Eliminating these truck trips reduces traffic, improves safety in the community, reduces fuel consumption and significantly reduces associated emissions. Using NG to replace diesel fuel resulted in more than one million gallons less diesel used in 2014. Completing 2,586 stages with Dual-Fuel significantly reduced CO₂ emissions – more than 12,200 tons per year eliminated or the equivalent to planting 509,000 mature trees. In addition to the reduction in CO₂ emissions, mono-nitrogen oxide (NOₓ) emissions are dramatically lowered as well.

Conclusion: Through innovative thinking and technology, Anadarko is operating in a more environmentally friendly manner as well as keeping safety a top priority.

Megan Starr currently works as a Senior Reservoir Engineer for Anadarko Petroleum Corporation covering the Wattenberg Field. As a Colorado native, she remained close and graduated with a Bachelors of Science degree in Petroleum Engineering from Colorado School of Mines in 2006. She has been involved as a leader and member of numerous organizations for over 9 years including SPE as Treasurer, Community Outreach Chair, and Young Professionals Chair. Megan's industry experience in completions, production and facilities has won her various awards and aided her to speak on behalf of the industry as an Advocate, participating in various public forums and site tours to government agencies.

Abstract 13

The Occurrence of Surface Casing Pressure in the Denver-Julesburg Basin and Implications for Stray Gas Migration

Greg Lackey, Harihar Rajaram, Owen A. Sherwood, Troy L. Burke and Joseph N. Ryan, University of Colorado, Boulder

Colorado regulations require oil and gas wells to be constructed with production casings that are cemented a minimum of 200 feet above the shallowest producing formation and surface casings that are cemented 50 feet below the depth of the deepest drinking water aquifer. This leaves uncemented production casing between the top of the production casing cement to the bottom of the surface casing. Most (86%) of the 17,948 wells in wells in the Wattenberg Field, the most productive region of the Denver-Julesburg (DJ) Basin, were constructed with annuli that are uncemented in this fashion. Faulty production casing cement and intermediate gas-bearing zones that are not isolated by cement can leak stray gas into the uncemented annulus, which may provide a pathway for upward gas migration. The Colorado Oil and Gas Conservation Commission (COGCC) requires the installation of a “bradenhead valve” on all oil and gas wells to seal annuli and prevent the leakage of hydrocarbons into the atmosphere. Consequently, stray gas in uncemented annuli may dissolve into the annular fluid and accumulate below the bradenhead valve. Thus, elevated pressure on the surface casing of a well (bradenhead pressure) indicates that stray gas potentially could be leaking into an aquifer. In this study, we analyze bradenhead pressure data from the COGCC in the DJ Basin. Since 2007, 1,492 wells in the DJ Basin have recorded bradenhead pressures greater than 20 psi. We investigate the influence of wellbore construction and surrounding geology on the occurrence of bradenhead pressure. These data are used to inform numerical simulations of bradenhead pressure buildup that are designed to understand the possible connection between bradenhead pressure and stray gas migration away from oil and gas wells in the subsurface.

Greg Lackey is a graduate research assistant at the University of Colorado Boulder who conducts his doctoral research with Dr. Harihar Rajaram. Dr. Harihar Rajaram is a professor of water resources engineering at the University of Colorado Boulder who studies fluid mechanics and transport phenomena. Dr. Owen Sherwood is a researcher at the Institute for Arctic and Alpine Research who is interested in the analysis of methane in groundwater. Troy Burke is the data manager for the AirWaterGas Sustainability Research Network who specializes in oil and gas data. Dr. Joseph Ryan is a professor of environmental engineering at the University of Colorado Boulder who studies the fate and transport of contaminants in natural waters.
Occurrence of BTEX from Oil- and Gas-Related Incidents in Groundwater above the Denver-Julesburg Basin

Katherine J. Armstrong, Jessica D. Rogers, Troy L. Burke, and Joseph N. Ryan

Public concern about water quality related to unconventional oil and gas development has grown in recent years, but little is known regarding the prevalence and exposure potential of organic contaminants linked to unconventional oil and gas fluids and wastewaters in groundwater. In this study, we characterized incidents in which groundwater has been contaminated by benzene, toluene, ethylbenzene, and xylenes (the “BTEX” compounds) by oil and gas activities. We investigated spill reports and remediation project reports submitted to the Colorado Oil and Gas Conservation Commission (COGCC) in 2010 and 2012 for incidents that occurred in and near the Wattenberg Field, an area of intensive unconventional energy development located within the Denver-Julesburg Basin. A fraction of these spills and remediation projects were identified as having potentially contaminated groundwater based on an operator-reported field. Using supporting documents attached to the reports on the COGCC website, groundwater impact was confirmed by consultant reports, laboratory data, or other documents. A fraction of these groundwater-affecting spills contaminated groundwater with BTEX, which we determined by seeking laboratory reports in which BTEX concentrations were measured in groundwater samples. The data were compared to indicators of overall development in the spatial and temporal range, such as the number of wells drilled and the number of active sites, to determine occurrence rates of spills, of spills that have affected groundwater, and of spills that have affected groundwater with BTEX. We also collected other information from the supporting documents, including the cause of incidents, facility types where incidents occurred, the materials released, and groundwater sampling locations (monitoring wells, domestic wells, etc.). These occurrence rates and incident data will contribute to an enhanced understanding of the probability that groundwater will be contaminated with BTEX from oil and gas activities, which could inform future exposure assessments.

Katherine Armstrong is an undergraduate research assistant in environmental engineering at the University of Colorado Boulder participating in CU’s Discovery Learning Apprenticeship program. Jessica Rogers is a graduate research assistant in environmental engineering at University of Colorado Boulder conducting her doctoral research on the potential groundwater impacts of unconventional oil and gas development. Troy Burke is the data manager for the AirWaterGas Sustainability Research Network at the University of Colorado Boulder. Dr. Joseph Ryan is a professor of environmental engineering at the University of Colorado Boulder who studies the fate and transport of contaminants in natural waters.

The Relative Importance of Critical Technical and Regulatory Factors that Define Injection Well Feasibility: Pressure Matters

Ken Cooper, PE; Engineering Manager and Principal¹
and Aaron Payne, PG; Senior Hydrogeologist¹ and Wes Janes, PG; Senior Operations Geologist¹
¹Petrotek Engineering Corporation, 5935 South Zang Street., Ste #200 Littleton, CO 80127, USA

The deepwell injection of waste water is often a critical part of waste management strategies for hydrocarbon production developments, the operation and restoration of ISR uranium facilities, and various types of industrial operations where brines are generated. Given suitable geology and waste characteristics, deepwell injection has often proven to be one of the safest and most cost-effective methods of liquid waste management available. Although injection technology alone can sometimes be the most logical choice for fluid management it can also complement and make waste minimization and surface treatment more practical and economical. For injection to be a useful component of fluid management strategies in different situations, a number of feasibility criteria must first be satisfied.

This paper presents general background regarding how disposal wells function from the perspective of siting criteria and reservoir engineering to identify the technical basis of some of the more critical factors necessary to evaluate technical and regulatory feasibility. Given the geologic challenges and dynamic
regulatory environment that can be present, especially in parts of the western United States, a comparison/contrast of some of the specific issues that should be considered when evaluating the feasibility and permitting of UIC wells is presented. Primary regulatory concerns for prospective operators are identified and the focus is concentrated on how pressure is integral to the evaluation of many technical feasibility concerns. The reasons that pressure is integral to many feasibility concerns is described in terms and graphics that will help both technical and non-technical staff visualize the process. Comparisons are drawn to illustrate the relative impact and importance of the different factors involved, including items such as reservoir and hydrogeological characteristics and boundaries, wellbore conditions, and injectate characteristics that can each impact an area of review concerns, well maintenance programs, injectate pretreatment requirements and well capacity limitations.

Ken Cooper is a managing principal of Petrotek Engineering Corporation in Littleton, Colorado. He holds both B.S. and M.S. degrees in Petroleum Engineering from the Montana College of Mineral Science and Technology (now Montana Tech) and is a registered professional engineer in Colorado along with numerous other states. Prior to helping found Petrotek in 1993, he gained engineering experience working in the petroleum industry and for several petroleum/uranium/injection well consulting firms.

Ken has almost 30 years of experience working with all classes of injection wells and specializes in investigating well feasibility, reservoir issues and testing, reservoir simulation, well compliance and permitting, along with optimizing injection well operation and maintenance.

Ken has published and given a variety of talks regarding subsurface injection, pressure transient well testing, and the simulation of subsurface fluid flow over the years, is a board member of the GWREF and has been an active member of both the GWPC (formerly the UIPC) and the Society of Petroleum Engineers since the late 1980's.

Abstract 16

Application and Analysis of Step-Rate Testing to Determine Fracture Pressure in Injection Wells

Lewis Wandke, PE, and Ken Cooper, Petrotek Engineering Corporation

A reliable estimation of fracture pressure has a multitude of valuable uses. For instance, this information can be vital during drilling operations to dictate drilling fluid density and casing design such that formations are not broken down. It can be used to optimize fracture stimulation treatments and can provide data useful for estimating the minimum horizontal stresses which can prove useful for geo-mechanical modeling. Most importantly for many injection well operators and regulators, the measurement and evaluation of fracture pressure data also has a significant regulatory impact since maximum allowable injection pressures are typically authorized as a function of fracture pressure. Injection pressure limits for Class I disposal wells are imposed according to 40CFR146.13(a)(1) to "ensure that the pressure in the injection zone during injection does not initiate new fractures or propagate existing fractures in the injection zone."

Because this information can have a direct impact on many technical and regulatory aspects of an injection project, it is important that accurate methods are utilized to collect and analyze relevant data. This presentation provides an overview of several tests that can provide insight into site specific pressures and stresses. We focus on a more in depth presentation of step-rate testing which is a useful method to evaluate stresses and formation pressure thresholds. It begins by describing in-situ stresses and forces that are present in a reservoir, and defines the criteria that must be met for a formation to be fractured. The step-rate testing process is then introduced, with basic methodology and plots to illustrate the testing process. Analysis methods are summarized along with common errors that can occur with data collection and analysis. Precautions and recommendations are introduced to help ensure that meaningful results are obtained from step rate tests.

Lewis Wandke is a Petroleum Engineer working at Petrotek Engineering Corporation in Littleton, Colorado. He holds a bachelor's degree in Petroleum Engineering from Montana Tech of the University of Montana. Prior to joining Petrotek two years ago, Lewis obtained almost ten years of oil and gas
engineering experience working as an engineer for a major operator in the DJ Basin in Colorado. He has been involved in all aspects of field development including drilling, production, operations, and reservoir evaluation.

At Petrotek, Lewis has responsibilities for injection well design and analysis, along with reservoir characterization in a number of emerging basins. In addition to his work with injection wells, Lewis provides permitting and evaluation services to oil and gas operators to support play development and characterization. He is an active member of the Society of Petroleum Engineers.

