EFD Sponsors' Report

January 03, 2014

The Environmentally Friendly Drilling Systems Program

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Contents

INTRODUCTION

The Environmentally Friendly Drilling Systems (EFD) Team is pleased to provide this report to the Sponsors. This report discusses progress, accomplishments and challenges. We believe we are successfully meeting our goals of providing (1) new research, (2) information, education and training, and (3) engagement and services to the community—all in the area of sustainable development of energy resources.

We want to recognize all our sponsors:

Research Partnership to Secure Energy for America (RPSEA)/National Energy Technology Laboratory
US Fish & Wildlife Service/Texas General Land Office (GLO manages on behalf of the Texas Coastal Land Advisory Board)
Apache
bp
Chevron
Hess
Pioneer Resources
Shell
Statoil
Basin Engineering
CSI Technologies
Det Norske Veritas
Halliburton
Huisman
Katch Kan
Keane Group
MI SWACO
National Oilwell Varco
Newpark Resources Inc.
Scott Environmental Services
Tenaris
WyoComposites, LLC

The EFD program, also has environmental and regulatory advisors that assist in the overall program, including:

The Nature Conservancy
Environmental Defense Fund
Ducks Unlimited
Texas Railroad Commission
Texas General Land Office
Texas Commission on Environmental Quality

The EFD team maintains a relationship with many more industry and environmental organizations as well as with various local, state and federal agencies across the USA and other governmental entities in other countries. This is an added and valuable benefit EFD provides to all sponsors. Organizations that the EFD team collaborates with include:

International Association of Drilling Contractors
Hart Publications
American Association of Petroleum Geologists
Alamo Area Council of Governments
Petroleum Technology Transfer Council
Consumer Energy Alliance
Groundwater Protection Council

Our EFD sponsors fund the program for three years, having the option to renew their membership on an ongoing basis. In addition to the financial support, our sponsors help us manage the overall effort, participating in meetings and research efforts. In return, our sponsors enjoy the following benefits:

- Access to EFD Alliance – EFD expert teams can be established to work with members on specific issues.
- Quarterly Advisors Meetings.

- Engagement in EFD Projects.
- Voice in Program Direction.
- Access to Reports, Review Meetings, etc.
- Networking with Environmental Organizations.
- Networking with Community Groups.
- Communication via EFD Team with Regulators, Legislators, Agencies.
- Direct Focus of Membership Fee – Consortium members may decide where their fees may be used.

This report discusses the entire EFD program. Begun with funding from the U.S. Department of Energy in 2005 and then receiving funding under the RPSEA Unconventional Natural Gas and Other Petroleum Resources Program in 2009, funding from the US Agency for International Development (USAID) in 2010, additional RPSEA funding in 2012, and funding from the US Department of Interior in 2011, along with funding from various stakeholders, the EFD program ***provides unbiased science and develops solutions to address environmental and societal issues associated with oil and gas development***. Featuring an international research team, the program has had many accomplishments. The accomplishments so far have been rather remarkable in that the program has successfully brought together government agencies and regulators, industry, academia, environmental organizations, a variety of associations and the public. As ***RigZone*** reported,

> ***"No other organization in the oil and gas area has ever been able to successfully link this broad spectrum of stakeholders, providing opportunities for communication between groups that normally do not communicate very well."***

A testament to the program's success is the number of speaking invitations and the large number of publications in a broad variety of media. Engaging sponsors and all stakeholders, the EFD team has accomplished it all by being objective and using sound science in supporting workable practices to reach our goals.

The EFD team has had several successes throughout the year. Notably, in 2013 the EFD team has:

- Issued Report concerning **Geographical, Geological and Hydrogeological Attributes of Formations in the Footprint of the Eagle Ford Shale**
- **Continued to develop EFD Regional Centers** throughout the USA and Europe to provide local expertise to regional environmental issues.
- **Continually updated the EFD website: www.efdsystems.org**
- **Expanded the EFD Virtual Rig Site: www.efdvirtualsite.org** hosted by Ralph and Rhonda Roughneck™ and initiated the development of a virtual Hydraulic Fracturing Site.
- **Issued** webinar **training for FracFocus 2.0.**
- **Tested and revised the EFD Scorecard** to measure the effectiveness of cost effective, environmentally sensitive technologies, systems and operations.
- **Received endorsement from Resources for the Future** for the EFD Scorecard.
- **Maintained website for best management practices (www.oilandgasbmps.org)** to address environmental rules and regulations.
- **Initiated comparative law study and uploaded the water quality component** of this searchable database (www.lawatlas.org/oilandgas)**.**
- Published ***Environment 24/7 – Building a Culture of Environmental Awareness***, a sequel to ***Safety 24/7.***
- **Assisted** The Nature Conservancy and other landowners in **Osage county, OK** on the environmental issues associated with the new Mississippi Lime activity. **Published the Osage Report.**
- Established the **"Powered by Natural Gas"** research initiative, **PbNG** ™, to explore natural gas power and fuel for drilling and hydraulic fracturing.
- **Issued the first in a series of PbNG White Papers** concerning the basics of powering drilling and hydraulic fracturing operations with natural gas.
- Held **numerous workshops** to discuss low impact systems for specific regions.
- **Worked with the Petroleum Technology Transfer Council** (PTTC) to provide speakers for their workshops and hosting a joint workshop with PTTC East Region on Well Integrity and Power by Natural Gas.

- **Regularly briefed state officials, Congress and Congressional staff members** on 'hot topic' E&P activities and on the value of the EFD program and the importance of the RPSEA program's financial support.
- **Exhibited** at the **Unconventional Resources Technology Conference** in Denver, CO (August 12-14).
- **Held SPE Research Forum *"Quest for Reducing the Environmental Footprint".***
- Held **joint workshop** with the **Sustainable Resources Network.**
- **Established Advanced Analytical Technology Round Table** for Emissions, Stray Gas, Produced Water Monitoring.
- **Created a new methodology** for estimating emissions of hydraulic fracturing.
- **Created a new methodology** for estimating emissions of drilling rigs.
- Created a **cost effective way to monitor total hydrocarbons** with low cost wireless sensors.
- Developed **low cost water screening kits** to detect chemicals associated with oil and gas operations.
- Successfully navigated the legal process to schedule field trials with operators involving the **collection of data at live drilling sites and fracturing operations.**
- Successfully scheduled field trials with service providers to **collect data at their R&D facilities.**
- Successfully **collaborated with numerous small companies** and vendors to test their equipment in the field while at the same time conducting our research.
- Successfully **trained young scientists and engineers** through hands-on internships allowing them to find employment and thus enhancing the job market and economic development of Texas and the Nation.
- Built a **functioning pathway between operators and regulators** to discuss important topics regarding air emissions and waste water reuse.
- **Created a you-tube video** that better connects EFD research with the general public. (Video can be found at: http://efdsystems.org/index.php/field-trials/.)
- Continued the development of best practices to **minimize or eliminate the spread of invasive plants from oil and gas operations.**
- **Supported RPSEA Program** by hosting various workshops and briefing industry by featuring numerous RPSEA projects.

None of the above could have been accomplished without the financial and technical support of your organization as a sponsor. Funding from the industry has enabled the EFD team to meet cost share requirements associated with U.S. Federal funding. **As a sponsor, your $100,000 investment leverages over $15,000,000 of research.**

The EFD program strives to ensure that the technologies included in the program are eventually used in the field. There are two different types of projects carried out in the EFD program: core projects and supplemental projects. All EFD sponsors have full access to the results from the core projects. Supplemental projects are funded by sponsors on a project-to-project basis with the results shared with those that fund the effort. The management of the EFD program encourages sponsors who wish to commercialize promising technologies or processes identified or initiated by this program.

The Core and Supplemental Projects are as follows:

Core	Supplemental
1. EFD Scorecard Development 2. The Environmentally Friendly Drilling Systems – Technology Integration Program 3. Advanced Analytical Methods for Air and Stray Gas Emissions and Produced Brine Characterization 4. The Coastal Impacts Technology Program 5. **Environmental 24/7** – Establishing a Culture of Environmental Awareness	1. Study to Identify and Measure the Environmental Impact of Onshore Drilling 2. Powered by Natural Gas (PbNG) Operations 3. Dopefree Pipe 4. FracFocus Webinar Training 5. Environmental Issues in Osage County ***6.*** Assessment of environmental, performance and economic impact of a High-Performance water-based drilling fluid in the Marcellus and Utica Shale Plays

Technology transfer is a key element of the Environmentally Friendly Drilling Systems Program. The EFD team is heavily involved in engaging stakeholders at multiple levels. The EFD team is routinely called upon to participate in various roundtables, both in industry and in the public and is actively engaged in planning activities for various conferences, forums and exhibitions.

The EFD Alliance continues to grow. Monthly teleconference calls are held with Alliance members to discuss synergies among research efforts, needs identified by Sponsors and potential collaboration opportunities. Current members include:

Argonne National Laboratory
Idaho National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
Sandia National Laboratories
Battelle
Clemson University
Colorado School of Mines
Mississippi State University
Penn State University
Rensselaer Polytechnic Institute
Rice University
Sam Houston State University
Texas A&M University
The Ohio State University
Utah State University
University of Alaska – Fairbanks
University of Arkansas
University of Colorado
University of Kentucky
University of Leoben
University of Oklahoma
University of Southern California
University of Texas
University of Vermont
University of Wyoming
West Virginia University
Houston Advanced Research Center

PROGRAM OBJECTIVES

The long term goal of the Environmentally Friendly Drilling Systems (EFD) program is to ensure that environmental and societal issues are appropriately addressed in oil and gas operations. This includes reducing the footprint of operations in environmentally sensitive ecosystems through integration of low-impact site access and operations. Research and technology development also address potential long-term reduction of the environmental footprint associated with operations and reduce drilling and operations expenses. The EFD Team works with industry, regulators, environmental organizations and other stakeholders to development cost-effective technologies and to provide unbiased science for sound policy that manages environmental risks associated with oil and gas drilling and production activities. In addition to technology and policy issues, the EFD team performs research on the public perception of operations and practices.

The overall key objectives of the program are to:

1. Identify, develop, test and demonstrate new cost-effective technologies that reduce the environmental tradeoffs of E&P operations.
2. Integrate current/emerging technologies into systems with no or very limited environmental tradeoffs.
3. Express the attributes of an optimized system by use of environmental scorecards for various ecosystems that can measure tradeoffs associated with unconventional natural gas production.
4. Develop case studies of applying technologies at environmentally sensitive ecosystems, capturing best practices and lessons learned that will enable replication at other locations.
5. Create and manage a joint project of industry, academic, government and environmental organizations partners to assess methods to mitigate individual costs and develop industry acceptance of an entire viable system to accomplish this task.
6. Through a technology transfer effort, educate industry, public, government, environmental organizations and others about practices, technologies and systems that enable the production of natural resources in environmentally sensitive areas. Hold various workshops to ensure that the overall program is appropriately focused.

7. Document findings to ensure that the technologies, methodologies and systems developed, reviewed and evaluated are available to all interested parties.

2014 LOOKING AHEAD

We believe that there will be several major accomplishments that will occur during 2014, particularly with the kickoff of the TIP program and the Costal Impact project that is underway including:

1. Develop workshop for **Environment 24/7.**
2. Complete EFD Virtual Site – Hydraulic Fracturing Site.
3. Activate website for the EFD Scorecard.
4. Initiate project to mitigate flaring.
5. Exhibit at the IADC/SPE Drilling Conference in Ft. Worth (March 4-6) and at the Unconventional Resources Technology Conference in Denver, CO (August 25-27).
6. Hold at least 3 EFD workshops across the USA.
7. Complete additional Powered by Natural Gas white papers for inclusion in the series.
8. Participate in IADC HSE Committees, SPE Forums, various conferences where we present topics relevant to specific sponsors' project goals.
9. Expand the BMP website and LawAtlas.org comparative law database, adding water quantity and air quality components.
10. Create an air emission estimation methodology for engines containing a natural gas dual fuel kit.
11. Determine the emission differences between drilling engines powered by diesel and engines powered with natural gas/diesel dual fuel.
12. Creation of additional videos that can be used throughout social media and as a technology transfer tool.
13. Further strengthen relationships between the regulators and the operators.
14. Create best practices for operators to minimize the spread of invasive plants through mobile wash technologies and soil management planning.
15. Create a wireless data transfer system for better emission management.
16. Create better sampling protocols for water and air.
17. Expand the Newsletter network from 1,017 to over 1,500.
18. Grow the University/National Laboratory Alliance Network to include members in the Bakken area.
19. Obtain at least one industry sponsorship to place the EFD Virtual Site exhibit at a regional museum.
20. Initiate the development of the Land Use Site Selection Information Tool (LUSSIT), a GIS based analytical tool that will aggregate a large number of spatially distributed attributes and considerations in the region of interest to support site selection decisions.
21. Provide support to the RPSEA-funded GSI project on analytical chemistry by coordinating a broad network of advisors, assisting with workshops. This effort focuses on optimizing sampling and analytical methods for stray gas, air emissions and produced water from hydraulic fracturing.

PROJECTS

Core Program

EFD Scorecard Development

Funded by RPSEA (through EFD program), US Department of Interior, Industry, Environmental Organizations

Development of the Environmentally Friendly Drilling Systems (EFD) Scorecard has been ongoing since 2008. The objective is to develop a methodology that documents the environmental and societal tradeoffs associated with energy development taking into consideration variances in geographic regions The first 3½ years focused on reaching a consensus for the various attributes/subattributes through a series of workshops, meetings and paper exercises. Then we focused on testing and fine-tuning the Scorecard through a series of table-top exercises and actual field tests.

Based on feedback from our operating advisors, we pursued and obtained an endorsement from the Resources for the Future and held discussions with the Center for Sustainable Shale Development (CSSD). We will contact CSSD again during the first quarter of 2014 to discuss applying the Scorecard for the Marcellus. In addition we will maintain the Scorecard online at www.efdscorecard.org and develop a training module.

The Scorecard will allow operators to objectively assess and continually improve their environmental performance as well as their service providers and it may enable companies to provide transparent documentation of performance.

The Environmentally Friendly Drilling Systems – Technology Integration Program

Funded by RPSEA and Industry

The overall mission of the EFD-TIP is to identify and facilitate the integration of various projects/programs that can impact the unconventional natural gas developments in an environmentally sensitive and cost effective manner. The project addresses both exploration and production. Environmental issues are related to land, air, surface and ground water, emissions and societal aspects. Technologies come from a variety of sources: (a) service providers, (b) other RPSEA and NETL funded projects, and (c) tasks related to the EFD Program. The TIP works with other RPSEA programs and builds upon the successful EFD program's growing network of operators, service companies/suppliers, universities, national labs and environmental organizations.

The goals are:

1. ***Speed the commercial development*** of technology developed through RPSEA programs.
2. Create an ***organizational structure*** that includes a network of regional centers that facilitate and coordinate field deployment of such technologies and document effectiveness of field operations.

3. ***Perform field trials*** so that results could be evaluated efficiently as to benefit both the industry, the organizations with the technology, and the public sector.
4. ***Document and provide the results*** of technology field trials so that promising processes, systems and products could be utilized in a wider range of unconventional natural gas plays.
5. ***Emphasize programs that reduce cost and improve performance***, lessen the environmental impacts, or address the societal issues associated with unconventional natural gas development.
6. ***Include and report on safety improvements in the planning/demonstration of technologies,*** emphasizing technologies that foster a culture of health/safety/environmental protection.

The objective is to identify *promising* technologies which had received prior funding from DOE, RPSEA, other government sources and the first two phases of the EFD program. Regional centers were established to provide unbiased science relating to local, regional and national policies and to perform case studies of applying the technologies.

The EFD-TIP program seeks sites for field testing. Sponsors can support this effort by providing input and making field sites available for conducting this work. As part of the program, all researchers must complete essential safety training for access to field sites.

The EFD built a regionally and technically diverse subcontractor team of experts; and a team of operators, service companies, regulators, environmental organizations and other subject matter experts that serve on an advisory committee. The committee in a valuable way vets ideas and also helps to identify field test sites and gauge the relevance of various project tasks as they progress.

The EFD-TIP is a 2 – 3 year, $10 million program ($6 million from RPSEA, $4 million in cost share). Various components of the program are discussed in the following.

Colorado School of Law, Best Management Practices: www.oilandgasbmps.org.

The Colorado School of Law is expanding the Best Management Practices (BMPs) website, www.oilandgasbmps.org. This site provides BMPs and other resource information to a wide audience, including industry, community, government and environmental advocates. The database contains 8,500 BMPs, from nearly 500 source documents in categories such as Wildlife, Water, Air, Health, Soils and Vegetation. Resource and Law & Policy sections provide additional information, such as Hydraulic Fracturing, Economics of BMPs, Reclamation and laws and policies governing oil and gas development in the Intermountain West.

In 2013, CSL initiated a comparative law project on the platform of the Temple University Public Health Law Research Program. The newly launched Oil & Gas – Water Quality dataset (www.lawatlast.org/oilandgas) was created as a comparative tool for examining water quality laws and regulations related to oil and gas development in Colorado, Montana, New Mexico, New York, North Dakota, Ohio, Pennsylvania, Texas, Utah, West Virginia, and Wyoming. These states overlay major shale formations such as the Bakken, Eagle Ford, Greater Green River, Mancos, Marcellus, Niobrara, Permian, Piceance, Powder River, San Juan, and Uinta. State and local governments in these jurisdictions are experiencing new or increased oil and gas development, and there is tremendous value in looking at other jurisdictions to guide statutory construction and rulemaking. The database is a resource that policymakers, local governments, regulated entities, and concerned citizens can use to inform themselves about the scope of laws and the best implemented laws for protecting water quality during oil and gas development.

From June 26, 2012 – June 26, 2013 we had 45,000 new visitors and 14,500 returning with 98,000 page views.

Most of our returning visitors are from the US - Colorado, Texas, California, Wyoming, NY, OK, MT, DC, and NM topping the list. There are 6,000+ unique returning visitors compared to 13,000+ returning visitors.

Texas A&M University – Institute for Renewable Natural Resources, West Regional EFD Center Field Tests.

The ***West Regional EFD Center*** has established test sites in the Eagle Ford where field tests have already been coordinated and managed by Texas A&M University – Institute for Renewable Natural Resources (IRNR). This work includes field tests for the study of air emissions during hydraulic fracturing. IRNR is also working with various subcontractors and EFD-TIP team members in the development of the detailed plans for the field tests to be coordinated by the West Regional EFD Center.

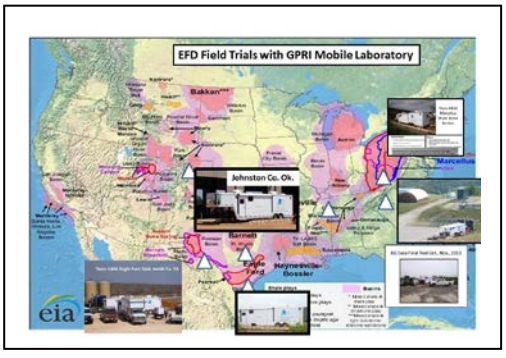
Environmental Land Steward Consultants works with the West EFD Regional Center to select field test sites throughout the Eagle Ford and has supervised the incorporation of new technology to minimize disturbance. Programs supported by the EFD Program during the years 2004-2011 are being adapted to South Texas to assist in site selection, lease roads, rigs, liners, frac ponds, compressor stations, and power lines. The goal is to enable new technology to influence positively land use, to reduce environmental impacts while retaining cost effective well plans and surface operations.

University of Texas Bureau of Economic Geology, Eagle Ford Characterization

The University of Texas Bureau of Economic Geology produced a comprehensive Technology Assessment report on the Eagle Ford Shale Play. This report covers the entire areal extent of the area and includes both surface and subsurface geological analysis and water resources. Features include topography, fresh water, brackish ground water and other features that would impact natural gas development. Ground water zones are identified with an analysis on the capacity of these zones to provide adequate water for drilling fluid and fracturing water make up. Analysis on the subsurface area show zones that are best candidates for disposal.

This work was completed in 2013.

Texas A&M University, Global Petroleum Research Institute, Field Tests – Water Management



The EFD-TIP team is testing new water treatment and re-use technologies. Water treatment business ventures are joining Texas A&M's team (*GPRI Designs TM Desalination Technology*) to test and document results of technology for pilot plant, field trials, and potentially full scale commercial operations.

Detailed plans were developed to perform tests on hydraulic fracturing water flowback and produced brine to identify the required level of treatment that is best for re-use in subsequent fracturing operations. In addition, trials are coordinated with the

Advanced Analytics Technology Advisory Sponsor's Committee chaired by GSI Environmental for testing of new analytical techniques to monitor process systems.

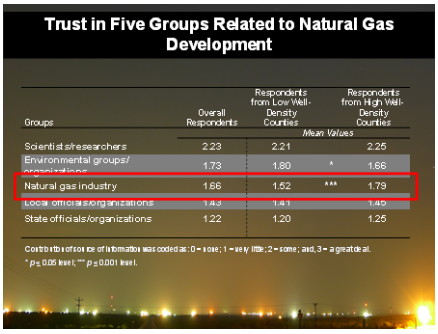
The proving ground concept allows this group to share information (basic water chemistry, water needs, logistics) and to have access to field sites in South Texas provided by landowners and operators. Sponsors and supporters are providing sites on their ranches and at their sites. The graphic shows 6 locations where trials have been performed. Field tours to sites to review operations are coordinated by Texas A&M, who provides the mobile lab to support the trials.

LEID, LLC, Field Tests – Drilling and Completion Operations

The EFD project has conducted studies on the advances of small footprint rigs and power sources that are quieter, safer, more efficient, require less fuel, and produce fewer emissions. Advanced design rigs have closed loop mud systems eliminating mud pits, and have a lower profile. Advances in automated drilling systems, measurement while drilling (MWD) and logging while drilling (LWD) and other downhole tools have enable development of a large geological spatial domain multiple wells from a single pad site. These advances have been incrementally incorporated by rig manufacturers and drilling contractors. Improved design and efficiency enables this new generation of rigs to move faster and with less environmental impact. Regulators, land owners and managers also need to be informed on these advantages and options.

One of the EFD sponsors, Husiman, has new rigs running in the Eagle Ford and several more being constructed. ***The TIP will plan a case study of these new rigs.*** Planned tests will demonstrate these advances in drilling technology, to better understand technical capabilities, cost effectiveness and environmental benefits.

Sam Houston State University, Utah State University and Penn State University, Field Tests – Community Issues



This proposed project will create a framework and solid foundation for identifying, gathering, and analyzing timely and salient social, economic, and environmental data associated with energy development, and then providing this information to industry and other stakeholders so that the variant social, economic, and environmental impacts can be minimized and/or avoided. In addition, a "Best Practices Communication Toolkit/Handbook" will be developed to improve communication and guide the use of effective community engagement activities between industry actors and local community residents/leaders. The scientific knowledge gleaned from this research will produce lasting and profound effects for industry. Successful completion of this project has the potential to accelerate adoption of new and existing technologies, services, practices, and methods, and to assure that these technologies will be accepted by industry, regulators, and the public. Recognizing and pro-actively addressing the concerns of key stakeholders and the general public can lessen or avoid unnecessarily long and complicated delays, civil actions, and potential litigation.

The objectives of this effort are:

- To empirically examine individuals' perception of the energy industry and their interest, knowledge, attitudes, experience, current behaviors, and behavioral intentions with respect to energy exploration and production issues in the Eagle Ford Shale.
- To enhance two-way communication between industry and community leaders and residents by developing, testing, and refining a communications toolkit/handbook in the Eagle Ford Shale.
- To ensure that the EFD Technology Integration Program expertise and information about best practices is readily available in energy-development communities and tailored to locally determined concerns.
- To develop a synthesized report on energy development regulations and ordinances across the states with oil and gas production.
- To establish dialog and increase levels of mutual understanding among representatives of the oil and gas industry, regulatory agency personnel, non-governmental organization representatives, and members of the general public with respect to the social, economic, and environmental effects of rapid energy development.

The scientific knowledge gleaned from this research will produce lasting and profound effects for industry.

- Successful completion of this project has the potential to speed up the use of new and existing technologies, services, practices, and methods, and to assure that these technologies will be accepted by industry, regulators, and the public.
- Recognizing and pro-actively addressing the concerns of key stakeholders and the general public can lesson unnecessarily long and complicated delays, civic actions, and litigation.
- By understanding and addressing public (mis)perceptions, and by improving two-way communication between industry and host communities, this project will assist industry to realize the full potential of the domestic shale oil and gas resources in the Eagle Ford region.

Texas A&M University-Kingsville (TAMUK), Texas Center for Applied Technology (TCAT – IRNR) and Oak Ridge National Laboratory (ORNL), Field Tests – Air Quality/Emissions

The team has identified a broad range of new and existing *in situ* and mobile sensors capable of measuring environmental conditions and which can be integrated with the Sensorpedia system.. Data sources include monitoring stations, vehicular emission sensors, leak detectors, open source sensors (e.g., from NOAA, USGS, EPA), enterprise sensors, and human field observations. Requirements and standards for data provenance and metrology for each of the sensor types—including human observations—have been developed. The ORNL team has provided guidance on the parameters to be included in the proposed demonstration of the Sensorpedia EFD network. As part of this guidance, Sensorpedia mashups have been specifically designed for the spatial display of the multi-sensor information in real time. The development and coordination of sensor data mashups have been documented in part through a blogging feature that ORNL deployed on an ALPHA version of the EFD branded Sensorpedia platform. TAMUK is responsible for the monitoring plan (including the development of general protocols for interfacing a prototype wireless air sensor network to Sensorpedia), and the TCAT-IRNR has developed the management plan for the field test effort. ORNL set the boundaries for the data and advised information prioritization and development of baseline and monitoring data for environmental impacts.

A "branded" EFD Sensorpedia server is being established at ORNL with basic features to allow users to publish, share, see and subscribe to sensor information. Oversight air quality monitoring will be implemented where TIP field tests are being conducted.

Once the field testing is implemented, this task will deliver a prototype environmental oversight package that accepts a wide variety of sensor data and displays information in an easily understandable manner through an existing network. The oversight monitoring program will be capable of monitoring small or large geographic areas. The field test will document the effectiveness of air emissions control technology being tested in the Eagle Ford Shale proving ground.

Oak Ridge National Laboratory (ORNL) will use the Sensorpedia network[1] for the integration and analysis of data streams from multiple, diverse sources. The network will be developed with input from Texas A&M University Kingsville Environmental Engineering Department and Institute for Sustainable Energy and the Environment.

As part of the management effort, IRNR created the Eagle Ford Air Emission Inventory Group to host discussions regarding data collection and proper estimation methods for air emission inventories. In the past, air emission inventories were conducted using worst case estimates. Results introduce significant to extreme error in the regional air shed models. New methods were tested in 2013 for both hydraulic fracturing and drilling operations. The results compared the variance created by use of default factors verses field data. It was shown that when using the horsepower method for estimating emissions from fracturing, collecting engine load data will make a creditable difference in the accuracy of the results. For drilling, basing the estimation on fuel consumption is both easier and more accurate. Both the regulators and the operators agree to the methods. IRNR is moving forward with formal recommendations through the Eagle Ford Air Emissions Inventory Group.

West Virginia University, Field Tests – Marcellus/Utica: Establishing East EFD Regional Center

West Virginia University (WVU) manages the East Regional EFD Center. WVU and HARC defined the following objectives for the East Regional Center:

- to establish and manage the East Regional Center, a center that will test and integrate developing technologies into systems that lower cost and improve performance of unconventional gas shale development;
- plan and implement field testing of new technologies in the East Region;
- document technology implemented to reduce the environmental footprint of oil and gas operations; and
- disseminate the information through a series of workshops.

The 3-year period of performance has been separated into two phases. During Phase I (8/15/12 to 10/31/12) the tasks were to:

- establish the East Regional Center;
- plan and schedule a project kickoff meeting;
- perform an assessment of RPSEA-funded field projects;
- schedule and host initial meetings and workshops; conduct technology transfer;
- cooperate with the West Regional Center; and
- identify field test sites in the Marcellus Shale play.

During Phase II (2/4/13 to 6/30/15) the main tasks are to:

- identify field test opportunities and help HARC manage field tests;
- identify new applied technologies;
- implement a plan to document field activities;

[1] http://www.Sensorpedia.com

- cooperate with other funded programs to form teams to integrate efforts;
- integrate geologic concepts with engineering issues coupled to production and environmental concerns;
- transfer technologies through workshops; and
- provide access to data gathered in the field to operators in other shale plays.

Phase II funding was obtained to continue the East Region Center, and additional funding was obtained to support one research project, discussed in the next section, and one field test.

The field test is an "Assessment of the Environmental, Performance and Economic Impact of a High-Performance Water-Based Drilling Fluids System in the Marcellus and Utica Shale Plays," a cooperative effort among WVU, The Ohio State University (OSU) and Newpark. This project also is separated into two phases. The Phase I objectives of this study were to:

- review the current regulatory framework regarding the use of drilling fluids in the Marcellus and Utica Shale plays, specifically in the states of Ohio, Pennsylvania & West Virginia; and to
- cite and detail the current regulations and the process for obtaining approval of the drilling fluid and disposal of cuttings obtained by drilling with a diesel or oil-based fluid.

Based on an extensive search through the laws, rules and regulations in all three states, all pertinent documents and organizations were identified that are relevant to the drilling fluids used in oil and gas drilling operations. These were summarized in a final report for Phase I.

A research plan for Phase II also was developed. This plan includes Laboratory and field testing of the new water-based fluid and field testing with industry partners in Marcellus and Utica shale wells. Research on the physical properties during drilling (effects on bit wear; estimated drilling rate) will be monitored by WVU; chemical properties (fluid analyses, rock-fluid interaction under pressure, fluid breakdown over time) will be conducted by OSU. Our industry partner, Newpark, will be responsible for recruiting drilling partners in the Utica and Marcellus play areas.

Two workshops were developed and hosted, on the 4th and 5th of September in Canonsburg, PA. The first of these was "Wellbore Integrity – Improving Zonal Isolation Practices," and the second," Natural Gas Power for Shale Development – Using Natural Gas Power for Drilling and Hydraulic Fracturing," the following day.

Finally, posters were prepared for the annual EFD Industry Advisors meeting in The Woodlands in November: "Assessment of the environmental, performance and economic impact of a high-performance, water-based drilling fluids system in the Marcellus and Utica shale Play," by The Ohio State University and West Virginia University Partnership; and "East Regional EFD Center Technology Integration Program."

West Virginia University, Field Tests – Integrated Microseismic and 3D Seismic Interpretations

The research project is being led by Dr. Thomas Wilson at WVU. Dr. Wilson and a student are interpreting large amounts of data gathered by DOE-NETL at a field site in southwestern Pennsylvania, an area where faulting may have breached the Tully Limestone "induced fracture seal" several hundred feet above the Marcellus Shale target zone. The objectives of this study are to: develop a 3D seismic interpretation of an active Marcellus shale gas development area; incorporate available geophysical logs and subsurface data into the geophysical characterization and subsurface interpretation; position microseismic events in the subsurface stratigraphic framework and 3D seismic interpretation; evaluate relationship between seismic-scale fault networks, other seismic attributes and microseismic distribution; and create a workflow you can use and modify for decision making on placement of future laterals.

Significant progress toward key deliverables of the seismic study was made during the year. Development of the data base in an integrated workstation environment was completed and post-stack processing workflows were developed to help enhance subtle faults and possible fracture zones in the 3D seismic data set. Interpretation of those subtle features is underway along with evaluation of interrelationships between microseismic activity, subtle faults and fracture systems. The efforts of the research team resulted in two abstract submissions noted below.