Abstract 17

Sources of Groundwater Methane in the Denver-Julesburg Basin of Colorado

Owen A. Sherwood, Jessica D. Rogers, Greg D. Lackey, Troy L. Burke, Stephen G. Osborn, Joseph N. Ryan, University Colorado, Boulder

The Front Range of eastern Colorado has seen intense development of unconventional oil and gas since 2010. This has generated concerns over potential impacts to groundwater quality. We mined Colorado Oil and Gas Conservation Commission (COGCC) data archives and examined the distribution and origin of groundwater methane in 1,062 water wells in the Denver-Julesburg (DJ) Basin. Stable carbon isotopes of methane and higher alkanes and gas molecular compositions were used to determine microbial versus thermogenic origins of the methane. Microbial methane, likely sourced from shallow coal seams, is pervasive in wells screened in the Denver formation aquifer and the confined part of the Laramie-Fox Hills aquifer at median (± 95% confidence limits) concentrations of 2.4 ± 1.8 and 8.2 ± 0.8 mg/l, respectively. Thermogenic gas was detected in 44 separate water wells, all within the Greater Wattenberg Area of the Denver-Julesburg Basin where most of the oil and gas development of the last 50 years has occurred. Due to clustering, these 44 wells correspond to 32 separate cases of stray gas migration, 10 of which were associated with known oil and gas wellbore barrier failures. Barrier failures occurred in older, vertical wells, all of which had “short” surface casings that did not adequately protect groundwater aquifers that are now in use. The remaining cases were either settled privately between the landowner and oil and gas operator (three cases) or were unresolved or are still under investigation by the COGCC (19 cases). The rate of stray gas occurrence has remained steady at about two cases per year since 1998. These results demonstrate occurrence and pathways of stray gas migration in an oil and gas field.

Owen Sherwood is a Research Associate at the Institute of Arctic and Alpine Research, University Colorado, Boulder, specializing in stable isotope analysis. Jessica Rogers and Greg Lackey are Ph.D. candidates in the Department of Civil, Environmental and Architectural Engineering at the University of Colorado, Boulder. Troy Burke is the data manager for the AirWaterGas Sustainability Research Network at the University of Colorado, Boulder. Stephen Osborn is Assistant Professor of Geological Sciences at California State Polytechnical University, Pomona. Joseph Ryan is Faculty Director of the AirWaterGas network and Professor of Civil, Environmental and Architectural Engineering at the University of Colorado, Boulder.

Abstract 18

Regulatory Actions to Reduce Risks from Wastewater Injection Induced Seismicity

Kathryn Mutz, Taber Ward, and Kayleen Glaser, University of Colorado, Boulder

With funding from the National Science Foundation, a University Collaborative for Induced Seismicity (CCIS) at the University of Colorado, Boulder is studying the mechanisms by which oil and gas wastewater injection wells induce earthquakes, the potential for these earthquakes to cause damage to the built environment, and the social and economic impact of induced earthquakes, to expand our knowledge of the complex interactions of the natural, built, and human environments in the creation and management of induced seismicity. As part of this effort, the authors are exploring the law and policy avenues for eliminating or minimizing induced seismicity associated with wastewater disposal activities. Using the LawAtlas comparative law database (http://lawatlas.org/oilandgas), the project is creating a database of state and federal law regarding induced seismicity focusing on Underground Injection Control (UIC) regulation under the Safe Drinking Water Act, state oil and gas statutes and regulations, and rules related to other sources of induced seismicity (reservoirs, geothermal, etc.). The project will explore geographic variability among existing regulations, the role of scientific investigations in development of new regulations, costs of enforcement and compliance, and appropriate jurisdictional levels for regulation. Preliminary results of the project research and database will be presented.
Kathryn Mutz is director of the Intermountain Oil and Gas BMP Project, University of Colorado, Boulder (CU). With a background in geography, ecology and law from the University of Chicago, Utah State University, and CU Law School, she has worked for 35 years on land management and energy issues. Taber Ward joined the BMP Project in June 2015. Taber is a graduate of McGill University and CU Law School with experience in public health, energy, environmental, and comparative law. Kayleen Glaser is a graduate of the Indiana Maurer School of Law and former research assistant for the BMP Project.

Abstract 19

Aquifer Storage and Recovery: A Management Tool for Upstream Operators
Lindsay Atkinson and James Dwyer, CH2M Hill

Water management is required throughout the unconventional oil and natural gas exploration and production (E&P) lifecycle. The amount of flowback after hydraulic fracturing varies by region and play, ranging from 10% to more than 100% of the total water used. Most operators currently manage excess produced water by recycling and reusing, treating for surface water discharge or, most commonly, disposing via injection wells.

Aquifer storage and recovery can be incorporated into the E&P water management tools to increase available water supply (by storing excess primary supplies or treated produced water), reduce dependence on disposal wells, and potentially increase existing groundwater supply well yields. Excess water can be recharged and stored using injection wells or recharge basins, or a combination of both, based on factors such as the quality of the recharged water and the storage zone, well depths and yields, recoverability of the water from the storage zone, plugging and maintenance and, for basins, hydraulic connection to the surface.

Aquifer storage wells would be regulated by the UIC program which regulates injection for protection of fresh water and underground sources of drinking water (USWD). The class of the injection well would be Class I or V depending on whether the storage zone is above or below the USDW. While Class I wells generally have greater cost and lower yields, permitting can be simpler (relative to Class V wells) for these potentially marginal quality supplies. The regulatory challenges associated with recharge of marginal quality water would include permitting to allow injection into a USDW with a total dissolved solids concentration of <10,000 mg/L, potentially increasing the degradation of the water quality of the storage zone and plugging of the well bore or recharge basin with suspended solids accumulation on the borehole.

Lindsay Atkinson, P.E: A graduate of University of Texas, Ms Atkinson has worked 10 years as a water resources engineer with CH2M with a focus on groundwater supply projects and water management for oil and gas. She is a registered professional engineer in Colorado.

James Dwyer, P.E., D. W.R.E., A graduate of Texas A&M, Mr. Dwyer has worked over 29 years as a water resources engineer with CH2M. He has completed numerous supply and recharge water well projects throughout the U.S. He is a registered professional engineer in Florida and Texas and has achieved the title of Diplomate with the American Academy of Water Resources Engineers.

Abstract 20

An Assessment of the Risk of Migration of Fracturing Fluids or Hydrocarbons into Fresh Water Aquifers in Colorado
W.W. Fleckenstein; A.W. Eustes; C.H. Stone; P. Howell, Colorado School of Mines

The United States National Science Foundation is funding a Sustainability Research Network (SRN) focused on natural gas development in the Rocky Mountain region. The mission of this network is to provide a logical, science-based framework for evaluating the environmental, economic, and social trade-offs between development of natural gas resources and protection of water and air resources and to convey the results of these evaluations to the public in a way that improves the development of policies and regulations governing natural gas and oil development.

As part of the tasks for the SRN, a team at the Colorado School of Mines reviewed and determined the probability of wellbore isolation failures that would allow the contamination of fresh water aquifers from fracture stimulation fluids or from hydrocarbon migration. A detailed analysis of the State of
Colorado’s public drilling data records was made to quantify the probability of contamination. In addition, current and historical casing and cementing practices for protecting aquifers were reviewed. This has been accomplished in the Denver-Julesburg and Piceance basins with work in the Raton and San Juan basins on going.

The significance of these results is helping to quantify the risks associated with natural gas development, as related to the contamination of fresh water aquifers. These results are shaping the discussion of the risks of natural gas development and are assisting in identifying areas of improved well construction and hydraulic fracturing practices to minimize risk.

W.W. Fleckenstein and A.W. Eustes are faculty members, C.H. Stone is a Master of Science candidate, and P. Howell is an undergraduate student in the Petroleum Engineering Department at the Colorado School of Mines.

Abstract 21

Prioritizing Well Inspections in Colorado: A Risk-Based Approach

Chris Eisinger¹, Ken Robertson², & Mike Leonard³
Colorado Oil & Gas Conservation Commission

State Senate Bill 13-202 mandated the Colorado Oil and Gas Conservation Commission (COGCC) to use a “risk-based strategy for inspecting oil and gas locations that targets the operational phases that are most likely to experience spills, excess emissions, and other types of violations and that prioritizes more in-depth inspections.” To achieve this goal, the COGCC has developed a geographic information system (GIS) model that calculates risk factor scores to be used in conjunction with other agency metrics for prioritizing field inspections. The GIS risk model is a systematic, automated, and statistically-based method that incorporates a selection of key population, environmental, facility, and regulatory datasets as input parameters.

Initially, a series of staff discussions established multiple risk factors applicable to the first SB 13-202 legislative recommendation – a recommendation that puts emphasis on more frequent inspections of production facilities. Input parameters relevant to the established risk factors were then classified using a simple 1 to 5 scale, with 1 representing a low risk and 5 a high risk. Some of the parameter values were classified directly, while others required one or more calculations before classification. The likely need for additional or modified parameters will become evident during initial field testing and implementation.

Presented here is a discussion of the COGCC’s previous approach to prioritizing well inspections, how we developed the GIS model and the initial results, and finally how we will use this information for current and future field inspection planning.

¹ Chris Eisinger is currently a GIS manager and research scientist at the COGCC. A geologist with 10 years experience in the oil and gas industry, Chris has also worked extensively in remote sensing and environmental sciences.

² Ken Robertson started at the COGCC as an application developer in 2000 and now holds the position of Senior Data Analyst. He throws right and bats left. Ken has led the National league in RBI’s for the last seven years.

³ Mike Leonard is a Field Inspection Quality Assurance Supervisor. He has been at the COGCC since 2006.
**Abstract 22**

**Rapid Response, Monitoring, and Mitigation of Induced Seismicity Near Greeley, Colorado**

J. Nakai\(^{1,3}\), W.L. Yeck\(^{1,2,3}\), A.F. Sheehan\(^{1,3}\), H.M Benz\(^{2}\), M. Weingarten\(^{1}\)

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2 US Geological Survey  
3 Cooperative Institute for Research in Environmental Sciences

On June 1st 2014 (03:35 UTC), an Mw 3.2 earthquake occurred in Weld County, Colorado, a historically aseismic area of the Denver-Julesburg Basin. Weld County is a prominent area of oil and gas development including many high-volume Class II wastewater injection wells. The University of Colorado, with support from the U.S. Geological Survey (USGS) and IRIS PASSCAL, deployed six seismic stations to characterize the seismicity associated with the June 1\(^{st}\) earthquake and to investigate a possible connection to nearby wastewater disposal. To establish a baseline on the first occurrence of earthquakes in the area, we ran correlation detectors across four years of prior continuous waveform data at the two closest permanent seismic stations, US ISCO and TA N23A at distance of ~110 and 125 km from the seismicity, respectively. The first detected earthquake occurred approximately three months after the Class-II disposal well C4A, the closest and highest rate injection well to the June 1\(^{st}\) event, began disposing of industrial wastewater at high rates (>250,000 barrels per month). Accurately located microseismicity from the six station temporary network demonstrated that the microseismicity lies within ~4 km of C4A and is primarily located near the top of the crystalline basement. The spatial and temporal proximity of earthquakes to C4A strongly suggests these earthquakes were induced, and therefore a mitigation strategy was employed. Mitigation efforts to reduce the occurrence of further earthquakes included a temporary moratorium on injection at C4A, cementing the bottom portion of C4A to minimize hydrologic connectivity between the disposal formation and the underlying crystalline basement, and allowing injection to resume at lower rates. This study demonstrates that the characterization of earthquakes in space and time relative to disposal can lead to objective and actionable mitigation that may reduce the rate of earthquakes and the possible generation of larger earthquakes.

**Abstract 23**

**Class I Injection Wells: Technological Opportunities for Improved Performance**

Robert G. Maliva and Wm. Scott Manahan

Robert Maliva is a Principal Hydrogeologist with Schlumberger Water Services, based in Fort Myers, Florida. Dr. Maliva specializes in underground injection control (UIC) projects and has been either the project manager or technical lead on numerous ASR and disposal injection well projects. He has considerable experience in all aspects of UIC projects including feasibility assessments, exploratory well programs, system design, permitting, construction supervision and management, and environmental impact assessments. Robert Maliva completed his Ph.D. in geology at Harvard University and has held research positions at the University of Cambridge, England, and University of Miami, Florida.