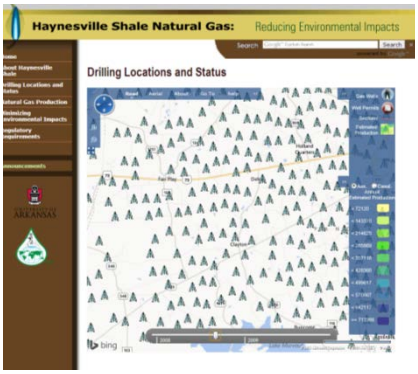
Dr. Wilson and the members of his research team submitted the following abstracts for presentations, both of which were accepted: *Hart, A. K., Wilson, T. H., and Sullivan, P., submitted,* "3D Seismic Attribute-Assisted Analysis of Microseismic Events within the Marcellus Shale:" *for presentation at the AAPG International Exhibition and Conference, Houston, TX, April, 2014;* and *Wilson, T. H., Hart, A. K., and Sullivan, P., submitted,* "3D Seismic Workflows Developed to Evaluate Out-of-Zone and Stealth-Zone Microseismic Behaviors: Marcellus Shale, Central Appalachians, USA:" *for presentation at the AAPG International Exhibition and Conference, Houston, TX, April, 2014.*

Finally, a poster was prepared for the annual EFD Industry Advisors meeting in The Woodlands in November: "Integrated Microseismic and 3D Seismic Interpretation," by Thomas H. Wilson, Ariel K. Hart, Pete Sullivan, and Doug Patchen.

***epic software*, Website Development**

The EFD TIP program will have one website to collate information relating to field tests and other activities of the EFD Regional Centers. In addition, the website will integrate RPSEA funded projects. From the home page of this website, a visitor can quickly navigate to find specific information about each region. Conversely, a visitor interested in a specific technology (for example, finding information concerning Integrated Basin Analysis) could instantly access the work being done in that technology across all regions. In addition, a powerful search application will supplement this matrix technology to enable a site visitor to locate information. Deliverables will be a a database driven, content managed website that features state-of-the-art computer graphics, simulation and video, where appropriate. This will include field trial testing results, photos and videos from work performed by the EFD Regional Centers.

***University of Arkansas, Latitude Geographics*, GIS Analytical Tool Development**



Latitude Geographics is working with the University of Arkansas to build and take to market a flexible and practical GIS software product for producers and regulators that will standardize the process of placing oil and gas wells and supporting infrastructure while preserving environmental values while….

- reducing operator costs
- improving performance and timelines associated with oil and gas development
- better assessing risks associated with infrastructure placement
- facilitating more efficient regulatory approval methods
- preserving environmental values
- incorporating flexible use of operator, regulatory, and 3rd party systems and information

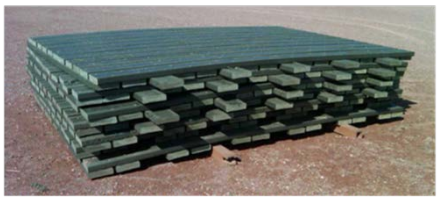
Key deliverables of the Land Use Site Selection Tool (LUSSIT) project are:

1. a definition of licensing of intellectual property from the University of Arkansas,
2. a business plan for commercialization of the LUSSIT application,
3. development of the LUSSIT application and
4. field trials and user acceptance.

This effort was inititated during fourth quarter 2013.

WyoComp, Life-Cycle Assessment on Composite Matting System

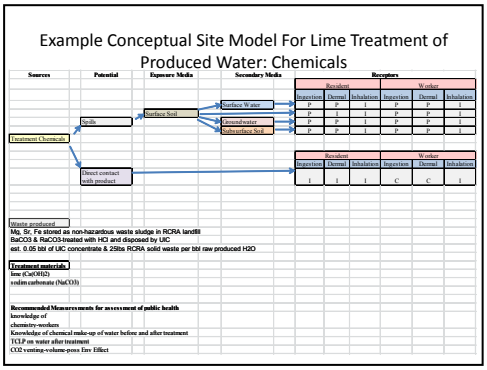
Composite mats made from recycled HDPE/wheat straw



A new road mat system was compared with conventional wood matting in a life-cycle assessment (LCA). A composite matting system made from recycled HDPE reinforced with wheat straw cellulose against wood matting systems made from pine. The LCA study covered key indicators associated with the range of cradle-to-grave attributes with a focus on manufacturing. Existing LCA impact category data from numerous peer reviewed LCA studies were applied to modeling the two different matting systems. Results indicated that the use of composite matting systems vs. wood matting systems can contribute substantially to the reduction in environmental impacts related to materials. Key findings show composite matting favorable with respect to environmental impacts related to acidification, eutrophication, energy-use and biodiversity loss. Wood matting showed minimal or slight favorable results related to global warming and ozone depletion. An economic analysis showed that while the composite matting system has a higher initial cost, a longer useful life cycle actually results in lower cost versus wood matting. This work was completed in 2013.

Colorado School of Public Health, Public Health Enhancement Opportunities

Example Conceptual Site Model For Lime Treatment of Produced Water: Chemicals



Development of new EFD technologies and processes in natural gas exploration and production (E&P) through the Technology Integration Program (TIP) provides opportunities to maximize the public health benefits of natural gas development by reducing the potential for negative public health effects during E&P activities.

The work performed by the Colorado School of Public Health (CSPH) includes the assessment of data collected by EFD TIP partners from field tests to qualitatively (1) evaluate the public health features of each field test and (2) to compare public features between tests. CSPH also are tasked to identify public health tradeoffs for a generic natural gas development site by incorporating public health measurements, including air and surface and ground water, emissions, and social measures EFD-TIP assessment, as well as to identify public health features and disseminate these features through reports and educational and outreach materials. Key deliverables include tabulated reports and conceptual site models summarizing public health advantages and disadvantages for field tests to be demonstrated at the Eagle Ford Play, public health assessment of modern low footprint rig, technical comments on written sections for the UGSIA, and assessment of Sensorpedia technology as a public health tool.

During 2013, CSPH focused on identifying potential public health effects associated with natural gas extraction and outreach activities. Identifying these public health effects is an essential step which will allow CSPH to then identify

the public health features of the EFD TIP technologies. A student was hired to aid in a comprehensive literature review, prepared a scientific manuscript summarizing the results of the literature review, and submitted this manuscript to Environmental Science and Technology for peer review and consideration of publication.

Outreach activities have included participating in scientific workshops addressing research needs concerning natural gas extraction, presentations at national and local conferences, and initiation of development a public health web page with the Getches-Wilkinson Center at the University of Colorado Law School. The following table summarizes manuscripts, presentations, and workshop participation during 2013. The public health web page will feature EFD technologies and best management practices that may mitigate health risks potentially associated with natural gas extraction, as well as links to relevant peer reviewed studies also will be incorporated.

Title	Date and Location	Participant	Summary
	Manuscripts		
Public Health Risks from Unconventional Natural Gas Development in the United States	Submitted to Environmental Science and Technology October 15, 2013	Drs. Adgate and McKenzie	Evaluation of risks to public health from chemical and non-chemical stressors, description of likely exposure pathways and potential health effects, and identification of major uncertainties associated with unconventional natural gas development.
	Presentations and Workshops		
Workshop to Develop Recommendations for Best Practices for Environmental Monitoring Related to Unconventional Oil and Gas Extraction	December 12-13, Washington DC, Sponsored by NRDC	Drs. Adgate and McKenzie	The purpose of this workshop is to develop recommendations for best practices for environmental monitoring related to unconventional oil and gas extraction
Public Health Enhancement Opportunities in EFD-TIP	EFD TIP Advisory Committee Meeting, November 12, 2013	Dr. McKenzie	Presented: Summary of Year 1 tasks and literature review manuscript.
Community & Public Health Panel: Research Questions and Needs	Third Annual Natural Gas Symposium at Colorado State University, October 15, 2013	Dr. Adgate	Presented and served as a discussant on the public health and community panel at this Symposium by the Center for the New Energy Economy, which focuses on science and policy issues.
Workshop on Air Quality and Oil &Gas Development in the Rocky Mountain Region	SRN AirWaterGas October 21-22, 2013	Drs. Adgate and Mckenzie	The purpose of this workshop was to bring scientists together to discuss air quality activities and studies occurring in the Rocky Mountain region.
Joint EFD-SRN workshop	Golden, Colorado August 15, 2013	Drs. Adgate and McKenzie	The purpose of this workshop was to bring scientists from the EFD TIP and SRN AirWaterGas studies to discuss collaboration and common research goals.
Forum on Science, Democracy, and Community Decisions on Fracking	University of California, Los Angeles, July 2013 Sponsored by the Union of Concerned Scientists	Dr. McKenzie	The purpose of this workshop was to bring experts together to discuss environmental and health effects potentially associated with unconventional shale gas development.
Natural Research Council's Workshop on Risks of Unconventional Shale Gas Development	May 30,-31 2013, Washington DC	Drs. Adgate and McKenzie	The purpose of this workshop was to bring scientists together to discuss research needs concerning environmental and health potentially associated with unconventional shale gas development.
Community Exposure and Risk Near Natural Gas Production Sites: Impacts and Research Needs	Society of Toxicology Annual conference, March 2013	Dr. Adgate	The purpose of this invited session at the national meeting of the SOT was to bring scientists together to discuss research needs concerning environmental and health potentially associated with unconventional shale gas development.
Natural Gas Development Health Impacts: Use of HIA and Quantitative Risk Assessment in Garfield County"	University of Denver, February 2013	Dr. McKenzie	Presented methods and results to students on the 2010 health impact assessment and quantitative risk assessment in Garfield County, Colorado.

CSPH also participated in a site visit to the Dewitt Ranch in June. This provided an opportunity to observe the air and water monitoring studies. CSPH learned about the perspective the ranch owners have on natural gas extraction, which will inform evaluation of psychosocial effects of natural gas development.

During 2014, CSPH will:

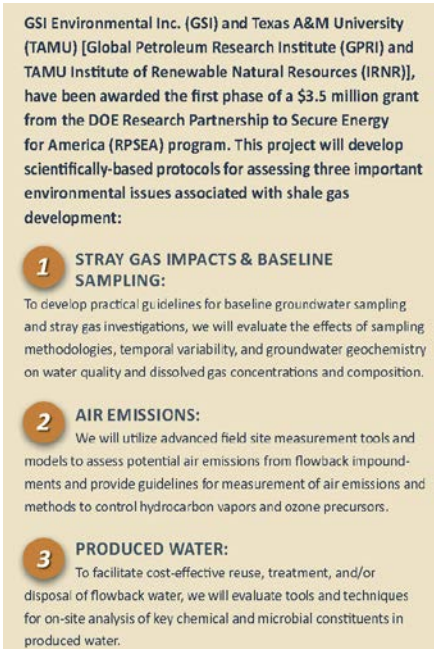
- Work with the Getches-Wilkinson Center at the University of Colorado Law School to complete and launch the public health web page.
- Update conceptual site models as data on EFD technologies is provided to us by our EFD partners.
- Evaluate and compare public health aspects of EFD technologies.
- Evaluate Sensorpedia as a public health tool.

Advanced Analytical Methods for Air and Stray Gas Emissions and Produced Brine Characterization

Funded by RPSEA and Industry

The EFD Team works with the prime contractor, GSI Environmental Inc. on this project that was initiated in 2013. The project will develop practical and cost-effective methods to address *collectively* three of the most important environmental risks associated with shale gas development. These risks, as expressed by legislators, regulatory agencies, and the general public; are a) potential emissions of volatile air contaminants from produced water impoundments, b) potential impacts of methane and other gases on groundwater resources, and c) ineffective treatment, disposal, or re-use of produced water due to insufficient analytical characterization.

The objective is to develop and evaluate ***scientifically-based protocols*** for the effective sampling, analysis, and interpretation of data during the monitoring and investigation of critical waste streams and potential environmental impacts. This project provides key industry stakeholders with accurate protocols for making informed decisions regarding the monitoring and mitigation of environmental risks.



The project team will evaluate sampling and testing technologies and develop decision-making protocols for three critical environmental issues, including: i) *Air Emissions*: Evaluation of sampling and analytical methods and modeling procedures to accurately characterize volatile organic emissions from ponds, ii) *Stray Gas Impacts*: Compilation of baseline isotopic and compositional data on dissolved gas and source gas, field testing of alternative sampling methods, analysis of temporal variation of dissolved gas in water wells, and development of practical guidelines for investigation of suspected stray gas impacts based on multiple lines of evidence, and iii) *Produced Water Characterization*: Field testing of on-site analytical testing methods for rapid characterization of produced water quality as needed for cost-effective reuse, treatment, or disposal, and reduction of fresh water demand.

The Coastal Impacts Technology Program

Funded by US Department of Interior/Managed by the Texas General Land Office on behalf of the Texas Coastal Land Advisory Board (TCEQ, RRC, GLO)

In 2012, we initiated the EFD Coastal Impacts Technology Program, EFD-CITP. This core EFD project will afford sponsors with opportunities to increase understanding of how cost effective, low impact technologies may be applied to mitigate environmental impact of oil and gas activities. The EFD-CITP is a 4 – 5 year, $4 million program.

The CITP is a comprehensive program that identifies environmentally friendly technologies, supporting research to implement and demonstrate impact mitigation potential along the Texas Gulf Coast. Program projects are aimed at developing methodologies and measuring effectiveness of technologies to conserve, protect or restore the natural coastal environment, educate the workforce. The goal is to provide a program of research and demonstration that

may lead to commercial application of technologies that will reduce environmental impacts of unconventional natural gas and other petroleum exploration and production activities along the Texas Gulf Coast. Objectives include:

- **Technology Road Mapping**: Identify technologies that will reduce the environmental impact of oil and gas activities along the Texas Gulf Coast;
- **Environmental Impact Mitigation**: Evaluate technologies that may mitigate the environmental impacts of oil and gas exploration and production on coastal areas;
- **Inter-state Collaboration**: Coordinate efforts with other producing states to identify, formalize and co-fund collaborations regarding applicable technologies; and
- **Workforce Program**: create and implement an educational workforce program to focus on a skilled workforce in environmental mitigation of exploration and production impacts in coastal regions, in particular, the Texas Gulf Coast.

During 2013, significant progress was made in implementing many research projects, discussed in the following.

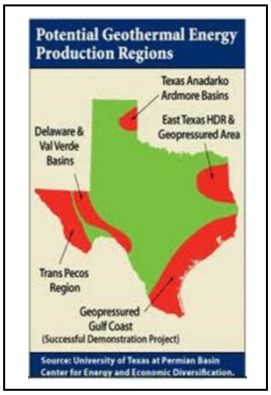
1 epic software, Workforce Development: "Environmentally Friendly Drilling Virtual Rig Website"

Objective of the EFD Virtual Site (www.efdvirtualsite.org) is to develop environmental awareness among employees and the public. In addition, the site allows for industry to demonstrate how environmental issues are addressed. The vision is to have the animation start with a drill site that includes technologies that were standard in the past. The animation would have two methods to interact with the viewer. The first method would be to have the drill site 'evolve' from the rig of the past to the rig of the future. This would go through all of today's EFD technologies. The second method would be to have a menu that allows the viewer to select EFD technologies. When a technology is selected, an explanation is given of the technology and that portion of the rig site is transformed to include the EFD technology.

During 2013 the virtual rig site was expanded so that now there are 13 hot spots where the viewer may interact with the equipment. In addition, a prototype kiosk was developed to enable the site to be access at exhibits. Complementary funding was also obtained from the Ground Water Protect Council's Research Foundation to develop a hydraulic fracturing site.

During 2014 we will pursue placing the kiosk in museums as a means of public outreach. The hydraulic fracturing virtual site will be developed. More technologies will be added to the rig site and we will pursue funding from the Society of Exploration Geophysicists for development of a virtual seismic survey. We will also explore the possibility of developing a virtual well pad site, a virtual gas gathering site and a virtual gas processing plant.

2 *Texas A&M University, Site Restoration: "Stakeholder Perceptions of Low-temperature Geothermal Energy Development in Environmentally Sensitive Coastal Areas in Texas"*



This study addresses the potential impact of societal issues and attitudes surrounding development of low-temperature geothermal energy (LTGE) in an environmentally sensitive area. The purpose of such pre-development research is to effectively mitigate social concerns regarding LTGE if the development of this unconventional energy source is determined to be technically, economically, and environmentally feasible. Historically, the lack of broad-scale stakeholder input has led to public resistance and divisive confrontations that have slowed or terminated the development of energy production initiatives. The intent of this study is to create a methodology that could be used to reduce the probability of such actions. Preliminary results include:

- Communities want to be involved from the onset
- Small Focus Groups allow open discussion
- Residents are not willing to spend the community's capital solely for economic gains. The 'whole picture' including water, land and air need to be evaluated along with the economic impact.
- There is limited knowledge of LTGE – insufficient to make decisions.

3 *Houston Advanced Research Center, Site Restoration: "Assessing the Ecological Integrity of Wetland Functionality in Response to Energy Exploration and Production Operations on the Upper Texas Gulf Coast"*

The Wetland Functionality research project will assess the ecological integrity of wetland functionality in response to energy exploration and production operations along the Upper Texas Gulf Coast. Objectives are to prioritize wetland functions dependent on wetland type, location and other factors. Key wetland functions involved include coastal flooding mitigation, habitat for wintering waterfowl, and importance for commercial and recreational fishing. These analyses in the context of potential impacts from energy exploration and production operations will be used to develop a decision support tool in determining:

- Where to drill
- Technical alternatives to mitigate certain impacts
- Most effective mitigation with limited financial resources.

This project was begun in 2013.

Consequences of Wetland Alteration

County	Date	# of permits issued by Corps	Rainfall event in inches	Property Damage
Galveston	April 1997	546	.09	$5,000
	September 2000	921	.09	$100,000
Brazoria	June 1997	356	1.5	$5,000
	August 2001	615	1.5	$500,000
Harris	April 1997	685	3.66	$131,000
	May 2000	1217	1.3	$200,000

Wetland Alteration Permits Issued by Corps correlated with property damage by flooding

- Loss of wetlands is the most important indicator of flood damage severity
- Wetlands reduce property loss from floods more so than Dams
- The Clean Water Act: anyone who wishes to discharge dredged or fill material into the waters (including adjacent wetlands) of the U.S. must obtain a Section 404 permit from the U.S. Army Corps of Engineers (Corps)

4 Texas A&M University, Kingsville, Air Emissions: "Biological Emissions Treatment Technology Deployment to Reduce Air Pollution for Refining Operations"

Biological treatment of air emissions is a cost effective and sustainable alternative to high-temperature thermal oxidizers or flares as a means removing Hazardous Air Pollutants and Volatile Organic Compounds for emissions reductions. This project will demonstrate the capture and treatment of air pollutants using two-stage biofiltration technology. Biological treatment of waste air achieves pollutant destruction at ambient temperatures and does not generate secondary pollutants that result from flaring and other high-temperature oxidation technologies. In this study, two types of biological treatment will be used together in tandem. Contaminants are transformed to innocuous products through the action of microorganisms present in the treatment filter media. This technology has been previously successfully tested for removal of volatile organic compounds (VOCs) and other substances associated with hydrocarbon emissions. Benefits of this technology include fewer greenhouse gas emissions, as well as economic and energy savings.

Investigators are working with an industrial collaborator.

Preliminary plans have been developed to pilot test the technology at a Corpus Christi Area refining application, to capture and treat fugitive emissions in vapor. The anticipated start-up for the pilot is January 2014.

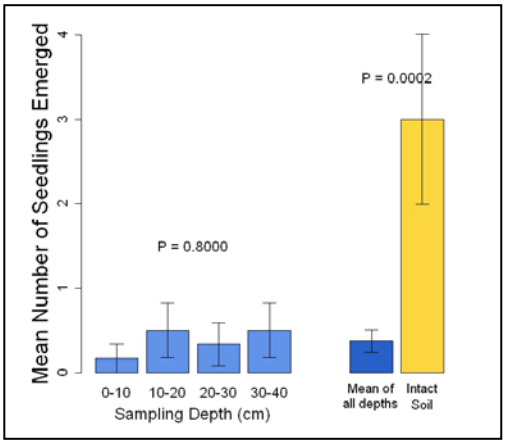
5 The Nature Conservancy, Site Restoration: "Restoring Altered Surface Hydrology at Texas City Prairie Preserve"

Deeprooted sedge (*Cyprus entrerianus*, hereafter "DRS") is a South American plant that has invaded the warm, humid environments of coastal Texas and the southeastern U.S. and grows abundantly in low lying, heavily disturbed areas such as abandoned well sites. This species can create dense monocultures, reducing the diversity and quality of wildlife habitat. This species is of particular concern at The Nature Conservancy's Texas City Prairie Preserve, where this project is being conducted. Here, it is one of the most abundant and costly invasive species to manage.

This project will restore drainage patterns on 2 sites totaling about 30 acres of the preserve by replacing and improving road culverts, trenching existing ditches, and grading land where needed to improve surface flow, and removing drainage impediments that have resulted in areas for water to pool. The objective of this work is to improve site conditions so as to discourage the infestation of DRS.

To monitor the success in controlling deep-rooted sedge, existing sedge infestations were mapped. Monitoring will continue for 18 months to following hydrology restoration, comparing the extent of sedge infestation before and after. The project will also evaluate whether native species are recolonizing the formerly infested areas using comparisons of species richness and cover.

6 *Texas A&M University, Kingsville, Site Restoration: "Effects of Age and Depth on Topsoil Properties and Seed Banks Characteristics"*



The stockpiling of topsoil for later use in site restoration is recommended as a "standard practice". This practice changes the chemical and biological properties of the soil and seed banks in ways that can influence the success of subsequent site restoration. Along with the initial soil properties, such as soil type, the age and depth of the stockpile impact ways in which the soil and seed bank are affected.

Analyses being conducted include soil chemical properties, soil biological properties and seed bank composition and dynamics. Data collected in this study will help improve soil storage practices through better understanding of relevant ecosystem processes and recommendations for greater success in site restoration. This work would serve as a basis for a related project on restoration of soil mixtures, to experimentally investigate methods for restoration of areas where soil and seed bank have been adversely affected by energy development.

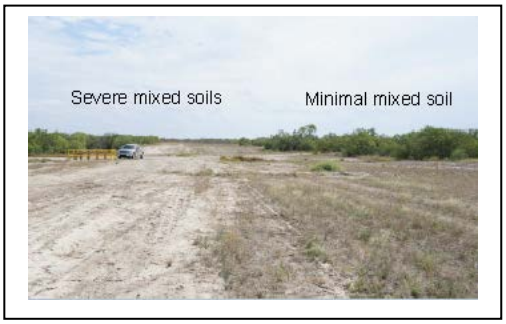
Preliminary Results

- Number of emerged seedlings was not affected ($P > 0.4409$) by sampling depth in stockpiled top soils.
- Differences between stock piles and intact soil depended on site.
- Soil microbial community composition differed between intact and stockpiled top soils.

Conclusions

- Stockpiling top soils has immediate effects on microbial community composition and may affect seedling emergence.
- These results will likely be affected by time of sampling after stockpile construction and will be documented as this study progresses.

7 *Texas A&M University, Kingsville, Site Restoration: "Restoration of Soil Mixtures" [Related to Project #6]*



Extraction of oil and gas is accompanied by the need for pipelines for energy transportation. When subsoil and top soil becomes mixed during pipeline construction, restoration of affected areas can be challenging.

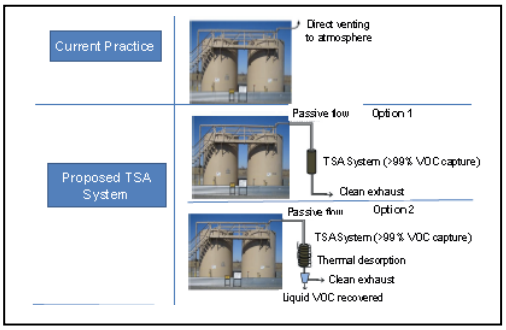
The stockpiling of topsoil for later use in site restoration results in the mixing of soils, disrupting chemical and biological properties. In two complementary experimental approaches, restoration guidelines for mixed soils in the coastal counties will be developed. Growth medium manipulation and soil amendment practices will be examined. In combination with these soil cultural practices, screening for plant species adaptability will be conducted in greenhouse studies. Objectives are to:

- Develop strategies to ameliorate unfavorable growing conditions in surface soils that are affected by mixing of subsoil and top soil materials, and
- Identify adapted species to enhance chances for restoration success.

Preliminary Results

- Mixed soils and top soils differ markedly in chemical and physical properties.
- Hydro-mulching ameliorates soil surface environments to enhance seedling survival.
- Even with soil surface amelioration, adapted species must be selected to enhance restoration success.

8 *Texas A&M University, Kingsville, Air Emissions: "Thermal Swing Adsorption to Capture Toxic Air Emissions from Point Sources"*



With the goal of capture and recovery of toxic air emissions from point sources such as oil and condensate storage tank vents, this project involves the development and testing of an innovative thermal-swing adsorption (TSA) system. The system will make use of commercially available granular activated carbon (GAC) as the adsorbent to passively capture gas emissions. The system will focus on the capture of volatile organic compounds (VOC) in both gaseous and liquid forms. Electrothermal heating integrated with the system functions to desorb the captured compounds for disposal, treatment or reuse.

***Objective 1*: To quantify emission rates of VOCs from condensate tanks.**
Bench scale apparatus has been constructed to simulate hydrocarbon condensate storage conditions and characterize emissions. Measured and calculated emissions will be compared with results of computer modeling to design and size the GAC TSA system.

***Objective 2*: To quantify the effect of ambient temperature and air volumetric flow rate on the adsorption of organic chemicals using a TSA system.**
Adsorption tests are being conducted at varying conditions to assess TSA adsorption capacities and removal efficiencies.

***Objective 3*: To quantify the effect of gas temperature on the desorption of VOCs from the adsorbent and the recovery of the liquid VOCs through condensation.**
Using electrical heating, saturated adsorbent material will be regenerated to release VOC-rich gas which is then subjected to condensation. Mass and energy balance will be used in conjunction with measurements to assess performance of the TSA system.

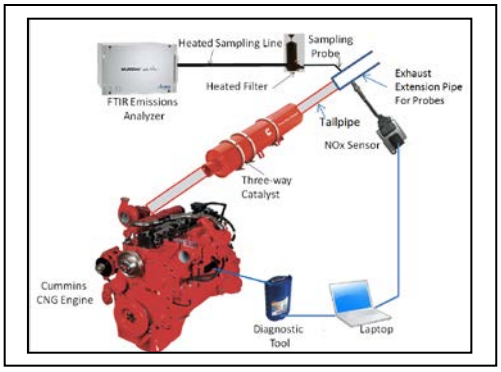
9 *Texas A&M University, Site Restoration: "Impacts of Oil and Gas Interests on Environmentally Sensitive Coastal Areas of Texas"*

With most remaining Coastal Prairie located on private lands, engagement with landowners is critical for conservation and the recovery of species reliant on this habitat. In an effort to understand and minimize the impacts of oil and gas interests on private land conservation, this research will study the social dimensions of oil and gas development, and impact on the habitat and fate of endangered species such as the Attwater's prairie-chicken. The objective of this work is to develop a framework to facilitate voluntary landowner enrollment in incentive-based Coastal Prairie conservation programs.

Key study parameters include the influence of oil and gas interests on attitudes toward conservation programs, attitudinal interaction with economic considerations, land use decisions and spatial orientation. This work will include development of recommendations for best management practices, and development of a spatial decision support tool to assist with infrastructure siting to minimize impacts of oil and gas extraction activities.

10 *Texas A&M University, Institute of Renewable Natural Resources (IRNR), Air Emissions: "Capturing Accurate Air Emission Data from Oil and Gas Exploration and Production"*

This project focuses on development of improved air emissions management through better emissions estimation methodologies, best available measurement techniques and integration of emission control strategies for sources in congested nonattainment or near-nonattainment coastal counties.



The objective is to gather more accurate data that can be used to formulate emissions calculations and regulatory policy. This will be accomplished through process mapping of hydraulic fracturing operations, collecting emissions data on equipment engines, modeling load factors and monitoring operation time. Data analysis and emission estimation will employ methodology acceptable to both industry and regulators. This research will be distributed as an updated resource for industry and the regulatory community. The project team will:

- Conduct direct measurement of NOx, VOCs, CO and CH4 from the exhaust of diesel and natural gas engines at a drilling rig.
- Conduct ambient measurement of the downwind NOx, VOCs, CO and CH4 from diesel engines and natural gas engines at a drilling rig.
- Conduct an advanced air emission inventory to estimate for NOx, VOC's CO, PM10 and PM2.5 at both diesel powered and natural gas powered drilling rigs.
- Conduct ambient particulate measurement of the downwind emissions from diesel engines and natural gas engines at a drilling rig.
- Conduct direct measurements for tailpipe PM in diesel powered and natural gas powered drilling rigs.

11 *Texas A&M University, Institute of Renewable Natural Resources (IRNR), Site Restoration: "Evaluation of Invasive Plant Species Control Technologies at Oil and Gas Production Sites in South Texas"*

This study seeks to identify the primary mechanisms of introduction and spread of invasive plant species, and to assess viable techniques to mitigate the transmission of invasive plant species. In three main tasks, this work includes: 1) identify sources of potential invasive species of environmental concern, 2) determine common methods for prevention, control and eradication of invasive species and 3) field trial planning for new technology.

In the first phase, coordination with Texas A&M Kingsville was established to determine top invasive plant species in the coastal and Eagle Ford regions. This includes such species as Salt Cedar, Chinese Tallow Tree, Giant Reed, Alligator Weed, and Buffelgrass. Species are chosen not only for their ecological impact but also for their impact to farms and ranches. For example, tree tobacco has a direct impact due to the fact that it is poisonous to cattle. Additionally, invasives can have indirect impacts, for example, certain types of inedible invasive grasses can easily and quickly outcompete native grasses that are important as forage for cattle.

The second phase of the research explores the various methods by which invasives may be transported on vehicle and equipment carriers or in soil contaminated with seeds of invasive species. This phase includes a process mapping of oil and gas activity from pad construction to rigging down.

The third and most robust phase of the project is the exploration of various control options including preventative methods and post-introduction control. Preventative methods being researched are vehicle and mobile wash technologies, soil management planning and education. Post introduction control includes herbicide application, prescribed burns, manual and biological controls.

12 *Texas A&M University, Kingsville, Water: "Assessment of Two Alternative "Smart" Shale Fracturing Fluids: Desalination Concentrate and CO_2 Foam"*

Increasing drilling and hydraulic fracturing (with associated water demand) in the Eagle Ford Shale is occurring during a time of drought, adding to concerns with demand for water resources. In this work, two alternatives to the use of fresh water in hydraulic fracturing operations will be investigated. First, the feasibility of using desalination concentrate (from brackish groundwater and flowback water treatment) as hydraulic fracturing fluid will be assessed by performing geochemical modeling analysis. Second, the feasibility of using nanoparticle-stabilized CO_2 foam as a fracturing fluid will be investigated. In this effort the feasibility assessment will focus on 1) generating a stable CO_2 foam using brackish groundwater desalination concentrate and nanoscale silica particles, 2) evaluating the rheological properties of the CO_2 foam as an alternative hydraulic fracturing fluid, and 3) development of a preliminary hydraulic fracturing treatment process using nanoparticle-stabilized CO_2 foam, including determination of proppant and foam schedules.