Scott Manahan has over 25 years of experience in subsurface exploration including hydrologic assessment, well construction, and commercial, remedial, and domestic water treatment. His extensive experience and engineering background have made him a specialist in aquifer performance testing, hydraulic analysis, injection and production well construction, wellfield design, and pumping system design.

Class I and V injection wells are increasingly being investigated and constructed for the disposal of brines from desalination facilities, in addition to their wider uses for the disposal of domestic and industrial wastes. Critical design and operational issues are that they must reliably accept the target liquid waste flow over the planned operational life of the system and not result in the endangerment of underground sources of drinking water or cause other adverse impacts (e.g., induced seismicity). Injection well systems vary greatly in their geological complexity and operational challenges. For example, in South Florida, an extremely high transmissivity interval of fractured dolomite is present, the “boulder zone”, which can accept flow rates in some wells exceeding 20 MGD with minimal wellhead pressure increase (< 100 psi) and clogging risk.
Elsewhere, relatively low transmissivity tight sand and sandstone units are used as injection zones, which require high pressures to maintain modest injection rates. These wells are particularly susceptible to clogging from various physical, chemical, and biological processes. Key technical issues are accurately identifying transmissive strata, optimizing completions to maximize well efficiency, and prevention and mitigation of clogging (well and formation damage).

The long-term performance of injection well systems can be improved by taking a more technically sophisticated approach in the various aspects of system design and construction. For example, detailed compatibility analyses are needed to evaluate clogging potential and develop site-specific pretreatment systems. Aquifer characterization programs involving quantitative analysis of standard and advanced borehole geophysical logs allow for the identification of both transmissive and confining strata and, in turn, optimize well completion. For example, by using the Platform Express™ integrated wireline logging and CHDT™ cased hole dynamics tester tool, injection strata were identified in a Colorado injection well that increased its capacity from a 350 gpm target to 2,000 gpm.

Abstract 24

**A Proactive Approach to Addressing Annular Pressure Issues and Stray Gas Migration in the Unconventional Shale Plays**

**J. Daniel Arthur, P.E., SPEC, Tom Tomastik, Senior Geologist, Kris Anderson, and Will Green, P.G., ALL Consulting**

Stray gas migration associated with the unconventional shale play development in the United States continues to be an area of concern. Stray gas zones and high reservoir pressures can create complex well control and primary cementing issues that can often lead to inadequate cement jobs and poor isolation of gas-producing formations. This lack of isolation can potentially cause sustained positive annular pressures behind multiple casing strings that can lead to annular overpressurization and to non-compliance of regulatory requirements. If annular pressures exceed regulatory guidelines, there is a concern that stray gas may migrate away from the well and create environmental and liability issues. In some instances, these annular pressures may be from shallower gas-producing zones or an artifact of drilling and completion operations. Remediation of an inadequate cement job can include the utilization of cased-hole geophysical logs to identify uncemented or inadequately cemented sections, perforation of well casings, and “squeezing” microfine cement, or other sealants, through perforations and into the annular space in an effort to isolate a stray gas issue.

ALL Consulting (ALL) has developed a comprehensive methodology that includes a site investigation, monitoring, analysis, and management of annular pressures. This process includes: Identification of oil and gas wells with potential positive annular pressure issues; wellhead field inspection and evaluation using standard well integrity standards; review of well construction, cementing, geology, and completion details; and performing pressure and volumetric analysis. Additionally, ALL uses infrared (IR) camera imaging technology to help characterize vented gas and identify leaks. Through the use of a variety of these successive tests and evaluations, a performance profile can be developed to demonstrate a course of action that is supported by scientifically-based results. Whether the annular pressure is an artifact of drilling and completions operations or stray gas issue from a gas-producing zone, a course of action may be developed to safely manage annular pressures and meet regulatory compliance requirements.

**Tom Tomastik** received his BS and MS degrees in geology from Ohio University in 1979 and 1981. From 1982 to 1988, Mr. Tomastik was employed as a consulting geologist involved in oil and gas exploration and development in southeastern Ohio. From December of 1988 until August of 2014, Tom was employed by the Ohio Department of Natural Resources, Division of Oil and Gas Resources Management, UIC Section. Tom retired from the Division in August of 2014. He was responsible for all of the Underground Injection Control (UIC) duties, which include performing independent reviews of applications for Class II saltwater injection, secondary and enhanced recovery projects, and Class III salt-solution mining wells in Ohio. Tom also planned and implemented highly complex groundwater conflict investigations involving oil and gas investigations. He provided technical expertise to the general public, oil and gas industry, governmental agencies and officials regarding Federal and State regulations, oil and gas and injection well construction, well
operations, and groundwater contamination and stray gas investigations. He has authored or co-authored articles on various aspects of Ohio’s oil and gas industry, groundwater investigations, injection wells, solution mining, and geology. Tom is currently employed as a Senior Geologist and Regulatory Specialist with ALL Consulting of Tulsa, Oklahoma and is involved in injection well evaluation, permitting, and oversight, stray gas investigations, groundwater complaint investigations, water sourcing, induced seismicity and seismicity monitoring.

Abstract 25

Deep Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste: An Old Concept Revisited

Bruce J. Kobelski - U.S. EPA OGWDW

Deep borehole disposal of spent nuclear fuel from power plants or solidified high-level radioactive waste (HLW) from the reprocessing of nuclear fuel is a concept originally dating from the 1970s. In the 1990s and early 2000s it had been mentioned as an alternative to disposal in a mined geologic repository in several locations, including Sweden and the UK.

More recently, the deep borehole disposal concept - involving the drilling of multiple large diameter boreholes to about 5,000 meters (about 16,400 feet) in crystalline basement rock and emplacing radioactive waste packages in the lower 2,000 meters of the boreholes and sealing the upper 3,000 meters, has been discussed in the United States.

In October 2015, the U.S. Nuclear Waste Technical Review Board held an international workshop in Washington, D.C. to evaluate technical and scientific issues associated with the potential use of deep boreholes by the Department of Energy to dispose of some radioactive wastes. The proceedings of the workshop (which was attended by several hundred scientists) along with the advantages and technical challenges associated with deep borehole disposal, will be presented. Questions related to the applicability, risks to ground water, and regulatory framework for this technology will be entertained.

Bruce Kobelski serves as Senior Advisor for the USEPA’s Underground Injection Control (UIC) program, Office of Ground Water and Drinking Water, in Washington, DC. Since 1986, he has covered numerous UIC initiatives and technical issues including mechanical integrity, Class I hazardous waste injection, coalbed methane hydraulic fracturing, and geologic sequestration.

His experience includes working as an oil and gas production and exploration geologist for industry, and resource evaluation for the Department of Interior’s OCS. He has his M.S. in Geology from Pennsylvania State University (1977) and a B.A. in Geology from Rutgers University (1973).

Abstract 26

Comparison of Pre-Mining and Post-Mining Groundwater Quality at Texas In Situ Uranium Mining Sites

David Murry, TCEQ

To assess the effects of in situ uranium mining on groundwater quality at mining sites in South Texas, pre-mining and post-mining groundwater quality data from 58 uranium production areas (PAs) were compared to the following categories of use: primary drinking water standards (PDWS), Wyoming standards for irrigation, and Wyoming standards for livestock. Based on these comparisons, changes in groundwater use categories, on a constituent by constituent basis, were identified. Results indicate that in situ uranium mining in South Texas has resulted in a change in use for the following constituents at certain sites:

PDWS: As, Cd, Hg, Se, U
Wyoming Irrigation: As, Se, Fe, Mn, SO4, TDS
Wyoming Livestock: As, Se
None of the 58 sites had pre-mining groundwater quality that met standards for drinking water, irrigation, or livestock. At 30 of the 58 sites, there was no change in use status based on individual Primary Drinking Water Standard constituents. At 19 of the 58 sites, there was no change in use status based on individual Wyoming Irrigation Standard constituents. At 45 of the 58 sites, there was no change in use status based on individual Wyoming Livestock Standard.

David is a geologist with the Underground Injection Control (UIC) Section of the Radioactive Materials Division of the Texas Commission on Environmental Quality (TCEQ) in Austin, Texas. He has a Bachelors Degree and a Masters Degrees in Science from University of Texas at El Paso, and is a Texas Licensed Professional Geoscientist (#1374) with 37 years of geologic and regulatory experience. He has worked as an exploration geologist for base and precious metals in the western United States, and for oil and gas in the offshore Gulf of Mexico, the Texas Gulf Coast, the Mississippi Salt Basin, southern California offshore, and the Alaskan offshore. At the TCEQ, David has worked as a permit writer in the Industrial and Hazardous Waste Permits Section of the Waste Permits Division, and as a permit writer reviewing applications for Class I, III, V UIC wells.

Abstract 27

The Potential for Induced Seismicity from Oil and Gas Wastewater Injection Wells in Pennsylvania
Joseph J. Lee, Jr., P.G., Ground Water Protection Council

Joe Lee received his Bachelor of Science degree in Geosciences from The Pennsylvania State University in 1977, and has completed course work for a Masters of Environmental Pollution Control. He has certificates in Hydrogeology and Geographic Information Systems. He has had over 35 years of experience, and is a subject expert in applying geologic and hydrogeological principles, and techniques in assessing environmental and public safety impacts of mineral resource development and other activities on groundwater, surface water, and water supply. He has developed and managed environmental protection programs for safe drinking water, groundwater and mineral resource development, including oil and gas. Mr. Lee served on the Board of Directors of the Ground Water Protection Council (GWPC) for over 10 years and has served as Treasurer, Vice-President, and President of the Board. Mr. Lee is a licensed professional geologist in the Commonwealth of Pennsylvania. He is the principle of Lee Geologic and serves on the GWPC staff.

Around the country, there has been a growing understanding and recognition of a potential to induce seismicity, under certain conditions, by underground injection of fluids. The primary subject of this paper is the potential for induced seismicity by deep injection wells for disposal of oil and gas waste fluids through class II underground injection control (UIC) wells. According to the U.S. Geological Survey (USGS), there are approximately 40,000 Class II UIC wells for disposal in the U.S. Of these, 218 (or 0.55 percent) of them have been indicated or suspected as a possible cause of earthquakes of any size. Some state regulatory authorities have already taken steps to manage the risks of inducted seismicity. Other states are considering if there is a significant potential of induced earthquakes associated with deep fluid injection in their state to determine what management strategy, if any, is needed to mitigate the earthquake risk. The extent to which the geologic conditions occur in a state with oil and gas development; and, there are corresponding Class II UIC disposal operations in formations of concern vary and are very site specific. This paper is a preliminary assessment of the geologic conditions in Pennsylvania related to the potential for inducted seismicity from Oil and Gas waste water injection.
Abstract 28:

**A Look at Underground Natural Gas Storage Operation and Regulation in the United States**

Nathan Alleman, Regulatory Specialist; J. Daniel Arthur, P.E., SPEC, President; Thomas E. Tomastik, Geologist; and Kris Andersen, Senior Environmental Manager; ALL Consulting

Nate Alleman has a Bachelor’s in Biology and a Master’s in Environmental Policy and Management, and has served as an environmental and regulatory consultant for ALL Consulting for 8 years. He has experience across a broad spectrum of oil and gas operations including well construction and siting; drilling and completion permitting; contractor management; lifecycle water management; spill response and cleanup; wildlife surveys; gas migration investigation; hydrocarbon storage; and public relations. Leveraging his experience with oilfield operations and regulations, Mr. Alleman specializes in working with operators to improve inter-office coordination and to develop field practices that are both effective and compliant.

The United States has long relied on the underground storage of natural gas for multiple purposes including balancing fluctuations in generation and consumption and providing a security buffer in case of unexpected supply interruptions. Increases in natural gas demand for electricity generation, among other uses, has resulted in an associated increased need for natural gas storage capacity. The underground storage of natural gas occurs in several forms including depleted oil & gas reservoirs; aquifers; domal and bedded salt caverns; and more. Each type of natural gas storage has its own benefits as well risks that are mitigated with operational controls. With the recent occurrence of multiple gas storage incidents across the United States, the operation and regulation of the practice has come under increased scrutiny.

This presentation will provide an overview of underground natural gas storage in the United States, how various types of gas storage facilities are operated, and some of the potential risks associated with gas storage facilities. Additionally, the presentation will provide a brief history of underground gas storage incidents as well as an overview of the current regulatory framework and some recent regulatory updates.

Tom Tomastik received his BS and MS degrees in geology from Ohio University in 1979 and 1981. From 1982 to 1988, Mr. Tomastik was employed as a consulting geologist involved in oil and gas exploration and development in southeastern Ohio. From December of 1988 until August of 2014, Tom was employed by the Ohio Department of Natural Resources, Division of Oil and Gas Resources Management, UIC Section. Tom retired from the Division in August of 2014. He was responsible for all of the Underground Injection Control (UIC) duties, which include performing independent reviews of applications for Class II saltwater injection, secondary and enhanced recovery projects, and Class III salt-solution mining wells in Ohio. Tom also planned and implemented highly complex groundwater conflict investigations involving oil and gas investigations. He provided technical expertise to the general public, oil and gas industry, governmental agencies and officials regarding Federal and State regulations, oil and gas and injection well construction, well operations, and groundwater contamination and stray gas investigations. He has authored or co-authored articles on various aspects of Ohio’s oil and gas industry, groundwater investigations, injection wells, solution mining, and geology. Tom is currently employed as a Senior Geologist and Regulatory Specialist with ALL Consulting of Tulsa, Oklahoma and is involved in injection well evaluation, permitting, and oversight, stray gas investigations, groundwater complaint investigations, water sourcing, induced seismicity and seismicity monitoring.
ISR Project Vicinity Well Sampling in Response to EPA's Proposed Amendment to the 40CFR192 Rule

Mark S. Pelizza, P.G., Principal, M.S. Pelizza & Associates

On January 26, 2015 the Environmental Protection Agency (EPA) proposed an amendment to 40CFR192. This rule is to establish changes to the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, in this case mostly for uranium in situ recovery (ISR) facilities. EPA proposed increased background data collection requirements/statistics, a 95% statistical confidence to demonstrate adequate restoration, increased post restoration stability periods, and a 30 year post stability monitoring period. Of these requirements, the uranium industry has voiced that the 30 year post stability monitoring period as most unfeasible.

Texas has an extensive uranium ISR history. The Texas Commission on Environmental Quality (TECQ) records account for 92 production areas at 28 individual ISR projects. Many of these projects have had background water well sampling programs conducted within the mandated area of review (AOR). Background data from hundreds of AOR wells are available in TCEQ files, where ISR operations have been conducted, and restoration/stability approved. Since these approvals the 30 year time horizon has passed that is analogous to the time period EPA contemplated for post stability monitoring in the 192 rule. Despite any evidence of diminished water quality, TCEQ has expressed a willingness to participate in a study that independently resamples many of these background wells at historic uranium ISR facility AOR’s. Conceptually the study would utilize TCEQ validated background water quality data, hydrogeologic tests and analysis from permit and license applications to be compared against the resampled water quality to determine if there have been changes in water quality three decades after uranium ISR operations have closed. To prioritize the wells that will be sampled, preliminary detailed area stratigraphic analysis/correlation, local hydrogeologic parameters, pump test results, groundwater travel direction and velocity, and historic background water quality data vetting (sorting, overlap, and validation) will be necessary.

Mr. Pelizza career in the uranium industry has spanned 37 years; 34 in various positions with Uranium Resources, Inc. where he most recently served as Sr. Vice President of Environment, Health, Safety and Public Affairs. He has been involved with 20 uranium projects.

Currently Mr. Pelizza is a consultant to the uranium industry through his firm M.S. Pelizza & Associates LLC. He serves as a Director with enCore Energy Corp. a publically held uranium company.

Mr. Pelizza holds a BS degree from Fort Lewis College and a MS from Colorado Sc. of Mines. He is a registered Professional Geoscientist in Texas and Certified Professional Geologist with the American Institute of Professional Geologists. He has served as President of the Uranium Producers of America, and Chairman of the Texas Mining and Reclamation Association.
Abstract 30:

**Injection-Induced Seismicity in Central Utah**

*Megan R. M. Brown*¹,² and Mian Liu²

1 Department of Geological Sciences, University of Colorado Boulder
2 Department of Geological Sciences, University of Missouri – Columbia

*Megan Brown* completed her master’s degree working with Dr. Mian Liu at the University of Missouri – Columbia in May 2015 and is currently a PhD student at the University of Colorado Boulder working with Dr. Shemin Ge. Dr. Mian Liu is the Curators’ Distinguished Professor and William H. Byler Distinguished Chair in Geological Sciences at the University of Missouri – Columbia.

Utah is one of the top producers of oil and natural gas in the United States. Over the past 18 years, more than 4.2 billion gallons of wastewater from the petroleum industry have been injected into the Navajo Sandstone, Kayenta Formation, and Wingate Sandstone in Carbon and Emery counties, central Utah, where seismicity has increased during the same period. Previous studies have attributed this seismicity to coal mining. Here we present evidence for wastewater injection being a major cause of the increased seismicity. We show that, in the coal mining area, seismicity rate increased significantly 1-5 years following the wastewater injection, and the earthquakes, mostly with magnitudes less than 3, are concentrated in areas seismically active prior to the injection. Using simple analytical and numerical models, we show that the injection in central Utah can sufficiently raise pore-pressure to trigger seismicity within 10-20 km of the injection wells, and the time needed for the diffusion of pore-pressure may explain the observed lag of seismicity increase behind the commencement of injection. The $b$-value of these earthquakes increased following the wastewater injection, which is consistent with these events being injection-induced. We conclude that the marked increase of seismicity rate in central Utah is induced by both mining activity and wastewater injection, which raised pore-pressure along preexisting faults.

Abstract 31:

**Water-use Requirements Associated with Hydraulic Fracturing within the Williston Basin**

Over the last decade, the rapid development of energy resources in the Upper Missouri River Basin, specifically in the Williston Basin, and the corresponding water resources needed to support energy development, has raised concerns of aquifer mining and water-level declines. Of particular concern is the amount of fresh water required to extract the oil and gas using hydraulic fracturing methods—in some cases, about three million gallons is needed to develop each well. Water is withdrawn from local aquifers and/or surface waters and then piped or trucked to the well pad. The withdrawal rate at many of these water sources can often exceed the sustainable recharge rate under current climatic conditions. The water that is returned to the surface after the fracturing process is often disposed in deep formations and effectively removed from the water cycle.

To date, there has been limited analysis of the amount of water used for hydraulic fracturing within this region. Data that identify the factors (technological, geological, and geographic) that influence the amount of water used for hydraulic fracturing at each oil and gas site is particularly lacking in analysis. This lack of information prohibits data-based management of the groundwater and surface water resources.

The objectives of this ongoing investigation are to (1) obtain and analyze water-use data at a well site (process) level, (2) identify the primary factors (predictor variables) controlling water use, and (3) enumerate the importance of these factors. Using available and surveyed water-use data, mathematical relations are being developed between the predictor variables and water-use quantities. These relations will then be used to estimate water-use requirements in the Williston Basin with respect to ongoing and future hydraulic fracturing and provide data for concurrent groundwater modeling studies to estimate groundwater availability under various development scenarios.

*Kyle Blasch* is currently the Director of the U.S. Geological Survey’s (USGS) Idaho Water Science Center in Boise, Idaho. Kyle earned a B.S. in Civil Engineering, a B.S. in Earth Sciences, and a M.S. in Meteorology from the Massachusetts Institute of Technology and a Doctorate in Hydrology from the
University of Arizona. For the past 17 years Kyle has been a USGS Research Hydrologist studying groundwater recharge, groundwater and surface water interactions, evapotranspiration, and stream flow permanence. Kyle is also a Bioenvironmental Engineer for the U.S. Air Force Reserve.

**Joanna Thamke** is a hydrogeologist with the U.S. Geological Survey's (USGS) Wyoming-Montana Water Science Center in Helena, Montana. Joanna has worked on groundwater projects throughout the Williston Basin for more than 30 years. She is currently project lead on multiple projects within the Williston Basin to delineate brine contamination in shallow groundwater, determine groundwater availability, and estimate water use related to energy development.

**Abstract 32:**

**Devon Energy’s 2015 Delaware Basin Water Management Program**

Jeff Sawyer and Ken Nichols, Devon Energy

Devon Energy has developed and expanded water conservation practices across our operating areas over the past decade. As a company that values water, Devon recognizes the need for a comprehensive approach to conservation. Devon has put into place a water management team to help guide the company’s ongoing conservation efforts. This team collaborates with technical working groups and professional disciplines companywide.

Components of Devon’s water management program include water demand and production forecasts, water quality data, targets, water storage, transfer options, regulatory, and commercial considerations. We have learned that each play’s water resources are unique and constraints on management options are highly variable. This presentation will summarize Devon’s past experiences through brief case studies from the Barnett Shale, Anadarko, and Midland Basin areas and will provide an overview of our 2015 Delaware Basin Water Management Program which allowed us to reuse approximately 3 million barrels of produced water; reducing our impact to fresh water resources of the region, reducing disposal volumes, reducing the number of trucks on the road, and demonstrating Devon’s ongoing commitment to being a good neighbor and steward of fresh water in a high water stress region of the country.

**Jeff Sawyer** received his BS in Civil Engineering from the University of Arkansas in 2007 and MBA from Webster University in 2010. He spent 12 years (2002-2014) working as a consultant for Pollution Management, Inc. in a variety of positions from Intern, Project Engineer/Manager, to Principal. He has worked with both upstream and downstream oil and gas facilities. He was on the team that designed, permitted, and built Arkansas' first operational NPDES permitted produced water treatment and discharge facility. In September 2014, Jeff joined Devon as a Water Management Engineer embedded in the Delaware Basin.