13 *Artist Boat, Workforce Development: "Watershed Education Training (WET) Eco-Art Workshop and Adventure"*

Energy production workforce personnel will participate in watershed education training focused on the Galveston Bay estuarine system. The place-based and experiential learning modules will promote a common lexicon of environmental vocabulary and concepts applicable to all watersheds, estuaries, and wetland regions. Participants will engage in hands-on, place-based, and meaningful watershed experiences through a class in Eco-Art Workshops and outdoor Eco-Art Adventures via kayaks that integrate the disciplines of art and science.

- Training for employees in the petrochemical industry–at no cost to the employer.
- A professional development program with fun, hands-on activities to promote team building and engage employees who may not typically work together in dialogue about the natural resources of the estuary.
- Participants will discuss issues facing the quality of the bay and how people can change behaviors to improve the bay, using the vocabulary and concepts of scientists and environmental workers on the Gulf Coast.

14 Artist Boat, Workforce Development: "Stewardship Training in the Coastal Zone for Petrochemical Industrial Workers"

This program will provide a regional mechanism for employees of oil and gas companies operating throughout the Galveston Bay region to participate in stewardship-based learning modules designed to develop a common lexicon of environmental vocabulary and concepts, promote permanent corporate and personal investments in maintaining a stewardship ethic based on broad understanding of the coastal environment through placed-based learning, and assure a continued and broadened participation in activities that address the priority environmental issues within the estuaries and watersheds impacted by oil and gas activities. This program will be centered on the Environmental Literacy Continuum of the Environmental Protection Agency and the science standards identified in the National Oceanic and Atmospheric Administration Ocean Literacy Principles.

Environment 24/7 – Establishing a Culture of Environmental Awareness

Funded by EFD Consortium Membership Fees

The Environmentally Friendly Drilling Program released a book exploring the importance of creating a culture that encourages individuals and the company as a whole to take personal responsibility for their impact on the environment. The book, ***Environment 24/7***, is now available through www.environment247.org. In narrative style, the book follows a manager charged with creating a culture of environmental awareness and his journey to navigate the change process in his company and his own life.

Today's headlines show the importance of taking care of our environment. More than 11 percent of the world's population cannot access clean water, while the average person in Texas is using more than 62,000 gallons of water annually (based on 2010 estimates). ***Environment 24/7*** provides information applicable to all industries and appeals to every level of experience and educational background. It can help organizations elevate Environmentalism to a core value to save our ecosystem and avoid creating tomorrow's headlines.

Significance in Application to Oil & Gas Industry

Companies face environmental constraints, including regulations and laws that can limit or completely halt oil and gas exploration and production in sensitive areas in the United States and around the world. In the recent past, more than 30 environmental regulatory impediments to domestic natural gas production have been identified and documented. Previously funded Environmentally Friendly Drilling (EFD) projects reveal that, as the energy industry becomes more environmentally friendly, citizen pressure for government regulation declines. Under the right circumstances, citizens will favor relaxing governmental regulations that limit exploration and production in sensitive areas.

The National Academy of Sciences reports an average of 27 oil spills occur every day somewhere in the world, and the Valdez spill doesn't even make the list of the top 30 all-time largest. In 2012, there were 905 natural catastrophes worldwide, 93 percent of these being weather-related disasters. This figure was nearly 100 more than the 10-year annual average for these types of events.

Environment 24/7 is an easy-to-read yet powerful book that clearly outlines the steps and level of commitment necessary to create a culture of environmental awareness within any organization. The book is the result of academia, industry and environmental organizations working together, through science, to address environmental issues associated with petroleum drilling and production.

Environment 24/7, written by Gregory Anderson, co-author of *Safety 24/7*, Rich Haut, and Tom Williams, shows how each person, family and company can change habits to make a difference … creating a cleaner, healthier planet before it's too late. The book is available at www.Environment247.org.

"Just as *Safety 24/7* has helped save lives," said Anderson, "***Environment 24/7*** helps to save ecosystems by illustrating that real change can only take place where there is an open mind and a willing heart."

This effort provides sponsors with a transformational tool based on a need identified in a 2011 IADC paper "*Creating a Company's Environmental Culture to Improve Performance in the Energy Industry*," by Thomas E. Williams, Rich Haut, HARC, David Burnett, Texas A&M, GPRI, Greg Anderson, Moody International, and Gene Theodori, Sam Houston State.

Supplemental Projects

Study to Identify and Measure Environmental Impact of Onshore Drilling

A proposal was submitted to the Drilling Engineering Association (DEA) to conduct a study that will determine how resource development can occur without negatively impacting the environment. This will address: current practices that impact the environment, practices that have been developed in protecting the environment, and determine what we can do better. This study will include information about changes in regulations and practices/perceptions related to environmental concerns that will affect drilling in different areas.

This project proposal is a broad and comprehensive effort requiring subject matter experts from various disciplines. The challenges we all face if we are to continue this trend of increasing drilling and production can best be met by a collective effort. If a study is solely conducted by or sponsored exclusively by industry, it, unfortunately, will lack the credibility of the intended goals to its intended audience; however, we do not believe this comprehensive study can be done without the input of leading industry experts.

We are continuing to pursue DEA funding.

Powered by Natural Gas

In 2013 the EFD team initiated a project to investigate the use of natural gas as a primary source for equipment used in drilling and fracturing operations. The objective is to determine how natural gas may be used in E&P operations to reduce emissions, optimize fueling and reduce overall site footprint. The study will examine natural gas fuel supply options and power technologies. The work effort will also identify safety issues/concerns including training and public outreach.

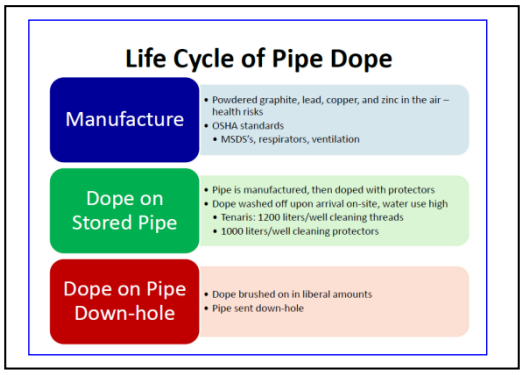
A series of white papers is being developed. Topics will include: Basics (issued in 2013), Dual Fuel and Bi-fuel, Turbine Power, Natural Gas Fueling, LNG, CNG, Field/Wellhead Gas, Cost, Electrification, Regulatory Issues.

The team is developing tools to estimate fuel cost savings with the use of natural gas as compared with conventional diesel, either in part or whole, for drilling and hydraulic fracturing operations. There are four calculators for both Drilling and Hydraulic Fracturing with fuel delivery options such as LNG, CNG, Pipeline/Sales gas, and Field/Wellhead gas. The Field/Wellhead Gas calculator includes calculation of Lower Heaving Value (LHV) and Methane Number (MN) of associated/produced gas as an indicator of the fuel quality. These calculators can be found on www.efdsystems.org,

Dopefree Pipe

In the make-up of pipe in the oilfield, a lubricating, sealing and thread protecting compound called "pipe dope" is generally applied to the threads of pipes. This pipe dope protects the connection threads, where the casing is the most susceptible to leaks, from galling, oxidization, and other frictional wear to ensure a good, secure connection throughout the life of the well and thwarting expensive repairs. Unfortunately, the use of leaded compounds may create health, safety, and environmental issues.

Dopefree technology is a practice that can substanially address environmental issues in drilling and completion operations. The objective of this project perform and document a case study of using dopefree connections. This will include understanding how the technology can impact casing running speeds, safety on the rig floor, environmental issues associated with the use of storage compounds, etc.



The most commonly used thread compounds are variations of dope established by the American Petroleum Institute, which contain as much as 30% to 60% lead by mass. Some dopes are even as much as 60% lead. Lead contamination is known to cause significant impacts to human health and the environment. Though current regulations dictate the disposal of unused pipe dope and dope on thread protectors, there is still the potential for discharge of leaded thread compounds. The presence of lead in the proportions used, along with improper handling and disposal or washing practices afford the opportunity for discharge of lead.

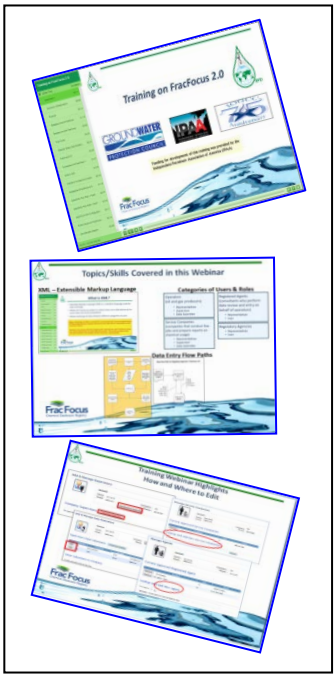
The application of pipe dope on a rig involves using a brush to dip into the dope container and lather onto the pipe threads. In this exchange, there is high probability of dope spilling or dripping onto the rig floor. By nature, pipe dope is a viscous compound that may create an unsafe work surface and contribute to slip-and-fall injuries. Pipe dope may adhere to workers' clothing in substantial amounts, creating concerns with lead contamination from laundering and exposure of workers' family members. An Oklahoma case study showed elevated levels of lead in the bloodstreams of oilfield workers' children.

HSE concerns and regulations by environmentally-proactive governments inspired a search for solutions to problems associated with leaded pipe dope. Green dopes that are lead-free and even metal-free were largely introduced into the oilfield supply market in the 1990's. These dopes effectively limit environmental lead discharge, though issues of efficacy and safety persist.

Another solution, dope-free technology, completely eliminates the need for pipe dope in storage and at the rig, thus eliminating HSE and operational risks associated with leaded and lead-free compounds. Tenaris' Dopeless® line of casing is made by application of a dry, multifunctional coating on the threads of pipes. While a high amount of VOCs are emitted in the process, simple VOC and NOx capture systems may be applied to create an overall cleaner emission and a friendly dope-free process.

FracFocus Webinar Training

Shortly after the launch of FracFocus, users of the site noted some difficulty in entering, uploading and storing data in The Chemical Registry.



In 2012, the GWPC and IOGCC began work on a newer version of FracFocus called FracFocus 2.0 in order to improve ease of use and facilitate management of the growing number of Registry entries as well as ease of use.

Training on the new system was needed, so a training webinar was created and is found on FracFocus' website (www.fracfocus.org) as well as on the Environmentally Friendly Drilling Systems (EFD) website (www.efdsystems.org/fracfocus).

This training presentation was developed based on the features and mechanisms included in FracFocus 2.0 as of December 2012.

The webinar has options designed to accommodate viewers' schedules. New terminology, data flow paths, and a case example is presented. Screenshots of the four user categories and icons that represent the varying tasks are provided along with step by step instructions on entering, reviewing and editing data.

The guidance manual and training presentations can be updated as new features and mechanisms become part of FracFocus 2.0.

This was completed in 2013.

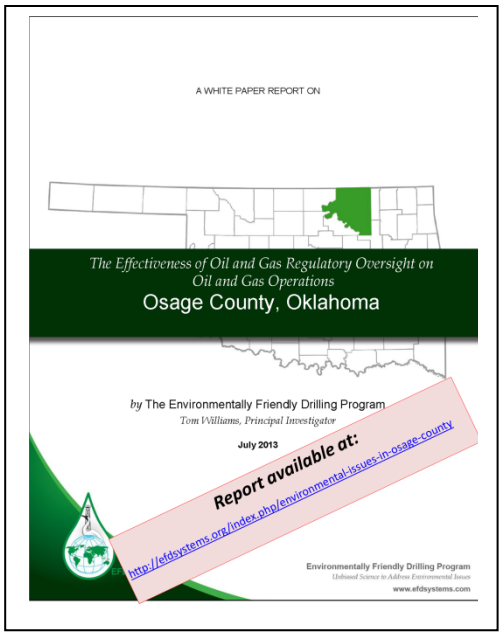
Environmental Issues in Osage County, Oklahoma

The Osage Nation Reservation consists of approximately 1,475,000 acres and is otherwise known as Osage County, Oklahoma. There are literally hundreds of thousands of old oil wells in the county which has been one of the most active areas in the US over the past 100 years. The Osage tribe owns all mineral rights located within Osage County and has an income from all oil and gas found in Osage County. The Bureau of Indian Affairs regulates the oil and gas operations and collects royalties. The Royalties are distributed to the Osage Nation "headright" owners by the Osage Mineral Council.

We were invited to visit Osage County by The Nature Conservancy (TNC) and meet with a number of large landowners, all members of the Osage County Cattlemen's Association (OCCA).

In 2011 the Osage Nation reached a $380 million settlement with the Federal government over mismanagement of the Osage oil and gas trust. The judgment was to compensate the tribe for claims of historical losses to its trust funds and interest income as a result of the government's lack of management of trust assets. The judgment in the case also required the DOI to rewrite the regulations for oil and gas found in Title 25, Part 226 of the Code of Federal Regulations.

The EFD Team Drafted a "Review of Oil and Gas Operations in Osage County" for TNC and OCCA. This included a review of the existing rules and on the regulatory process in Osage County. In addition,



- EFD participated in Public Hearings on a BIA Rulemaking Process initiated as a result of the lawsuit.
- Developed proposed rule changes for the OCCA during the public comment period.
- Met with many stakeholders: Osage Mineral Council, Osage Nation Chief, BIA, State Officials, Federal Officials (EPA, USGS, BLM), OK Senate and Congressional Members and staff, National and Regional Associations, Operators and the Oklahoma press.
- Conducted extensive research on comparable rules from States and other Federal agencies, reviewed several Best Practices documents and reviewed STRONGER state reviews.
- In July 2013, we published on the EFD website a White Paper "The Effectiveness of Oil and Gas Regulatory Oversight in Oil and Gas Operations in Osage County Oklahoma". This was provided to stakeholders and Federal officials.
- Met with DOI Assistant Secretary for Indian Affairs Washburn, BIA Director Black, DOI Deputy Solicitor Haugurd and their staff in Washington DC.
- Facilitated H2S Testing for landowners and provided safety guidelines.
- Drafted detailed comments for OCCA on the "Draft Revision of the BIA Osage Rules Governing Leasing of Osage Reservation Lands for Oil and Gas" which was posted in the Federal Register August 28, 2013. These proposed rules by the DOY followed a yearlong Rulemaking Process.
- October 24, 2013 we submitted a letter to the Department of Interior commenting on the published Draft Rule. This letter was also the basis for the OK Attorney General's comments on the rules.

The bottom line:

These proposed regulations lack adequate protection of the land, surface and ground water, air, environment and safety as compared to regulations on all other producing states and the current regulations covering other Federal lands enforced by the Bureau of Land Management. The current and proposed rules do not incorporate prudent oversight provisions, permitting processes or industry standards followed by all other areas, in particular the State of Oklahoma, where citizens in the remainder of the State outside of Osage County are better protected.

(upper left). New tanks at a legacy field (upper right) decades old oil spill (lower left) example of spills and unattended wells found in the county (lower right) littered un-reclaimed operations

The best and most logical alternative is for the DOI and the BIA to rescind the Draft Revision and re-start the Rulemaking Process to properly and officially include all stakeholders.

Assessment of the Environmental, Performance and Economic Impact of a High-Performance Water-bases Drilling Fluids System in the Marcellus and Utica Shale Plays

The drilling industry is continuously challenged with new regulations and rules impacting its daily operations. This in turn requires finding new methods as well as new environmentally acceptable products to address day-to-day operational challenges. An important component of drilling is the fluid used in the process. Due to problems associated with drilling through shale formations, especially when drilling highly deviated or horizontal sections, the high lubricity of oil-based drilling fluid is often preferred. However, the use of a non-aqueous base fluid

increases the cost of operations due to treatment needs and disposal requirements. An environmentally acceptable drilling fluid that can meet operational demands improve environmental performance.

Under the auspices of EFD, The Ohio State University and West Virginia University are conducting the analysis for this study. The results will be included in the EFD scorecard as these EFD practices may be cost effective, enhance public relations, increase productivity and reduce environmental impacts and potential liabilities.

There are three main tasks in the study.