**Ken Nichols** received his BS and MS in Civil Engineering from the University of Illinois. After college he worked for Dowell Schlumberger in Laredo, Texas. In 1999, Ken moved to Austin, Texas to work as a consultant for CH2M HILL focused on ground water resource planning and development, deep well injection, aquifer storage and recovery, ground water modeling, aquifer test analysis, well design, and well field construction. Since 2011, Ken has focused on water management for oil and gas. As a consultant, Ken worked on several projects for Devon and in 2014, he moved to Oklahoma City to join Devon full-time. Ken is currently Devon’s Water Management Coordinator for the U.S. Division.
Abstract 33:

**Agricultural Reuse of Treated Produced Water**

*Katie Lewis¹, Jaroy Moore¹, Bob Avant², and Bill Weathersby³*

¹Texas A&M AgriLife Research; ²Texas A&M AgriLife Research; ³Energy Water Solutions

Irrigation is a vital component of Texas’ productive agricultural economy; thus, conservation of water resources is of significant concern especially in areas experiencing severe shortages. In order to conserve groundwater and secure Texas’ agricultural economy, other sources of irrigation must be explored. A possible resource may be produced water, a byproduct from the oil and gas industry. Energy Water Solutions (EWS) has developed an innovative water treatment technology with tested and proven ability to provide fresh water from a previously regarded environmental liability. EWS technology has effectively demonstrated safe disposal of produced water and conservation of water resources in states such as Colorado, but is unable to do so in Texas. Current laws in Texas prohibit reuse of treated produced water as a recyclable product for agricultural use. To address these restrictions, EWS formed a coalition with the Texas Railroad Commission (RRC), Texas A&M AgriLife Research, Gibson Energy, and Anadarko to successfully obtain RRC Permit #1 for beneficial reuse and to demonstrate the use of EWS treated water to irrigate a non-commercial cotton crop. The objectives of the project were to: 1) evaluate cotton growth and yield response to irrigating with treated produced water blended with groundwater; and, 2) determine the impact of treated produced water on soil chemical properties by measuring soil elemental concentrations and pH and electrical conductivity (EC). Results demonstrated that irrigating with one part treated produced water blended with four parts groundwater does not impact cotton lint yield or quality and reduced soil salinization.

**Katie L. Lewis:** As an aspiring agricultural and environmental soil scientist, I am continually striving to enhance my understanding of the critical challenges currently facing agriculture and society. As the daughter of a South Texas farmer, I was introduced at a young age to these challenges of sustainable agriculture and how they affect society. My desire to investigate and develop solutions to these challenges motivated me to continue my education at Texas A&M University in the Department of Soil and Crop Sciences, where I obtained a Master’s of Science (2010) and Doctor of Philosophy (2014) in Soil Science. I consider soil to be one of our most valuable natural resources, with the ability to produce food, feed and fiber, recycle wastes, filter and break down contaminants, and sequester carbon. My position as an Assistant Professor provides me the opportunity through research to enhance the agricultural sustainability of a region that is vitally important to both Texas and the nation, while helping educate future scientists, producers, and policy-makers.

Abstract 34:

**Irrigation with Produced Water in Texas – Beneficial Use Case Study**

*Lloyd H. Hetrick, PE CSP, Operations Engineering Advisor*

Newfield Exploration Company

Over the past decade, oil and gas produced water management has been mostly a choice between two options: Class II UIC disposal and/or produced water treatment and reuse. Seeking additional options, industry has tested and in some cases successfully performed NPDES discharge and beneficial use. This case study will present a project where all the chemical, physical, biological, legal and risk management components aligned to allow for a commercially successful and sustainable beneficial use operation in Texas. The presentation provides a roadmap along with a few lessons learned and improvement opportunities.

Lloyd is a registered Professional Engineer (PE) and Certified Safety Professional (CSP) with more than 36 years of diverse experience spanning all phases of the exploration and production (E&P) industry, including: drilling, completions, production, Health, Safety and Environmental (HSE) and mechanical integrity. Before joining Newfield in 2010 he worked for a supermajor oil company and several smaller E&P operators. Lloyd’s current job duties include developing and sharing water use/reuse best practices within Newfield and the broader the E&P industry.
**Abstract 35:**

**Recent Legislative Changes Affecting the Texas Class V Injection Well Program**

Don Redmond, Texas Commission on Environmental Quality, Environmental Law Division  
Lorrie Council, P.G., Texas Commission on Environmental Quality, UIC Permits Section  
David Murry, P.G., Texas Commission on Environmental Quality, UIC Permits Section

**Don Redmond** is a staff attorney with the Environmental Law Division of the Texas Commission on Environmental Quality (TCEQ) in Austin, Texas. He represents the TCEQ in administrative hearings, administrative rulemakings, litigation, legislative hearings, public meetings, and interagency meetings. He has worked with TCEQ’s Underground Injection Control program over the past 16 years on Class I and III injection well permitting actions, rulemaking, legislative implementation, and applications for UIC program revisions submitted to EPA. Mr. Redmond earned a J.D. from the University of Texas at Austin, a M.F.S. in forest science from Yale University, and a B.S. in natural resources from the University of the South in Sewanee, Tennessee.

**Lorrie Council** serves as the UIC Permits Section Manager in the Radioactive Materials Division of the TCEQ. She manages the permitting process and professional geologists and engineers who review applications and write permits and authorizations for Class I, III, IV, and V injection wells in Texas. Ms. Council has 21 years of environmental consulting experience in groundwater protection and restoration and 14 years of Texas state government experience covering UIC permitting, waste disposal, and coastal erosion response. Ms. Council earned a B.S. in Geology from the University of Oklahoma and is a licensed professional geologist in Texas and Arizona.

**David Murry** is a geologist with the UIC Section of the Radioactive Materials Division of the TCEQ in Austin, Texas. He has a Bachelor’s Degree and a Master’s Degrees in Science from University of Texas at El Paso, and is a Texas Licensed Professional Geoscientist with 37 years of geologic and regulatory experience. He has worked as an exploration geologist for base and precious metals in the western United States, and for oil and gas in the offshore Gulf of Mexico, the Texas Gulf Coast, the Mississippi Salt Basin, southern California offshore, and the Alaskan offshore. At the TCEQ, David has worked as a permit writer in the Industrial and Hazardous Waste Permits Section of the Waste Permits Division, and as a permit writer reviewing applications for Class I, III, V UIC wells.

As the saying goes, “Texas is perpetually in a hydrologic drought, punctuated periodically by severe floods.” With increasing population, expanding industry, and the recent record drought, Texas water supplies are strained and the state is actively seeking ways to better manage and develop water resources. Water management techniques such as Aquifer Storage and Recovery (ASR) that had previously seen limited use in Texas over the last 25 years due to the structure of water rights and the Rule of Capture are actively being studied. Extensive, untapped brackish groundwater aquifers are also being explored for potential as new water resources in concert with more effective water treatment technologies. In response to the recent record drought, the 84th Texas Legislature enacted two bills in 2015 related to Class V injection well regulation. These bills pertain to regulation of ASR and disposal of drinking water treatment residuals. House Bill 655 (HB 655) made changes to the way Texas regulates ASR wells, addressing issues such injectate water quality requirements, reporting, and water recovery. HB 2230 made specific provision for TCEQ to permit or authorize disposal of drinking water treatment residuals under its Class V UIC Program into Class II injection wells permitted by the Railroad Commission of Texas. The presentation gives details of the bills and associated legislative implementation highlights.
Abstract 36:

Variations of Seismicity Parameters in Oklahoma and Their Spatial-temporal Correlation with M>4 Earthquake Occurrences
Robin K. McGuire and Arash Zandieh
Engineers with Lettis Consultants International, Boulder, Colorado, with experience in developing and applying methods and software to quantify earthquake hazard and risk for major engineering facilities
email: mcguire@lettisci.com, zandieh@lettisci.com

We analyze earthquakes in central and northern Oklahoma to evaluate the occurrence rate and b-value for moving windows in time, for the period January 2014—November 2015. Throughout much of this time period, using earthquakes with M≥3.0, high b-values appear to precede the occurrences of larger magnitude earthquakes (M>4.0). These results are consistent with other published results (Benz et al, 2015; Wang et al, 2015) but are based on a simple analysis of raw earthquake data published by the USGS, without using very small magnitude data and without separating main shocks from aftershocks. The results are consistent for a range of time windows, time steps, and other parameters of the analysis. Many, but not all, of the larger (M>4.0) earthquakes occur spatially at the edges of prior clusters. In November 2015, the rate of M>4.0 earthquakes increased and the temporal correlation of those events with high b-values decreased. This increase in rate of M>4.0 earthquakes occurred in the northern and western part of the study region, with four M≥4.3 earthquakes occurring during a period of 20 days within a geographical area measuring 60 x 60 km. This is a geographical area where only three M>4.0 earthquakes had occurred in the prior 22 months. This could be the result of changes in underground injection rates, volumes, and pressures. The conclusion from these results is that even gross statistics of M≥3.0 earthquakes in Oklahoma, without detailed statistical analysis of main shock-aftershock dependencies, can produce correlations with subsequent earthquake occurrences and indicate possible dependencies on changes in underground injection rates and volumes.

Abstract 37:

Water Exchange for the Energy Ecosystem
Domenic Corso, Sourcewater

Sourcewater is an online platform developed at MIT that enables energy companies to optimize produced water disposal, treatment, recycling and transport decisions while allowing disposal, treatment and trucking companies to maximize their utilization. The result is lower average costs for operators and higher profitability for service providers at the same time. The principles and processes applied are similar to those employed by the airline and hotel industries to maximize utilization and profitability of airline seat and hotel room sales. Airline seats and hotels rooms are known as perishable inventory: capacity that is not sold today is lost and cannot be sold tomorrow (i.e., once a plane takes off with an empty seat, that seat can never be sold.) Similarly, disposal and hauling capacity that is not sold today cannot be sold tomorrow.

Airlines and hotels solve this perishable inventory problem by creating a deep pool of buyers and sellers on the Internet, so that changes in price and availability are instantly communicated to many potential buyers to match demand with supply. They use tools such as discounts for advanced bookings and fare sales. These influence potential customer decisions on whether and when to travel with whom.

Sourcewater’s Internet marketplace achieves the same benefits for energy companies and service providers, like an “Expedia for water management.” For example, E&P production managers typically choose to dispose of produced water when storage capacity is nearly full. This means they are always paying the last-minute necessity price for disposal. Meanwhile, disposal wells typically charge the same rate every day, whether they have a line of trucks waiting
for disposal or no one showing up at all. If a low utilization disposal well could instantly communicate a discount “fare sale” price to all E&Ps with produced water in its area, an E&P could choose to dispose of a half-full impoundment of produced water at a the sale price today instead of waiting until the storage is full and paying full price. Both sides win through better information. The same model holds for hiring trucking, transfer and treatment services.

Sourcewater went live in April 2015 and now has over 150 registered users including most of the leading E&Ps in the Appalachian Basin.

Domenic Corso is Director of Sales for Sourcewater www.sourcewater.com. Sourcewater, a spinout from MIT’s Energy Ventures program, is the first online exchange for sourcing, transporting, recycling and disposing of water for oil and gas production. Our marketplace enables energy companies to minimize their single largest operating cost, water management, ensure a reliable mission-critical water supply chain, and reduce the environmental and community impacts of energy production.

Prior to joining Sourcewater, Domenic consulted for several water management technology companies including Keystone Pure Water Tech, Lewis Environmental Services and Abtech Industries, with their proprietary technologies for recycling flowback, produced water and acid mine water. He has presented at conferences in the U.S. and Europe on shale water management strategies.

Abstract 38:

New Protocol: Procedures for 7520 Reporting and Updated 7520 Instructions

Beth Hall, USEPA Office of Groundwater and Drinking Water

EPA has developed a new document, Procedures for 7520 Reporting. This document does not ask for changes to the processes currently in place. It does put greater emphasis on detailed review of completed forms. It is, in part, a response to a recent General Accounting Office (GAO) report, EPA Program to Protect Underground Sources from Injection of Fluids Associated with Oil and Gas Production Needs Improvement (GAO-14-555), in which they recommended that EPA develop and implement a protocol for data consistency and completeness so that this data may be reported at the national level.