Task 1: This effort involved gathering of rules, regulations, pending legislation, regionally published best practices that impact drilling operations, drilling fluids and cuttings. WVU provided a report on documents from the State of West Virginia, similar data from Pennsylvania were provided by OSU and the WVU team. OSU provided an overview on Ohio existing and pending rules and regulations. The report discusses all state regulations and practices, as well as pending or proposed rules for Ohio, Pennsylvania and West Virginia related to drilling fluids, including the disposal of drilling fluids and cuttings. Task 1 was completed in 2013.

Task 2: This study will include the well construction "life-cycle" of drilling fluids and cuttings waste management/disposal of the high-performance water-based fluid as compared to oil based/diesel fluids typically used to drill the lower section of wells in this region. The beginning of this task will include a workshop in the region. The purpose of the workshop will be to develop a consensus on the selection and planning of operational parameters related to data needs during the application of proposed new water based drilling fluid. The goal is to establish the parameters to monitor and analyze during and after the use of new water based drilling fluid. This may include independent laboratory analysis of the fluids and cuttings. The intended use of the fluid study will be the section drilled after setting the intermediate casing through the horizontal section where then well is drilled to total depth. Collection of data will start after drilling the cement plugs used with intermediate casing. The task will also identify the elements of the study: Performance, Environmental and Economics. Task 2 will be performed in 2014.

Task 3: The project team will work with operator(s) who will provide data for comparable wells in each of the two shale plays. Data from offsetting wells drilled with oil based fluids will be compared to the high-performance water based fluid. The operator(s) will preferably be EFD sponsors. The goal is to have a willing participant active in the drilling of shale formations in the region. The parameters selected during task two will be recorded and analyzed for efficiency and economics of the drilling operations conducted by the operator participating in this project. If available, additional data from the experimental study by OSU will be incorporated into the analysis and evaluations. All data and results will be shared among team members. The impact of the new proposed fluid will be determined and findings will be reported to participating teams. As part of the technology transfer plan, additional papers will be prepared and submitted to national meetings for presentation. Task 3 will be initiated in 2014.

PUBLICATIONS, PRESENTATIONS AND FORUMS

Technology transfer is a key element of the Environmentally Friendly Drilling Systems Program. The EFD team is heavily involved in engaging stakeholders at multiple levels. Members of the EFD team from Texas A&M University were involved in the EPA hydraulic fracturing study and the US Department of Energy's Energy Advisory Board – Natural Gas Subcommittee. Currently, the EFD team has various members on:

- National Research Council: Unconventional Hydrocarbon Roundtable
- Eagle Ford Center for Research, Education and Outreach/External Advisory Board
- SPE Fall Technical Program Subcommittee – HSE
- Drilling Engineers Association (DEA) Board
- Research Partnership to Secure Energy for America (RPSEA) Board

The EFD team is routinely called upon to participate in various roundtables, both in industry and in the public and is actively engaged in planning activities for various conferences, forums and exhibitions.

The following is a list of publications, presentations, and forums pulled together by the EFD team:

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2. Gamboa, Y.P. and L.W. Clapp, 2013. Characterization of brackish groundwater desalination concentrate discharge impacts on water quality in a Texas coastal area (D. Ramirez, J. Ren, K. Jones, and H. Lamm, Eds.) - *Environmental Sustainability Issues in the South Texas - Mexico Border Region*. Springer.
3. LaFleur, Carolyn. 2013 (October). "The Basics of Natural Gas Power & Fuel. Natural Gas Fuel for Drilling and Hydraulic Fracturing, PbNG.
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6. Theodori, Gene L. 2013. "Perception of the Natural Gas Industry and Engagement in Individual Civic Actions." *Journal of Rural Social Sciences* 28(2):122-134.
7. Wilcox, Andra 2013 (April). "Working Towards Green E&P." Article published in OilField Technology, Volume 6, Issue 04 pp 48-52.
8. Williams, Tom. 2013 (July). "The Effectiveness of Oil and Gas Regulatory Oversight on Oil and Gas Operations: Osage County, Oklahoma."
9. Willits, F.K., A.E. Luloff, and G.L. Theodori. (*forthcoming, 2013*). "Changes in Residents' Views of Natural Gas Drilling in the Pennsylvania Marcellus Shale, 2009-2012." *Journal of Rural Social Sciences* 28(3).
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1. **Rigzone** Articles:
   a. 'First Movers in Eco-Drilling: Going 'Dope'-less', 25 April 2012.
   b. 'First Movers in 'Green' Drilling Series', 23 March 2012.
   c. 'First Movers in Eco-Drilling: What to Do with Those Pesky Drill Cuttings', 21 March 2012.
   d. 'The Great Crew Change Meets Eco-Drilling: Disappearing Roads', 15 February 2012.
2. **Hart E&P Techbook** Article:
   a. "Environmentally Friendly No Longer an Oxymoron to Oil and Gas", August, 2012.
3. C.E. Cooke, Jr., SPE, Cooke Law Firm; J.T. Watters, SPE and L.T. Watters, SPE, CSI Technologies, LLC; S.R. Wann, Danimer Scientific, LLC; D. Zhu, SPE and Y.S. Hwang, SPE, Texas A&M University (2012). "Eco-Friendly Creation of Propped Hydraulic Fractures" paper SPE 152189 presented at the SPE Hydraulic Fracturing Technology Conference, 06-Feb-12, The Woodlands, TX.
4. Haut, R.C. Williams, T. "Reducing Environmental Tradeoffs Along Texas Coastal Areas." Presented at the GCAGS 2012 62nd Annual Convention in Austin, TX.
5. Horner, Robert. "The Evolving Regulatory Landscapes of Shale Gas Development," paper to be presented at the Western Energy Policy Research Conference, Boise, ID, August 30-31, 2012.
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10. Redden, Jim. "Drilling Advances." **World Oil**, December 2012. (http://www.worldoil.com/December-2012-Drilling-advances.html)

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1. **Rigzone** Articles:
   a. '*First Movers in Eco-Drilling: Greener Results to be Clicks Away*', 21 December 2011.
   b. '*First Movers in 'Green' Drilling: Low-Footprint Rigs*', 17 November 2011.
   c. '*Haut Spearheads Green Drilling Movement*', 3 October 2011.
   d. '*Analysis: Research Group Defines 'Best' Fracking Practices to Ease Concerns*', 6 September 2011.
2. **Hart E&P** Articles:
   a. '*EFD Program Expands*', 1 October 2011.
3. **Drilling Contractor** Articles:
   a. '*Drilling automation: Is resistance futile?*', 6 July 2011
   b. '*JIP aims to minimize environmental risks, coastal impact through technology*', 24 May 2011.
4. **Discover Magazine** Article
   a. '*Fracking Nation*', May 2011.
5. EFD Team quoted by the press:
   a. '*Producers find environmentally-friendly technology can boost bottom line*', **Midland Reporter – Telegram**, 16 November 2011.
   b. **Dot Earth:** '*A Fracking Method With Fewer Water Woes?*', **New York Times**, 8 November 2011.
   c. '*Shale Gas Fracking Without the Hazards*', **Daily Yonder**, 8 November 2011.
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6. Alonzo, J. and Stuver, S., *Hydraulic Fracturing Phase Emissions Profile (Air Emissions Field Survey No. 1,* Texas A&M Technology Commercial Applications Technology Technical Report to the Environmentally Friendly Drilling Program, December, 2011.

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11. Quinlan, E., van Kuilenburg, R., Williams, T., Thonhauser, G.: "The Impact of Rig Design and Drilling Methods on the Environmental Impact of Drilling Operations," paper AADE-11-NTCE-61 presented at the 2011 AADE National Technical Conference and Exhibition, Houston, TX, 12-14 April 2011.
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11. Clark, M. and Hotby, Q.: "Prevention Technology Can Help Drilling, Service Rigs to Minimize Environmental Footprint at the Source," Drilling Contractor, November/December 2009, pp. 74-79.
12. Mutz, K. and Haut, R.: "Best Practices Database Reduces Impact of Drilling, Production," April, 2010.
13. Theodori, Gene L., Mona E. Avalos, David B. Burnett, and John A. Veil. (forthcoming). "Public Perception of Desalinated Water from Oil and Gas Field Operations: A Replication" Journal of Rural Social Sciences.
14. Theodori, Gene L. and Douglas Jackson-Smith. 2010 (September). "Public Perception of the Oil and Gas Industry: The Good, the Bad, and the Ugly," paper SPE-134253 presented at the 2010 Society of Petroleum Engineers Annual Technical Conference and Exhibition. Florence, Italy.
15. Theodori, Gene L. 2009. "Paradoxical Perceptions of Problems Associated with Unconventional Natural Gas Development." Southern Rural Sociology 24(3): 97-117.
16. Theodori, Gene L., Brooklynn J. Wynveen, William E. Fox, and David B. Burnett. 2009. "Public Perception of Desalinated Water from Oil and Gas Field Operations: Data from Texas." Society and Natural Resources 22(7): 674-685.
17. Anderson, Brooklynn J. and Gene L. Theodori. 2009. "Local Leaders' Perceptions of Energy Development in the Barnett Shale." Southern Rural Sociology 24(1): 113-129.Yu O.K., Medina-Cetina Z, Briaud, J.L. and Burnett, D. (2009), "Towards a Probabilistic Selection of Environmentally Friendly Drilling Systems," 16th International Petroleum and Biofuels Conference, Houston TX, 3-5 November.
18. Al-Yami A.S., Schubert J., Medina-Cetina Z. and Yu O-Y, (2010), "Members Drilling Expert System for the Optimal Design and Execution of Successful Cementing Practices," Proceedings of the IADC/SPE Asia Pacific Drilling Technology Conference and Exhibition, Ho Chi Minh City, Vietnam, 1–3 November 2010.
19. Yu O.K., Medina-Cetina Z. and Briaud J.L. (2011), "Towards an Uncertainty-Based Design of Foundations for Onshore Oil and Gas Environmentally Friendly Drilling (EFD) Systems," Proceedings of the Geo-Frontiers Conference, Dallas TX USA, March 13-16.
20. Yu O.Y., Medina-Cetina Z., Geikema S., Briaud J.L. and Burnet D., (under review), "Causal vs. Non-Causal Selection of Environmentally Friendly Drilling Systems," Journal of Economics and Management of the Society of Petroleum Engineering SPE.
21. Yu O.Y., Medina-Cetina Z., Geikema S., Briaud J.L. and Burnet D., (under review), "Risk-Based Selection of Environmentally Friendly Drilling (EFD) Systems," Journal of Systems Engineering.
22. Burnett, D.B, Yu, O.Y., and Schubert, J.J., "Well Design for Environmentally Friendly Drilling Systems: Using a Graduate Student Drilling Class Team Challenge to Identify Options for Reducing Impacts," SPE/IADC 119297, Prepared for presentation at the SPE/IADC Drilling Conference and Exhibition held in Amsterdam, The Netherlands, 17-19 March 2009.

Presentations

2013

2013-11-20 "New Markets for Shale Gas Consumption." Total Energy USA Conference, Houston, TX

2013-11-15 "Freshwater use and alternatives for hydraulic fracturing operations." - Sustainable Eagle Ford Shale Water and Transportation - Challenges and Solutions Workshop" - Cotulla, TX

2013-11-15 "Groundwater quality mapping in Kenedy County, Texas." - Sustainable Eagle Ford Shale Water and Transportation - Challenges and Solutions Workshop - Cotulla, TX

2013-11-15 Wireless sensor network for monitoring VOC levels near drilling operations. *Sustainable Eagle Ford Shale Water and Transportation – Challenges and Solutions Workshop* – Cotulla, TX [student poster/presentation]

2013-11-15 Design for a mobile solar energy unit to power air monitoring equipment at hydraulic fracturing well sites. *Sustainable Eagle Ford Shale Water and Transportation – Challenges and Solutions Workshop* – Cotulla, TX

2013-11-13 *Developing Advanced Analytical Sampling Protocol for Produced Water, Stray Methane Gas and Fugitive Emissions;* International Petroleum Environmental Conference- San Antonio TX

2013-11-12 *Advanced Air Emission Inventories for Drilling and Completions;* Environmentally Friendly Drilling Systems Advisory Committee Meeting- The Woodlands TX

2013-11-12 "Field tests - Air quality monitoring." Environmentally Friendly Drilling Systems Advisory Committee Meeting - The Woodlands, TX

2013-11-12 "Local Perceptions of the Oil and Gas Industry in the Eagle Ford Shale." Environmentally Friendly Drilling Systems Program – Advisory Committee Meeting;- The Woodlands, TX

2013-11-08 Assessment of using reject concentrate streams from brackish groundwater desalination plants in the Eagle Ford region as hydraulic fracturing fluid. *Texas A&M University System 11th Annual Pathways Student Research Symposium* – Kingsville, TX [student poster presentation]

2013-11-08 Groundwater quality mapping in Kenedy County, Texas. 2013. *Texas A&M University System 11th Annual Pathways Student Research Symposium* – Kingsville, TX [student poster presentation]

2013-11-08 Wireless sensor network for monitoring VOC levels near drilling operations. *Texas A&M University System 11th Annual Pathways Student Research Symposium* – Kingsville, TX [student poster presentation]

2013-11-07 "EFD TIP Program – Frac Water EFD Water Recycle Research" Infocast Eagle Ford & Burgos Basin Cross Border Development Summit, Houston, TX

2013-11-05 "Introduction to air quality topics for oil and gas operations." Supply, Flowback, and Waste Water Treatment Training Course for Hydraulic Fracturing - Kingsville, TX

2013-11-05 "Water treatment and management: Secondary and tertiary." Supply, Flowback, and Waste Water Treatment Training Course for Hydraulic Fracturing - Kingsville, TX

2013-11-01 "Natural Gas Usage for Powering Operations on Your Lease." National Association of Royalty Owners (NARO) Annual Conference, Columbus, Ohio

2013-10-29 "Management, Disposal, and Reuse of Produced and Frac Flowback Waters: Views from the General Public" - 9th Annual Practical Short Course on Water Desalination, Process and Wastewater Issues & Technologies - College Station, TX

2013-10-27 "Characterization of desalination plant concentrate discharge impacts on water quality in a Texas coastal area." Professional short-course presentation at the Water Issues & Technologies: Process Water, Wastewater, and Desalination Short Course, Texas A&M University - College Station, TX

2013-10-27 "Characterization of desalination plant concentrate discharge impacts on water quality in a Texas coastal area." Water Issues & Technologies: Process Water, Wastewater, and Desalination Short Course, Texas A&M University - College Station, TX

2013-10-26 "Objective and Perceived Effects of Shale Gas Development." Society of American Foresters 2013 National Convention - Charleston, SC.

2013-10-23 *Hydraulic Fracturing – Hype or Health Hazard;* Oil and Gas Course; South Texas Farm and Ranch Show- Victoria, TX

2013-10-21 *Briefing on the Environmentally Friendly Drilling Systems Program – lessons learned concerning shale development*, delegation from the United Kingdom, hosted by the UK Consulate, Houston, TX.

2013-10-16 Assessment of using reject concentrate streams from brackish groundwater desalination plants in the Eagle Ford region as hydraulic fracturing fluid. *Texas A&M University- Kingsville 5th Annual Javelina Research Symposium* - Kingsville, TX [student poster presentation]

2013-10-16 Groundwater quality mapping in Kenedy County, Texas. 2013. *Texas A&M University- Kingsville 5th Annual Javelina Research Symposium* - Kingsville, TX [student poster presentation]

2013-10-16 Wireless sensor network for monitoring VOC levels near drilling operations. *Texas A&M University- Kingsville 5th Annual Javelina Research Symposium - Kingsville, TX* [student poster presentation]

2013-10-16 Design for a mobile solar energy unit to power air monitoring equipment at hydraulic fracturing well sites. *Texas A&M University- Kingsville 5th Annual Javelina Research Symposium*- Kingsville, TX [student poster presentation]

2013-10-15 "The EFD Program Research with a Focus on Water and Air in the Eagle Ford." Hart Energy DUG Eagle Ford Conference, San Antonio, TX.