Additionally, the office has proposed updated 7520 instructions as part of the EPA’s UIC program’s Information Collection Request (ICR) renewal. Once approved, the forms will have the revised instructions and new dates. The current and proposed forms are included as part of the attached document with a summary of changes. The proposed forms cannot be used for reporting until the Office of Management and Budget approves the final ICR.

Abstract 39:

Rethinking Class V Wells: Improving Efficiency and Effectiveness

Candace C. Cady, PG and Brianna Ariotti

Utah Department of Environmental Quality, Division of Water Quality, 1422 UIC Program

Abstract – The UIC Program is an ever evolving program with this year’s priorities upstaging last year’s. Recent topics that have participated in this ‘upstaging’ include: hydraulic fracturing, induced seismicity, and geologic sequestration of carbon dioxide to name a few. These topics are typically associated with the deep UIC well classes. While we certainly do not wish to minimize the importance of those topics, there are still challenges associated with the implementation of the UIC program for Class V wells. With the recent unfreezing of the Class V inventory in the Grant Allocation Model for the UIC Program, it seems like a good time to check in with the Class V programs to discover what the current pressing issues are in the Class V universe of injection wells. To that end, GWPC’s Class V Workgroup has prepared a questionnaire which we hope all Class V programs will complete. Our intent is to focus on those issues of importance to the Class V programs. By building upon the knowledge base in the 1987 Report to Congress, the 1999 Class V Study, and the
file rooms of our Class V program partners, we hope to come together to share our successes and maybe even come up with some suggested new tactics for improving the efficiency and effectiveness of implementing the Class V program.

**Candace C. Cady** has administered the 1422 UIC Program for the Utah Division of Water Quality since 2003. In addition to day to day activities of program administration, Ms. Cady spearheaded the development of the enterprise geodatabase for Utah’s UIC Program; participated on the National Integrated Project Team for the development of the National UIC Database; and served as State Co-Chair of the National UIC Data Management Steering Committee. She also served on the UIC National Technical Workgroup for 2 years. Ms. Cady has been actively involved with the Ground Water Protection Council serving on several workgroups including, most recently, the Class V Workgroup and the Aquifer Exemption Workgroup. Ms. Cady received a B.A. in Earth Sciences from DePauw University in Indiana and an M.S. in Geology from the University of Utah. [https://www.linkedin.com/in/candaceccady](https://www.linkedin.com/in/candaceccady)

**Brianna Ariotti** - Brianna Ariotti is an Environmental Scientist with the Utah Department of Environmental Quality, Division of Water Quality in the Ground Water Protection Section. She is a graduate of Utah State University and has been with the Division for 12 years. Class V wells have been her priority for the past few years while also focusing on outreach and division/agency coordination in order to maximize efficiency and progress within the UIC program.

Abstract 40:

**Water Treatment and Car Washes**

Craig Boomgaard, USEPA Region 8

As treatment technology improves and the cost goes down, many municipalities and residences are turning to filtration and reverse osmosis systems to improve the quality of their drinking water. While this method improves water quality for the user, it generates some concentrates that may create disposal issues. In addition to great quality drinking water, this water makes spot free rinses at the car wash possible, which can generate wastes that may also have disposal issues.

This presentation covers the water treatment industry and how wastes from water treatment are disposed by injection. It also looks at the car washing industry, the potential contaminants generated, and how their wastes are regulated.

Region 8 Class V Session

- Water Treatment Residual Management and Class V UIC with a short discussion of Class I municipal disposal wells.
  - Home water softener treatment residual management
  - Small municipal and industrial water treatment residual management
- Carwash Rinse Disposal Permitting
  - On site pre-treatment
  - Water/oil separation
  - Water recycling units
  - Water treatment residual
  - Constituents of concern

**Mr. Boomgaard** has over 21 years of experience in the hydrogeologic and geologic fields. He is a graduate of Colorado State University B.S. Geology. He currently serves as EPA Region 8’s Class V team leader among other duties. He worked for the South Florida Water Management District writing water use permits and served on the South Florida UIC technical advisory committee. Has experience in the UST, hazardous waste clean up and mine reclamation, specializing in uranium mills. Craig is a licensed well driller in Florida, a professional geologist in Florida and Texas and a Project Management Professional.
Abstract 41:

Aquifer Storage and Recovery in Region 8
Craig Boomgaard, USEPA Region 8

Aquifer Storage and Recovery (ASR) is becoming more prevalent in the Region due to the dry climate and increasing population, especially in Colorado. EPA has direct implementation authority for Class V wells in Colorado, South Dakota and Montana. New concerns about disinfection by products, more stringent MCLs, and a re-evaluation of EPA’s ASR program have changed how EPA assesses ASR projects.
This presentation covers:
- How ASR is different in Region 8 than in other parts of the country, like Florida
- What constituents in the injectate, native formation waters (connate), and recovered water EPA is looking at as part of its risk evaluation, including disinfection by products
- Coordination with the Drinking Water program in looking at treatment processes, which may impact geochemical reactions in the subsurface.
- Startup cycle testing
- Water quality and regulatory outcomes

Mr. Boomgaard has over 21 years of experience in the hydrogeologic and geologic fields. He is a graduate of Colorado State University B.S. Geology. He currently serves as EPA Region 8’s Class V team leader among other duties. He worked for the South Florida Water Management District writing water use permits and served on the South Florida UIC technical advisory committee. Has experience in the UST, hazardous waste clean up and mine reclamation, specializing in uranium mills. Craig is a licensed well driller in Florida, a professional geologist in Florida and Texas and a Project Management Professional.

Abstract 42:

Treating Produced Water for Beneficial Use – Current Challenges and Potential Future Advances
Rick C. McCurdy, Chesapeake Energy

While a whole session could easily be devoted to the regulatory aspects of treating produced water for beneficial reuse, this presentation instead focuses on the technical, environmental and economic challenges associated with this treatment. Along with a discussion of treatment technologies applicable to certain produced waters, this presentation will also address the often over-looked by-products of this treatment such as waste disposal and transportation of same. Additionally, power demands of some of these technologies will be addressed along with potential effects on the local environment. Finally, the presentation will cover several promising technologies that offer potential solutions to many of these hurdles.

Rick McCurdy – Manager, Chemicals and Water Reclamation – Chesapeake Energy Corporation
Rick currently leads the team that oversees Chesapeake’s production and completion chemical usage. He is also one of the primary architects of Chesapeake’s Industry-leading GreenFrac® program that focuses on environmentally friendly hydraulic fracturing additives and Chesapeake’s initiative championing reuse of produced water – AquaRenew®. During his career, Rick has worked with chemical and water issues from the North Slope of Alaska to the Gulf of Mexico and from offshore California to the Northern Marcellus Shale. Rick is an active member of SPE, NACE International and Mensa International, has served as a technical expert during the US EPA workshops on hydraulic fracturing and has presented to the National Academy of Sciences, the Government Accountability Office and the Department of Energy regarding water use in the Energy Sector. Rick has an AAS degree in Petroleum Technology.
Abstract 43:

Treatment of Hydraulic Fracturing Wastewaters through a Hybrid Coagulation-Nanoporous Membrane Filtration-Biological Treatment Process

Richard D. Noble, James Rosenblum, Sarah Dischinger, Douglas Gin, Karl Linden

University of Colorado, Boulder

Hydraulic fracturing uses large volumes of potable water in the fracturing fluid, that then returns as wastewater (produced water) during oil and gas production. These wastewaters contain high levels of total suspended solids (TSS), dissolved organic carbon (DOC), and total dissolved solids (TDS), posing a challenge for classic wastewater treatment methods. Innovative approaches are needed to remove all three fractions to achieve dischargeable water. This research investigates the development of an innovative treatment train which allows for the simultaneous recovery of dischargeable water (Water Reuse standards, < 2,000 mg/L TDS) and the production of biofuel, from the substantial biodegradable carbon present in produced waters. This train consists of coagulation, a custom polymer-based nanofiltration membrane, and biodegradation (biofuel generation). Coagulation reduced the turbidity of the raw water (110 NTU) by 77%. The resulting water, having a TDS of around 18,500 ppm and a DOC of 1360 ppm was then passed through the nanofiltration membrane, achieving a 90% reduction of TDS and 87% reduction of DOC, given a 37% water recovery. The permeate was then fed to municipal activated sludge, in which 87% of the remaining DOC was consumed, suggesting that the majority of what passed through the membrane is bio-degradable. The resulting water was at conditions suitable for discharge by Water Reuse Standards. This three-step treatment train is unique in its ability to isolate the biodegradable portion of DOC; reverse osmosis membranes reject everything while commercial nanofiltration membranes do not have the same capacity to reject TDS while letting small organics permeate. Further research is under way to confirm these initial rejection results, the stability of the nanofiltration membrane under long term exposure to produced water, and the ability to produce biofuel or biomaterials from the biodegradable DOC present in the membrane permeate.

Prof. Noble is the Alfred T. and Betty E. Professor of Chemical Engineering and Co-Director of the NSF Membrane Applied Science and Technology (MAST) Center at the University of Colorado. He has 80 patents/applications and 320 research publications. He is an internationally recognized leader in the use of novel membrane and thin film materials for chemical separations.

His sixteen research awards include CU Inventor of the Year, AIChE Excellence in Industrial Gas Technology and ACS National Award for Separation Science and Technology. He has been chair of the Gordon Research Conferences on Separation and Purification, and Membranes: Materials & Processes.

Abstract 44:

Class II UIC Roundtable Agenda

Mark Bohrer, North Dakota Industrial Commission, Moderator

Mike Nickolaus, GWPC, Notes

1. Induced seismicity (The next “Hydraulic Fracturing” target for the media?)
2. Dual permitting of Class I and Class II wells (A legal or technical question and what does the CFR say?)
3. Aquifer exemption in the Class II programs (USEPA position and discussion)
4. 7520 reporting (Beth Hall, USEPA)
5. “New Protocol: Procedures for 7520 Reporting and Updated 7520 Instructions” (Abstract 38)
6. Open discussion of other issues
Class III UIC Roundtable Agenda

Abstract 45:

TIME TOPICS
2:30 PM Introductions and Review Topics below for Discussion and Identification of Missing Topics
2:40 PM
- Permitting and Permit Revision Issues
  - Impacts of Mining Slow Down to Direct Implantation and Delegated Programs
    - Have the programs (EPA and States) seen a corresponding decrease in the number of Class III applications being submitted?
    - Have any applications been treated by EPA as higher than a “non-substantial” revision to a state program?
- Aquifer Exemptions
  - Update from EPA on the AE database and how they propose it would be maintained/updated
  - Discussion from all regarding EPA Aquifer Exemption Checklist implementation
  - Discussion on how “future use” is being determined.
- NRC’s IMPEP review of the TCEQ’s radioactive materials program and how it related to the Class III program.
- UMRCA 192 Rule change status and discussion of how this proposed rule may impact your program if adopted as proposed. Final Rule is projected to be published in FR 12/2016
  http://yosemite.epa.gov/opei/rulegate.nsf/byrin/2060-ap43
- Electronic Reporting Issues/Problems Reporting requirements:
  - Abstract 38: New Protocol: Procedures for 7520 Reporting and Updated 7520 Instructions, Beth Hall, USEPA Office of Groundwater and Drinking Water
- General Information
  - Update on progress on revisions to the UIC Section of the GWPC Report to the Nation for Class III. Information needed on what is wanted?
  - Revision of ASR/AE Working Group Resolution -- Coordination with Class V Committee

3:35 PM Wrap-up, Identification of Action Items, and set Next Meeting
3:40 PM Adjourn

Abstract 46:

Class I UIC Roundtable Agenda

- EPA Presentation
  “New Protocol: Procedures for 7520 Reporting and Updated 7520 Instructions” (Abstract 38)
  Beth Hall, USEPA Office of Groundwater and Drinking Water
- Formation of a UIC Class I State Regulators Working Group
  Board of Directors Resolution
  Industry participation
  Hazardous Waste Disposal Wells – No Migration Petitions
  UIC Reporting Requirements and Procedures
- Aging Wells Issues - Lifespans and Repermitting
- Pore Space competition with Class II wells
- Discussion of Aquifer Exemption Checklist relative to Class I Injection wells
- Update: Ground Water Report to the Nation – Underground Injection Control Chapter
Abstract 47:

**Well-Specific Class V Data: 200,000 Wells and Counting**

Keara Moore, USEPA Office of Ground Water & Drinking Water

Keara Moore is a team lead in EPA’s national UIC program at the agency’s Office of Ground Water and Drinking Water in Washington, DC. She has worked on water quality issues at the EPA for 11 years, the last four in the UIC program. Her primary project areas are the National UIC Database and Class V policy. Keara has a B.A. in Chemistry and an M.S. in Hydrology.