2013-10-10 *Air Emissions: A Report on South Texas;* Energy, Air and Water: A Comprehensive Study of the Issues of Today; Texas Alliance of Energy Producers; San Antonio, Texas

2013-10-06 "Oil & Gas – Water Quality Regulations." University of Colorado Law, Environmental Law Society – Boulder, CO

2013-09-26 "Oil and Gas Leases and Surface Use Agreements." Water, Oil and Gas: Nuts and Bolts of Leases, Surface Use Agreements and Water Rights for Non-Oil and Gas Attorneys – Denver, Colorado

2013-09-25 "How Industry is Partnering/Can Partner with the Communities in Which They Serve: A Sociological Perspective." Shale Insight 2013 - Philadelphia, PA

2013-09-05 *A Better Way to Estimate Emissions;* Natural Gas Power for Shale Development; EFD Workshop- Pittsburg, PA

2013-08-15 "Wireless sensor network for monitoring VOC levels near drilling operations." EFD-SRN Joint Air-Water-Gas Workshop - Golden, CO

2013-08-07 *Balancing Water Supply and Demand for Industrial Use: Challenges with Perception at the Local Level;* Water and Wastewater, Challenges and Treatment Options Short Course- College Station, TX

2013-08-07 "Residents' Views of Natural Gas Drilling in the Pennsylvania Marcellus Shale, 2009 and 2012." 76th Annual Meeting of the Rural Sociological Society- New York, NY.

2013-07-19 *Hydraulic Fracturing Hype or Health Hazard;* Agrilife Extension Oil Water and Gas Planning Seminar- Austin County, TX

2013-07-11 FracFocus 2.0 Training - GWPC Stray Gas Incidence & Response Forum and Water Management Unconventional Oil & Gas Forum, Grapevine, TX

2013-07-09 *Advanced Analytics for Stray Methane Gas, Produced Water Sampling and Fugitive Emission Measurement;* Groundwater Research and Education Foundation- Grapevine TX

2013-06-20 *Coastal Impacts Program Overview and Project Objectives;* Environmentally Friendly Drilling Systems Alliance Members- Houston TX

2013-06-20 Texas Coastal Impacts Assistance Program - CITP, The Woodlands, TX

2013-06-18 *Briefings on Osage County;* EFD along with a delegation of major Osage County Ranchers and Landowners, Department of Interior, Bureau of Indian Affairs and Oklahoma Congressional and Senate Members and Staff, Washington, DC>

2013-06-11 "Water Recycling in Ohio and Pennsylvania." Water, Oil, and Gas: Water Sampling and Recycling – Denver, Colorado

2013-06-06 "Regulations and BMP Research Task." National Science Foundation workshop, Air, Water, Gas Sustainable Research Network. – Washington D.C.

2013-06-05 "Hydraulic Fracturing and the Management, Disposal, and Reuse of Frac Flowback Waters: Views from the Pennsylvania Marcellus Shale Region." 19th International Symposium on Society and Resource Management- Estes Park, CO.

2013-06-03 *Introduction to Hydraulic Fracturing and the Energy Program – Building Partnerships with Extension;* Agrilife Extension Retreat - College Station, TX

2013-05-31 Re-Use of Produced Water & Alternate Water Sources - GAO-NAS Water & Energy, Washington, D.C.

2013-05-30 *IRNR Programs, Key Projects, Goals and Vision;* Texas A&M Collaborative Luncheon- San Antonio, TX

2013-05-15 *IRNR Energy Program Projects, Goals and Vision;* Meeting with Agrilife Extension Director- San Antonio, TX

2013-05-14 *Moderator / Facilitator for Powering Energy Production with Natural Gas Workshop;* Environmentally Friendly Drilling Systems Program- San Antonio, TX

2013-05-01 *Moderator for Breakfast Water Panel Discussion;* Leadership San Antonio-San Antonio,TX

2013-04-25 "Groundwater Constituent Mapping for Kenedy County, Texas." *Frank H. Dotterweich 2nd Annual College of Engineering Graduate Student Research Poster Competition* – Kingsville, TX [student poster presentation]

2013-04-25 Use of desalination concentrate streams for hydraulic fracturing operations." *Frank H. Dotterweich College of Engineering 2nd Annual Graduate Student Research Poster Competition* – Kingsville, TX [student poster presentation]

2013-04-25 "VOC monitoring at drilling sites using a wireless senor network." Frank H. Dotterweich 2nd Annual College of Engineering Graduate Student Research Poster Competition - Kingsville, TX [student poster presentation]2013-04-18

2013-04-18 "Analysis and diagnosis of membrane filtration fouling." 23rd Annual Membrane Filtration Short Course, Texas A&M University - College Station, TX

2013-04-17 "Analysis and diagnosis of membrane filtration fouling." Water & Wastewater: Issues, Challenges, Solutions and New Technologies Short Course - College Station, TX

2013-04-17 *Hydraulic Fracturing Hype or Health Hazard;* Texas Groundwater Protection Council- Austin, TX

2013-04-17 "VOC monitoring using wireless sensor networks." Water & Wastewater: Issues, Challenges, Solutions and New Technologies Short Course - College Station, TX

2013-04-12 *Improving Eagle Ford Communities;* Council of Government Day at the Texas Capitol- Austin, TX

2013-04-10 "The Sociology of Shale Gas Development." Purdue University's Ecological Sciences & Engineering Keystone Series Interdisciplinary Panel on High Volume Shale Gas Extraction- West Lafayette, IN

2013-04-08 EFD Program: Addressing Environmental Issues & Increasing Environmental Awareness - 2013 IADC Conference, New York, NY

2013-03-13 "The Scientific Perspective." What the Frack! Do You Know What You're Investing In? – Boulder, Colorado2301-02-13 Site Assessment and Baseline Monitoring Measurements in Ohio - EFD Workshop, Columbus, OH

2013-02-27 *Air Emission Reduction Technologies and Methods;* Bureau of Energy Resources, Department of State and Agencia Nacional de Hidrcarburos (ANH); Unconventional Natural Gas Development: Social, Economic and Environmental Implications- Bogotá Columbia

2013-02-21 *West Regional Center Field Trial Overview and Expectations;* West Regional Center Strategic Research Roundtable- San Antonio, TX

2013-02-13 *Know the Facts About Emission Factors;* Environmentally Friendly Drilling Systems Site Assessment and Baseline Monitoring Measurements Workshop- Columbus, OH

2013-02-12 *Texas A&M Collaborative Research Partnership;* AACOG Day at the Capitol Workshop and Planning Meeting-Austin, TX

2013-02-07 *Advanced Analytical Protocols for Fugitive Air Emissions Measurement;* Chesapeake and Devon; Strategic Research Roundtable- Oklahoma City, OK

2013-01-07 *Safe Fracturing and the Conversion of Oil Field Produced Brine to Fresh Water;* National Oil Well Varco; H2O: Pain and Possibilities Round Table- Houston, TX

2012

2012-11-14 Proposal: A Study to Identify and Measure the Environmental Impact of Onshore Drilling. Presented to the Drilling Engineering Association http://www.worldoil.com/December-2012-Drilling-advances.html

2012-11-13 Shale Gas: Environmental Baseline and Environmental Monitoring. Presented to Ukraine Government.

2012-10-31 Simple and Economic Testing of Groundwater for Contamination – Industrial & AgriBusiness, International Petroleum Environmental Conference – Denver, CO

2012-10-30 *Environmental Impacts from fracturing – Hype or Health Hazard;* American Industrial Hygiene Association; Eagle Ford Health Impacts Workshop- San Antonio, TX

2012-10-23 Reducing Environmental Tradeoffs Along the Texas Coastal Areas – GCACS – Austin, TX

2012-10-22 The Environmentally Friendly Drilling Systems Program. Presented at the Eagle Ford Shale Stakeholders Summit, Laredo, TX.

2012-10-17 Demonstrating Technologies that Reduce Environmental Footprints . Presented at the Texas Alliance of Energy Producers, The 21st Century Energy Technology Conference

2012-10-11 *Eagle Ford Environmental Impacts – Fact of Fiction:* San Antonio Manufacturers Association Workshop-San Antonio, TX

2012-10-09 *Getting Ahead of the Regulators by Building your own Emissions Profile:* Society of Petroleum Engineers; Annual Technical Conference and Exhibition- San Antonio, TX

2012-10-04 *Water and Air Concerns in the Eagle Ford:* American Society of Agricultural and Biological Engineers Conference- San Antonio, TX

2012-09-21 Innovation, Safety & Environment culture and how they should impact your career choices - Colorado School of Mines.

2012-09-13 *Environmentally Friendly Drilling in the Eagle Ford Shale:* Air and Waste Management Association luncheon-San Antonio, TX

2012-07-16 Utica Shale Appalachian Basin Research Consortium (focus on industry-government collaborations) presented to representatives from the Shenhua Group; within the DOE Fossil Energy Global Knowledge Network program.

2012-07-16 Preliminary Results on the Effect of Land-Use Land-Cover Methods of Classification and Data Resolution on SWAT Model Predictive Ability. Poster presented at the 3rd Biennial Colloquium on Hydrologic Science and Engineering of the Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI), Boulder, CO.

2012-06-19 Environmentally Friendly Drilling: Air & Waste Management Association Annual Conference & Exhibition, San Antonio, TX.

2012-06-18 "Assessing Opposition and Support for Energy Development in Environmentally Sensitive Areas." Presented at the 18th International Symposium on Society and Resource Management in Edmonton, Alberta, Canada.

2012-06-06 Best Management Practices for Oil and Gas Development. Presentation made at The Institute for Energy Law 3rd Law of Shale Plays Conference in Fort Worth, TX.

2012-06-05 The EFD Technology Integration Program *An opportunity to demonstrate, technologies which will reduce the environmental impacts.* IOGCC, Vancouver.

2012-06-05 BMPs on Public Lands: Protecting Water and Wildlife. Public Lands Committee session, Developing North America's Oil and Gas Resources, Interstate Oil and Gas Compact Commission, Midyear Summit, Vancouver, B.C.

2012-06-04 The EFD Technology Integration Program: IOGCC, Vancouver, B.C.

2012-06-03 Developing North America's Oil and Gas Resources. Presented at the Interstate Oil and Gas Compact Commission, Midyear Issues Summit (Public Lands Committee) in Vancouver, B.C.

2012-05-24 Ukraine Shale Gas: Environmental and Regulatory Assessment presentation at the Regional Shale Gas Workshop in Poland, Ukraine and Kyiv.

2012-05-01 An ArcGIS-Server based framework for oil and gas E&P decision support. PowerPoint resented at the ESRI Petroleum User Group (PUG) Meeting, Houston, TX.

2012-04-27 *Estimating Emissions from Oil and Gas Sites:* CREST-RESSACA Environmental and Energy Sustainability Conference- Houston, TX

2012-04-27 "Public Reaction to Shale Gas Development." Presentation delivered at the Center for Research Excellence in Science and Technology—Research on Environmental Sustainability in Semi-Arid Coastal Areas (CREST-RESSACA) Environmental and Energy Sustainability Conference. Houston, TX.

2012-04-25 Assessing Opposition and Support For Shale Gas Development. Presented at SPE Reducing Environmental Impact of Unconventional Resource Development workshop, San Antonio, TX.

2012-04-25 Energy and the Environment: Application of Framing Theory to Gas Shale Development. Presented at SPE Reducing Environmental Impact of Unconventional Resource Development workshop, San Antonio, TX.

2012-04-24 An ArcGIS-Server based framework for oil and gas E&P decision support. PowerPoint presented at the Mid-America GIS Consortium Biennial Meeting, Kansas City, MO.

2012-04-24 The Industry Must Apply Best Practices for Shale Gas Development. Presented at SPE Reducing Environmental Impact of Unconventional Resource Development workshop, San Antonio, TX.

2012-04-24 Produce Water Analytical Field Trials and Methodology Development. Presented at SPE Reducing Environmental Impact of Unconventional Resource Development workshop, San Antonio, TX.

2012-04-23 Emissions from Oil and Gas Sites are at Risk of being Overestimated. Presented at SPE Reducing Environmental Impact of Unconventional Resource Development workshop, San Antonio, TX.

2012-04-23 Advanced Geoprocessing with Python. Workshop presented at the Mid-America GIS Consortium Biennial Meeting, Kansas City, MO.

2012-04-23 *Emissions from Oil and Gas Sites are at Risk of being Overestimated; SPE*: Reducing Environmental Impact of Unconventional Resource Development Conference -San Antonio, TX

2012-04-10 "Water Management in Oil & Gas Unconventional Developments: A Sociological Perspective." Plenary presentation delivered at the 2012 American Association of Drilling Engineers Fluids Technical Conference and Exhibition. Houston, TX.

2012-03-20 Modeling the Effects of Non-Riparian Surface Water Diversions on Flow Conditions in the Little Red Watershed. PowerPoint presented at the 2012 Fayetteville Shale Symposium, Fort Smith, AR.

2012-03-11 *Reading and Writing Spatial Data for the Non-Spatial Programmer*. Poster presented at the PyCon U.S., Santa Clara, CA.

2012-02-28 *Air Quality Research Needed in the Coastal Environment:* Coastal Impacts Technology Program Workshop- Kingsville, TX

2012-02-17 Ukraine Shale Gas: Regulatory and Environmental Review: Washington, DC

2012-02-07 Creating A Company's Environmental Culture to Improve Performance in the Energy Industry: IADC Health, Safety, Environmental & Training Conference & Exhibition, Houston, TX.

2012-02-05 "A Big Fracing Mess: An Examination of Public Perception of Hydraulic Fracturing." Presented at the annual meeting of the Southern Rural Sociological Association, Birmingham, AL.

2012-01-24 Fact-based Regulation for Environmental Protection in Shale Gas Resource Development: Ground Water Protection Council UIC Conference, Austin, TX.

2012-01-18 Natural Gas Research and Resources at CU Boulder. "Drawing the Blueprint for a Sustainable Natural Gas Future." Presented at the Museum of Nature and Science in Denver, CO.

2011

2011-12-13 Environmentally Friendly Drilling Programs. Presentation given at the Oklahoma Unconventional Resources Forum, Tulsa, OK.

2011-12-07 Low Impact O&G Activity; Environmentally Friendly Drilling Systems. Presentation given at the Crisman Institute for Petroleum Research Forum, College Station, TX.

2011-11-30 Intermountain Oil and Gas Best Management Practices. Presentation given at the RPSEA Onshore Production Conference: Technological Keys to Unlocking Additional Reserves, Golden, CO.

2011-11-07 Reducing Environmental Footprints by Providing Unbiased Science for Policy and Cost Effective Operations. Presentation given during panel discussion at the World Shale Gas Conference & Exhibition, Houston, TX.

2011-11-01 Shale Gas – The Energy-Water Nexus. Presented as part of the webinar series Hydraulic Fracturing: Fresh Facts & Critical Choices sponsored by the Clean Water for America Alliance and the American Water Resources Association.

2011-11-02 Providing Science and Solutions to Shale Development. Presentation given during special environmental panel discussion at the SPE Annual Technical Conference and Exhibition, Denver, CO.

2011-10-27 Balancing Environmental Tradeoffs – Clearing the Air. Presentation given at the Colorado Oil and Gas Association Western Slope Annual Meeting, Grand Junction, CO.

2011-09-15 *Research on the Eagle Ford:* Industry Council on the Environment Austin Section – Austin, TX

2011-09-08 *Research on the Eagle Ford:* Air and Waste Management Association SW Section – Austin, TX

2011-08-18 *Air Quality Project Ideas:* Research Partnership to Secure Energy for America and the Houston Advanced Research Center; Environmental Issues Associated with Unconventional Natural Gas Operations- Houston, TX

2011-07-26 *New Technologies for Lowering Emissions:* Appalachian Basin Petroleum Technology Transfer Program; Lowering the Footprint of Marcellus Shale Development Workshop – Morgantown, WV

2011-06-28 Testimony given to the Secretary of Energy/Energy Advisory Board/Natural Gas Subcommittee. Washington, DC.