The National UIC Database collects well-specific inventory and compliance data with the long term goal of replacing paper 7520s for reporting. There are currently 16 agencies using the NUICDB as the official data of record for their Class V programs, representing more than 200,000 active wells. With this, we have achieved sufficient population to find value in beginning to apply and evaluate the data and have conducted some data analysis. While data provides a foundation for understanding Class V programs, it does not tell the whole story, so we also met with Regions to learn more about how the data represented their programs. We will be presenting results from this consideration to stimulate discussion about how data can be most helpful and ways to improve and better target data collection.

Abstract 48:

**Opportunities and Challenges for Beneficial Use of Produced Water**

Erik Anglund, Anadarko Petroleum Corporation

Anadarko Petroleum Corporation has long held safety and environmental protections as a high priority, and as the company continues to grow its operations, it is continuously evolving its water management practices through technology and innovation to minimize impacts. As part of this effort, the company is evaluating how to manage its water supply and demand characteristics in a resilient and sustainable manner for the benefit of operations and the region. Produced water provides both opportunities and challenges for the company and industry. Keys to effective management include balancing resources, risk, the public, and regulations with available infrastructure, technology and regional water demand. This presentation will address such challenges, including regulatory conditions, and highlight opportunities for beneficial use of produced water.

Erik Anglund is a Water Resource Engineer for Anadarko Petroleum Corporation supporting the Wattenberg Field and additional Rockies and Corporate water related activities. As a native Colorado farm kid, Erik has spent his career working in water resources and navigating the challenges of Colorado hydrology and water law. In previous roles, Erik worked on substitute water supply plans, augmentation plans, and engineering for state and local water court cases. Erik was also responsible for municipal water supply planning, water quality monitoring and reporting, water conservation programs, and water rates analyses. At Anadarko, Erik is involved with the company’s many operations that rely on the water lifecycle including construction, drilling, hydraulic fracturing, production, disposal and recycle. Erik received a B.S. in Mechanical Engineering, M.S. in Agricultural Engineering, M.S. in Organizational Leadership, and PE license in Civil Engineering.
## Class V UIC Roundtable Agenda

<table>
<thead>
<tr>
<th>TIME</th>
<th>TOPICS</th>
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<tbody>
<tr>
<td>3:45 PM</td>
<td>• Introductions and Agenda Review</td>
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<tr>
<td>3:50 PM</td>
<td>• General Class V Information Exchange</td>
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<td>- Reporting requirements:</td>
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<td>- Abstract 38: New Protocol: Procedures for 7520 Reporting and Updated 7520 Instructions, Beth Hall, USEPA Office of Groundwater and Drinking Water</td>
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<td>4:00 PM</td>
<td>• Class V Well Subclasses Workgroup</td>
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<td>- Well-Specific Class V Data: 200,000 Wells and Counting, Keara Moore, Underground Injection Control Program, Office of Ground Water and Drinking Water</td>
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<td>- Abstract: The National UIC Database collects well-specific inventory and compliance data with the long term goal of replacing paper 7520s for reporting. There are currently 16 agencies using the NUICDB as the official data of record for their Class V programs, representing more than 200,000 active wells. With this, we have achieved sufficient population to find value in beginning to apply and evaluate the data and have conducted some data analysis. While data provides a foundation for understanding Class V programs, it does not tell the whole story, so we also met with Regions to learn more about how the data represented their programs. We will be presenting results from this consideration to stimulate discussion about how data can be most helpful and ways to improve and better target data collection.</td>
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<tr>
<td></td>
<td>- GWPC questionnaire to gather information on Class V programs (handouts)</td>
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<td>- Purpose and who will be polled</td>
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<td>- What topics will be addressed?</td>
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<td>- Sneak-peek of the questionnaire</td>
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<td>4:25 PM</td>
<td>• Process that will be used to conduct survey.</td>
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<td>- When to expect to receive the questionnaire and timeframes for response</td>
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<td>4:35 PM</td>
<td>• Aquifer Storage and Recovery/Managed Aquifer Recharge (ASR/MAR)</td>
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<td>- GWPC ASR Task Force: Reactivation, Membership, and Purpose (handout)</td>
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<td>- ASR National Inventory (F. Bloetscher) and Oklahoma ASR Survey</td>
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<td>- ASR Chapter Groundwater Report to the Nation</td>
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<td>• General discussion if time permits or if of interest to participants</td>
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<td>- Program funding Issues</td>
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<td>- Problems with registration/inventory forms for new wells/compliance</td>
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<td>- Drinking water residuals disposal/injection</td>
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<td>- Other well type specific problems</td>
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<tr>
<td>5:00 PM</td>
<td>• Wrap-up and Next Meetings</td>
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Abstract 50: Biographical Sketches

Richard J. Simmers
Ohio Department of Natural Resources

Richard J. Simmers, Chief Division of Oil & Gas Resources Management Ohio Department of Natural Resources

As Chief of the Ohio Department of Natural Resources’ Division of Oil and Gas Resources Management, Rick Simmers is responsible for enforcing Ohio’s laws related to oil and gas drilling, production, plugging, orphan wells, solution mining, enhanced recovery, gas storage, and underground injection control operations.

An ODNR career employee, Simmers began working for the Oil and Gas Program in 1985. Over the years he has served as a staff geologist, ground water investigator, acting chief and statewide field enforcement administrator.

Rex Buchanan
Interim Director, Kansas Geological Survey

Rex grew up near Little River, in Rice County, Kansas, on the edge of the Smoky Hills. He has been at the Kansas Geological Survey, based at the University of Kansas, since 1978, and has been the Interim Director since 2010. He is the co-author of Roadside Kansas: A Guide to its Geology and Landmarks (rev. edition, 2010) and editor of Kansas Geology: An Introduction to Landscapes, Rocks, Minerals, and Fossils (rev. edition, 2010), both published by the University Press of Kansas; co-author of The Canyon Revisited: A Rephotography of the Grand Canyon, 1923-1991, published by the University of Utah Press (1994); and co-editor of Geowriting, published by the American Geological Institute (1995).

He is currently the Secretary of the Association of American State Geologists, past chair of the Geology and Public Policy Committee of the Geological Society of America (GSA), and past president of the Kansas Association for Conservation and Environmental Education (KACEE), the Kansas Academy of Science, and the Association of Earth Science Editors. He chairs the Kansas Task Force on Induced Seismicity. In 2008 he was named a Fellow of GSA, and in 2009 was given the John Strickler award for environmental education from KACEE. He also provides occasional commentaries on Kansas Public Radio.

He has an undergraduate degree from Kansas Wesleyan University and graduate degrees from the University of Wisconsin-Madison.

Ivan Wong
Principal Seismologist and Vice President, AECOM

Ivan Wong is an internationally recognized expert in seismic hazard evaluations with more than 40 years of experience in the fields of engineering seismology and seismic geology. A major focus in his career has been earthquake hazard reduction and awareness and public outreach. At AECOM, Mr. Wong has directed the seismic hazard evaluations of more than 600 critical and important facilities worldwide, many for the Federal government. He has managed some of the largest seismic hazard evaluations performed in the U.S. including the Yucca Mountain Project, the largest study ever performed.

One of Mr. Wong’s areas of applied research has been induced seismicity due to fluid injection and extraction, hydraulic fracturing, reservoir impoundment, and mining. He has evaluated the causes and impacts of wastewater injection and/or hydraulic fracturing-induced seismicity in Colorado, Ohio, West Virginia, Texas, California, and Alberta, Canada. He served on the U.S. Bureau of Reclamation’s expert panel on induced seismicity in the Paradox Valley, Colorado. Mr. Wong was a coauthor of DOE’s Protocol and Best Practices documents on geothermal induced seismicity.

In addition to his work at AECOM, Mr. Wong has been actively involved in the activities of several professional organizations. He is past member of the Earthquake Engineering Research Institute (EERI) Board of Directors, past President of the EERI Northern California Chapter, past member of the Editorial Board for EERI’s Earthquake Spectra, and serves as an Associate Editor for the Seismological Society of America. He has been or is a member of numerous scientific and engineering committees, panels, and working groups. For example, Mr. Wong serves as the Chair of the Working Group on Utah Earthquake
Probabilities and is a member of the California Integrated Seismic Network Advisory Panel, National Steering Committee for the Advanced National Seismic System, and the American Nuclear Society Working Groups on Probabilistic Seismic Hazard Analysis and Surface Fault Rupture and Deformation. He has also been particularly active in serving the U.S. Geological Survey on several review and advisory panels including the review panel for the 1996 national hazard maps.

Mr. Wong has been an invited speaker at more than 150 professional meetings and conferences. He has been an invited lecturer at 14 universities worldwide and has taught courses on earthquakes and earthquake hazards including at the California Academy of Science. Mr. Wong has authored or coauthored more than 350 professional publications.

Leslie Savage  
**Assistant Director for Technical Permitting, Oil and Gas Division, Railroad Commission of Texas**  
Over her 32 years of employment with the Commission, Ms. Savage helped develop and/or supervised the Commission’s programs for underground injection control, surface waste management, hazardous oil and gas wastes, naturally occurring radioactive material, waste minimization, and geologic storage of carbon dioxide. Ms. Savage currently is responsible for managing the Groundwater Advisory, Engineering, UIC, and Environmental Permitting Units, as well as coordinating rulemaking for the division, coordinating with federal and other state agencies, and water quality certification of federal permits.

Ms. Savage has represented the Commission in several state and national organizations, including the Texas Groundwater Protection Committee, the Executive Committee of the Coastal Coordination Council, the Governor’s Environmental Task Force, and the Interstate Oil and Gas Compact Commission, and currently is on the boards of the national Ground Water Protection Council and the State Review of Oil and Natural Gas Environmental Regulations, Inc. (STRONGER, Inc.). Ms. Savage graduated from the University of Texas at Austin in 1982 with a B.S. in Geology.

Vanessa Ryan  
**Chevron Corporation**  
Vanessa Ryan is Senior Adviser, Shale Issues at Chevron Corporation. Previously, she was Senior Advisor for Chevron Asia-Pacific Exploration and Production, responsible for providing advice to Chevron’s Asia-Pacific business on government and public affairs issues, including trade and community engagement. She has served as Coordinator for Policy, Government, and Public Affairs for Chevron Vietnam in Ho Chi Minh City. Ms. Ryan joined Chevron as a Public Policy Adviser, where she was responsible for the corporate responsibility report and advised on environmental, social, and geopolitical issues. She holds a Masters of Public Policy from the University of Southern California and a B.A. in Political Economy from the University of California, Berkeley.

Michel J. Paque  
**Executive Director, Ground Water Protection Council**  
Among the responsibilities of Executive Director for the Ground Water Protection Council (GWPC) are developing and maintaining an effective relationship between the GWPC, its member components, and the U.S. DOE and U.S. EPA; monitoring legislation, rule making and guidance development related to groundwater issues; increasing membership; developing position papers; and representing GWPC on national and federal work groups and committees.

John Veil  
**Veil Environmental, LLC**  
John Veil founded Veil Environmental, LLC, a consulting practice specializing in water issues affecting the energy industries, upon his retirement from Argonne National Laboratory in January 2011. Mr. Veil spent more than 20 years as the manager of the Water Policy Program for Argonne National...
Laboratory. Before joining Argonne, Mr. Veil managed Maryland’s regulatory programs for industrial wastewater discharge and injection and served as a faculty member of the University of Maryland. Mr. Veil has degrees in Earth and Planetary Science, Zoology, and Civil Engineering. Mr. Veil has been recognized by the Society of Petroleum Engineers as a Distinguished Lecturer in 2008-2009 and 2013-2014 and as the recipient of the 2009 international award for Health, Safety, Security, Environment and Social Responsibility. Mr. Veil has published many articles and reports and is frequently invited to make presentations on environmental and energy issues.

Matt Lepore, Director
Colorado Oil and Gas Conservation Commission
Matt Lepore is an attorney by profession, with nearly 20 years’ experience in environmental and natural resources law and policy. In 2009, after many years in private practice, Mr. Lepore joined the Colorado Attorney General’s office where he served as counsel to the Colorado Oil and Gas Conservation Commission. Mr. Lepore became Director of the Commission in August 2012. During his tenure as Director, Mr. Lepore has guided the Commission through three significant rulemakings; one historic flood; an earthquake of suspicious origins; bans, moratoria, and ballot initiatives; a Governor-appointed Task Force on State and Local Regulation of Oil and Gas; a five-fold increase in the number of horizontal wells drilled each year; two-successive years of record-breaking oil production; and one breath-taking drop in the price of oil.

Mr. Lepore speaks frequently on Colorado’s model for regulating oil and gas development generally and unconventional development in particular. He has been privileged to testify before the U.S. House Committee on Energy and Commerce, and before the Secretary of Energy Advisory Board FracFocus 2.0 Task Force. He has traveled to Indonesia and South America at the request of the U.S. State Department to speak about developing unconventional oil and gas resources; he has recently participated in The Aspen Institute’s Energy and Environment Program; and in an international dialogue, “Defining and Measuring Regulatory Excellence,” hosted by the University of Pennsylvania’s Program on Regulation.

Mr. Lepore is a Colorado native who graduated from the University of Colorado, Boulder, and later earned a J.D. from Stanford Law School. He is a past Chair of the Environmental Law Section of the Colorado Bar Association, as well as Colorado Lawyers for the Arts. He currently Chairs the Legal and Regulatory Affairs Committee of the Interstate Oil and Gas Conservation Commission. In his “spare time” he practices yoga, skis, and rides his bike while wearing a helmet.

Peter Grevatt, Ph.D.
Director, USEPA Office of Ground Water & Drinking Water
Peter Grevatt is the Director of the Office of Ground Water and Drinking Water. The Office of Ground Water and Drinking Water in collaboration with states, tribes and its many stakeholders, is responsible for safeguarding America’s drinking water. Over 300 million Americans nationwide rely daily on public water systems to provide them with safe drinking water in the convenience of their home.

He is responsible for the development and implementation of national drinking water standards, oversight and funding of state drinking water programs and the implementation of source water protection and underground injection control programs to protect public health nationwide.

Prior to joining the OGWDW in October of 2012, Peter Grevatt served as the Director of the Office of Children’s Health Protection and served as the Senior Advisor to EPA’s Administrator for Children’s Environmental Health. Peter has held leadership roles in EPA’s national hazardous waste and water quality programs. Peter received his M.S. and Ph.D degrees in Basic Medical Sciences from New York University Medical Center and earned his bachelor’s degree in Biology from Earlham College.
Holly Pearen  
Environmental Defense Fund  
Holly Pearen is a Senior Attorney for EDF’s US Climate and Energy program, where she focuses on oil and gas regulation and policy. Holly works with stakeholders in key states and federal agencies to improve environmental performance and oversight of oil and gas production activities, with specific focus on mitigating potential impacts to land and water from oil and gas waste, and beneficial use of produced water. Prior to EDF, Holly worked in the Department of the Interior’s Office of the Solicitor, counseling BLM and NPS on issues related to oil and gas leasing, and in private practice.

Ben Binder, PE, PLS, MBA  
Digital Design Group  
Ben is a Registered Professional Engineer and Land Surveyor. He has an engineering degree from Tufts and an MBA from Cornell. After college, Ben joined the Peace Corps and constructed rural schools in Ecuador and the Galapagos Islands. In 1982, Ben founded Digital Design Group which developed the first automated systems for both the Colorado Oil & Gas Commission and the Colorado State Land Board. Ben played an early role in the development of the GWPC’s RBDMS system and has worked for oil and gas commissions and state land offices throughout the nation. He testified before a US Senate Committee investigating the Secretary of Interior’s management of Indian oil and gas, and assisted the Southern Ute Indian Tribe with their landmark lawsuit determining ownership of natural gas produced from coalbeds. For over 20 years, Ben has represented Colorado on the Energy Resources, Research and Technology Committee of the IOGCC.

Linda A. Capuano  
Baker Institute Center for Energy Studies  
Linda A. Capuano, Ph.D., is the fellow in energy technology at the Rice University’s Baker Institute Center for Energy Studies. Her research interests focus on the energy-water-food stress nexus. She is also an instructor in Operations Strategy at Rice University’s Jones Graduate School of Business. Capuano’s career has centered on commercializing technology innovation through her network and experience in high-tech companies, where she has navigated new technologies from design to successful commercialization. She previously served as company officer and vice president of technology at Marathon Oil Corporation; senior vice president of engineering design at Solectron Flextronics; executive vice president and chief technology officer at Advanced Energy Industries; corporate vice president of technology strategy at Honeywell; general manager of wide body aircraft auxiliary product units (APUs) at AlliedSignal Aerospace; and manager in computer memory product development at IBM. She was co-founder and served as chief financial officer of Conductus, a Silicon Valley start-up that commercialized ceramic superconductor technology discovered in the 1980s.

She currently serves on the board of directors of Peak Reliability, providing bulk electricity system oversight within the Western Electricity Coordinating Council’s (WECC) footprint. She is also a technical advisor to Green Earth Greens Ecopia Farms, dedicated to urban food sustainability, and an associate member of the National Academies of Sciences, an elected lifetime position. Capuano was awarded the Technical Excellence Award by the Society of Women Engineers and the IBM Outstanding Achievement Award, recognizing contributions to computer memory storage. She received her Ph.D. in materials science and engineering and M.S. in engineering management from Stanford University; an M.S. in chemistry and B.S. in chemical engineering from the University of Colorado at Boulder; and a B.S. in chemistry from the State University of New York at Stony Brook.
Vanessa Ryan
Chevron Corporation
Vanessa Ryan is Senior Adviser, Shale Issues at Chevron Corporation. Previously, she was Senior Advisor for Chevron Asia-Pacific Exploration and Production, responsible for providing advice to Chevron’s Asia-Pacific business on government and public affairs issues, including trade and community engagement. She has served as Coordinator for Policy, Government, and Public Affairs for Chevron Vietnam in Ho Chi Minh City. Ms. Ryan joined Chevron as a Public Policy Adviser, where she was responsible for the corporate responsibility report and advised on environmental, social, and geopolitical issues. She holds a Masters of Public Policy from the University of Southern California and a B.A. in Political Economy from the University of California, Berkeley.

Michael Teague
Oklahoma Secretary of Energy and Environment
Michael Teague is serving as Oklahoma’s first secretary of Energy and Environment. Prior to his appointment, Teague served in the U.S. Army for nearly 30 years before retiring with the rank of Colonel.

Teague served in many capacities during his time in the Army including commander for the Tulsa District of the U.S. Army Corps of Engineers where he was responsible for a civil works program encompassing all of Oklahoma, a large portion of southern Kansas and the panhandle of northern Texas. He oversaw over 700 employees in engineering, construction and operations, as well as an annual budget of $700 million.

Throughout his career, Teague has dealt with power generation and distribution, water desalinization, and environmental impact studies. He has facilitated and negotiated numerous solutions regarding federal and state agencies, tribes, and local stakeholders.

Teague also served in operational assignments in Germany, Honduras, Saudi Arabia, Egypt, and numerous stateside duty stations. He deployed several times to the Middle East and central Asia including commanding the 52nd Engineer Battalion in Mosul, Iraq in support of the 101st Airborne Division as part of Operation Iraqi Freedom in 2003.

Teague received a Bachelor’s of Science degree in civil engineering from Norwich University. He also received Master’s degrees in operations analysis from the Naval Postgraduate School and in national security and strategic studies from the Naval War College.

Jill E. Cooper
Anadarko Petroleum Corporation
Jill Cooper is a Corporate HSE Manager of Reporting and Advocacy for Anadarko Petroleum Corporation and works on global health, safety, and environmental matters for the company. She received her MBA in International Business at Thunderbird School of Global Management and continued on to receive her JD in Environmental Law at the University of Colorado Law School (1996). She has since then held several positions including the Senior Advisor to the Executive Director on environmental matters, Director of the Sustainability Division and Legal Administrator for the Air Pollution Control Division at the Colorado Department of Public Health & Environment. She also practiced environmental, natural resource and sustainability law as an Attorney with Faegre & Benson LLP. Ms. Cooper was the Group Lead in the divisional environmental program for Encana Oil & Gas Inc., which included air, water, waste, land, wildlife, and sustainability. She specializes in sustainability, environmental and regulatory legal, management as well as oil and natural gas.
Mike Hightower  
**Sandia National Laboratory**

Mr. Hightower is a Distinguished Member of the Technical Staff in the Military and Energy Systems Analysis Department at Sandia National Laboratories in Albuquerque, New Mexico. Mike holds Bachelor’s and Master’s degrees in civil and environmental engineering from New Mexico State University and has over 35 years of experience in structural and environmental research. His current research focus is on the use of distributed and renewable energy technologies and distributed water and waste water systems to enhance sustainable development, global public health, and infrastructure resiliency and security. Since 2006 he has supported the US Department of Energy in developing a science and technology program to address energy and water interdependencies. Most recently he co-authored a research program plan for the National Science Foundation on energy and water, assisted the National Research Council in identifying key energy water challenges and needs, and authored a chapter on energy development impacts on water resources for a new Sustainable Energy Development book being published by CRC Press. Mike has published over 120 technical papers and reports including articles in *Nature*; Reports to Congress on establishing a national brackish groundwater desalination research center in New Mexico, and on emerging water and energy interdependencies challenges; and has co-authored chapters on advanced desalination technologies and global energy and water challenges in two additional books.
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