2011-06-06 Examining the Effects of Unconventional Natural Gas Development on Community Attachment, Satisfaction, and Action: Data from the Barnett Shale. Presentation given at the 17th International Symposium on Society and Resource Management, Madison, WI.

2011-06-06 Produced Water Management and Disposal: Toward Beneficial Reuse Practices. Presentation given at the 17th International Symposium on Society and Resource Management, Madison, WI.

2011-05-18 Public Perception and Reaction to Shale Gas Development. Presentation given at the East Texas Energy Expo, Center, TX.

2011-05-13 Creating a Company's Environmental Culture to Improve Performance in the Energy Industry. Presentation given at the IADC Environmental Conference & Exhibition, Trinidad.

2011-05-11 Public Perceptions of Marcellus Shale Knowledge Gaps: Preliminary Findings and New Questions. Paper presented at the Marcellus Shale Multi-State Academic Research Conference. Altoona, PA.

2011-05-08 EPA Technical Workshops Office of Research and for the Hydraulic Fracturing Study: Chemical & Analytical Methods.

2011-04-28 Reducing Environmental Footprint in Shale Gas Development – Emerging Technologies. Presentation given at the SPE ATW Workshop, Pittsburgh, PA.

2011-04-19 Environmentally Friendly Drilling Systems. Program review given at RPSEA forum in Denver, CO.
2011-04-19 Shale Gas – The Energy-Water Nexus. Presented at the American Water Resources Association spring specialty conference- Baltimore, MD.
2011-04-13 *Science on the Eagle Ford:* American Association of Drilling Engineers; National Technical Conference
2011-03-29 Balancing Environmental Tradeoffs Associated with Natural Gas Production. Presentation given at Cornell University.
2011-02-23 *Environmentally Friendly Drilling on the Eagle Ford:* Texas Association of Energy Producers; Clean Energy from an Old Friend Conference
2011-02-12 *Frac Flowback Water Treatment:* San Antonio Association of Professional Landmen; Midwinter Seminar.
2011-02-06 This is All New to Us: Rural Residents' Views on Gas Drilling and Water Resources in an Emerging Energy Hotspot. Paper presented at the Annual Meeting of the Southern Rural Sociological Association. Corpus Christi, TX.
2011-02-01 Environmentally Friendly Drilling Systems Program. Presentation given at the USEA Luncheon Forum, Washington, DC.
2011-01-27 Environmentally Friendly Drilling Systems Program. Presentation given at the SPE Hydraulic Fracturing Forum, The Woodlands, TX.

The following presentations were made by Texas A&M during 2011:

2011-12-08 Burnett, D. B., Environmentally Friendly Drilling: How Texas A&M can Save America, Texas A&M Crisman Institute
2011-11 Burnett , D. B., "Eagle Ford Shale: Impact of Gas Shale Development on South Texas Counties, Texas A&M Agri-Life Extension Service
2011-11 Burnett, D. B. "Produced Water "Desalination: Science and Solutions", Drilling Engineering Association, Houston, Nov., 2011
2011-11 Burnett, D. B., McLeroy, K. E., "Technology for Management and Re-Use of Produced Water," Nieva, Colombia
2011-09 Burnett, D. B., McLeroy, K. E. Lowering the Environmental Footprint of E&P Operations: by the Land, Sea(water), and Air, Brigham Energy, Austin, TX
2011-09 Burnett, D. B., "Treatment and Re-Use of Frac Flowback Brine and Produced Water," U. of Wyoming Hydraulic Fracturing Forum Ruckelehouse Energy Institute, Laramie, WY.
2011-08-17 Burnett, D. B., Nathan, V., "Drilling the Eagle Ford Shale: Science and Solutions", presented to Friends of the Shale, Laredo, TX
2011-08 Platt, F. M., Burnett, D. B., Report on Field Trials of Mobile Filtration Unit. Texas A&M Membrane/Filtration Short Course Texas, College Station, TX
2011-07 Burnett, D. B., McLeroy, K. E. "Environmentally Friendly Drilling: South Texas Brine Management Practices," ConocoPhillips, Houston
2011-07 Burnett, D. B. Lowering the Environmental Footprint of E&P Operations: by the Land, Sea(water), and Air, Chesapeake, Energy, OK City OK
2011-06 Higgins, M. E., Burnett, D. B., Societal Issues Related to Leasing Fort Worth Nature Center for (Barnett Shale) Drilling , International Symposium for Society and Resource Management, Madison, WS.,
2011-06-02 Burnett, D. B., McLeroy, K. E. "Lowering the Environmental Footprint of E&P Operations: by the Land, Sea(water), and Air. The Environmentally Friendly Drilling Systems Program, Duke University Nichols School of the Environment
2011-05 Burnett, D. B., "Desalination as an alternative to off-site disposal in conventional oil, Global Water Intelligence
2011-04 Burnett, D. B. Lowering the Environmental Footprint of E&P Operations: By the Land, Sea(water), and Air" Calgary CA.
2011-04 Burnett, D. B., Reducing Environmental Footprint in Gas Shale Operations, SPE Advanced Technology Workshop, Pittsburgh, PA.

2011-04-07 Burnett, D. B., TAMU *Mobile desalination and disappearing roads, Texas A&M Agri-Life Extension Services Workshop, Ft. Stockton, TX*

2011-04-06 Burnett, D. B., TAMU *Mobile desalination and disappearing roads, Texas A&M Agri-Life Extension Services Workshop, Midland, TX*

2011-04-05 Burnett, D. B., TAMU *Mobile desalination and disappearing roads, Texas A&M Agri-Life Extension Services Workshop, Ozona, TX*

2011-04 Burnett, D. B., Texas A&M Membrane/Filtration Short Course Texas, College Station, TX

2011-02 Haut, R. S. Stuver, S., Burnett, D. B., Reducing Water Needs in Energy Production and Lowering Environmental Footprint of Oil and Gas Development", Alamo Area Council of Governments, San Antonio

2011-01-27 Burnett, D. B., Vavra, C.J., Platt, F. J., McLeroy, K. E. Membrane Treatment to Optimize Beneficial Re-Use of Oil Field Brines, SPE Summit Environmental Issues Related to Hydraulic Fracturing, The Woodlands.

2011-01-12 Burnett, D. B., Vavra, C. J., Platt, F. M., Reducing Water Needs in Energy Production and Lowering Environmental Footprint of Oil and Gas Development , presentation to Cleanwater Solutions, LTD., College Station, TX.

2009 – 2010

2010-11-16 Geospatial Decision Support for Reducing Environment Impact in Natural Gas Shale Operations, Managing Fayetteville Shale Play Development Workshop. Workshop held in Fayetteville, AR.

2010-10-28 Decision-Support System for Pad Siting, West Slope Colorado Oil & Gas Association Environmental Summit, Grand Junction, CO.

2010-10-27 Reducing Environmental Impacts in the Fayetteville Shale Play using Geospatial Decision Support, A Spatial Quest: Twenty Years of Mapping the Natural State, Arkansas GIS User's Forum, Hot Springs, AR.

2010-10-25 Natural Gas in the New Energy Economy, Panel discussion part of Clean Energy Day, University of Colorado, Boulder, CO.

2010-10-22 Natural Gas Development and Social Well-Being. Presentation delivered at the Pennsylvania State University, Department of Agricultural Economics and Rural Sociology, M.E. John Lecture Series. University Park, PA.

2010-10-14 Geospatial Decision Support for Reducing Environment Impact in Natural Gas Shale Operations, Opportunities and Obstacles to Reducing the Environmental Footprint of Natural Gas Development in the Uintah Basin. Workshop held in Vernal, UT.

2010-10-14 Intermountain Oil and Gas BMP Project, Presented at the Opportunities and Obstacles to Reducing the Environmental Footprint of Natural Gas Development in the Uintah Basin Conference, Vernal, UT.

2010-10-10 *Minimizing the Surface Footprint for Unconventional Gas,* Presented at the 2010 GCAGS/GCSSEPM Annual Meeting, San Antonio, TX.

2010-09-26 *Water Availability and Management in Shale Gas Operations*, Presented at the Ground Water Protection Council Water/Energy Sustainability Symposium, Pittsburg, PA.

2010-09-22 Public Perception of the Oil and Gas Industry: The Good, the Bad, and the Ugly. Presented at the 2010 Society of Petroleum Engineers Annual Technical Conference and Exhibition. Florence, Italy.

2010-09-01 Water Modeling in the Fayetteville Shale, 17th International Petroleum & BioFuels Environmental Conference, San Antonio, TX.

2010-08-31 *Water Availability and Management in Shale Gas Operations*, Presented at the 17th International Petroleum and Biofuels Conference, San Antonio, TX, August 31-September 2, 2010.

2010-08-31 *The Regulatory Environment*, presented at the 17th International Petroleum and Biofuels Conference, San Antonio, TX, August 31-September 2, 2010.

2010-08-12 *'Deep in the Heart of Texas' Barnett Shale Perceived and Objective Community Level Impacts of Unconventional Gas Development*, Presented at the annual meeting of the Rural Sociological Society, August 12-15, Atlanta, GA.

2010-08-10 Findings for the Publics' Willingness to Adopt Desalination (Purification) of Oilfield Brine. Presented at the 6th Annual Practical Short Course on Water Desalination, Process and Wastewater Issues & Technologies. College Station, TX

2010-07-12 Assessing Opportunities and Barriers to Improving the Environmental Footprint of Oil and Gas Development in Utah. Presented at the Utah Governor's Energy Forum. Salt Lake City, UT.

2010-07-08 *Water Management Technologies & Regulatory Requirements for Different Locations and Environments,* Workshop presented at the 2010 Summer Meeting of the IOGA of New York, Findley Lake, NY.

2010-07-07 *The Inextricable Linkage between Water and Energy,* Presented at the 2010 Summer Meeting of the IOGA of New York, Findley Lake, NY.

2010-07-07 Exploration and Production of Oil and Natural Gas in Environmentally Sensitive Areas: Views from the Public. Presented at the 15th International Symposium on Society and Resource Management. Vienna, Austria

2010-06-24 *Water and Energy Relationships with a Focus on Oil and Gas Produced Water,* Presented at the 10th Biannual Research Review Meeting, National Science Foundation Industry/University Cooperative Research Center for Multiphase Transport Phenomena, East Lansing, MI.

2010-06-17 *Minimizing the Surface Footprint for Unconventional Gas,* Presented at the 2010 Global Unconventional Gas Forum Amsterdam, Netherlands.

2010-06-15 *Water & Energy - Inexorably Entwined Dance Partners, but without Perfect Choreography,* Seminar presented to staff at the Oak Ridge National Laboratory, Oak Ridge, TN.

2010-06-13 *Options for Management of Produced Water,* Presented at the Goldschmidt Conference, Knoxville, TN.

2010-06-07 *Opportunities and Barriers to Environmentally Friendly Energy Exploration and Production Practices in the Uinta Basin,* Presented at the 16th International Symposium on Society and Resource Management, Corpus Christi, TX.

2010-05-25 *Produced Water – Nuisance Byproduct or Valuable Resource?* Presented at the University of Wyoming Produced Water Conference, Laramie, WY.

2010-05-24 *Water & Energy - Inexorably Entwined Dance Partners, but without Perfect Choreography*, seminar presented to staff at the National Renewable Energy Laboratory, Golden, CO.

2010-05-20 Disappearing Roads Competition Finals, Texas A&M University.

2010-04-07 *The Environmentally Friendly Drilling Systems Program,* Presented at the RPSEA Unconventional Natural Gas Forum, Golden, CO.

2010-04-06 Conference Keynote Speaker for the AADE Conference, Houston, TX.

2010-03-18 Houston Association of Professional Landmen (HAPL), Petroleum Club, Houston, Luncheon Presentation.

2010-03-03 *Natural Resources and Environmental Issues and Energy Policy: A Sociologist's Perspective,* Presented at the Center for Environmental Research, Education, and Outreach, Washington State University, Pullman, WA.

2010-02-08 Energy Development, Natural Environments and Quality of Life: The Good, the Bad, and the Ugly as Perceived by Texans. Presented at the Annual Meeting of the Southern Rural Sociological Association. Orlando, FL.

2009-11-05 *From the Past to the Future: The Environmentally Friendly Drilling Systems Program,* Presented at the 2009 IOGA Conference, Buffalo, NY.

2009-11-03 *Environmental Stewardship of Natural Gas Operations,* Presented at the 2009 IPEC Conference, Houston, TX.

2009-11-03 *Causal vs. Non-Causal Selection of Onshore Environmentally Friendly Drilling Systems,* Presented at the 2009 IPEC Conference, Houston, TX.

2009-11-03 *Pretreatment Options for Water Based E&P Wastes,* Presented at the 2009 IPEC Conference, Houston, TX.

2009-11-03 *Environmental Benefits of KERS System with Electrical/Diesel Rigs,* Presented at the 2009 IPEC Conference, Houston, TX.

2009-11-03 *Team Challenge: Environmentally Friendly Drilling Using Low Impact Access Practices for Desert Ecosystems,* Presented at the 2009 IPEC Conference, Houston, TX.

2009-11-03 *Public Opinion on Exploration and Production of Oil and Natural Gas in Environmentally Sensitive Areas,* Presented at the 2009 IPEC Conference, Houston, TX.
2009-11-03 *Constructed Wetland Treatment Systems for Environmentally Friendly Drilling,* Presented at the 2009 IPEC Conference, Houston, TX.
2009-11-03 *A Crystal Ball View of the Energy Industry in 2025: How Environmentalists Hold the Key to America's Future Energy Security,* Presented at the 2009 IPEC Conference, Houston, TX.
2009-10-14 Intermountain Oil and Gas BMP Project, Presented at the Best Practices for Community ad Environmental Protection Workshop, Rifle, CO.

Workshops

2013

2013-11-15 Sustainable Eagle Ford Shale Water and Transportation – Challenges and Solutions Workshop – Cotulla, TX
2013-11-12 EFD Advisory Committee Meeting - The Woodlands, TX
2013-11-05 Supply, Flowback, and Waste Water Treatment Training Course for Hydraulic Fracturing – Kingsville, TX
2013-09-26 Water, Oil and Gas: Nuts and Bolts of Leases, Surface Use Agreements and Water Rights for Non-Oil and Gas Attorneys – Denver, CO
2013-09-05 Powered by Natural Gas - Canonsburg, PA
2013-09-04 Wellbore Integrity - Canonsburg, PA
2013-08-16 Joint EFD-SRN Workshop - Golden, Colorado
2013-07-22 SPE Forum on the Quest to Reduce the Environmental Footprint – Ashville, NC
2013-06-20 Texas Coastal Impact Assistance Program - The Woodlands, TX
2103-06-11 Water, Oil and Gas: Water Sampling and Recycling – Denver, CO
2013-05-14 Powered by Natural Gas Workshop - San Antonio, TX
2013-05-07 EFD-EU Workshop - Houston, TX
2013-04-10 Sustainable Eagle Ford Shale Community Infrastructure – Challenges and Solutions Workshop – Kingsville, TX
2013-04-10 Water, Oil and Gas 101 – Denver, CO
2013-02-13 Site Assessment & Baseline Monitoring Measurements - Ohio

2012

2012-06-12 EFD Program: Milestone Review held in The Woodlands, TX.
2012-05-17 Best Management Practices for Utica and Marcellus Development Workshop, Morgantown, WV.
2102-05-02 EFD Tour of the Offshore Technology Conference, Houston, TX.

2011

2011-11-10 EFD Program: Managing the Eagle Ford Development Workshop held in Kingsville, TX.
2011-08-17 Eagle Ford Shale Fracturing: Science and Solutions Workshop held in Laredo, TX.
2011-07-26 Lowering the Environmental Footprint of Marcellus Shale Development Workshop held in Morgantown, WV.
2011-05-26 Best Management Practices Workshop held in Boulder, CO.
2011-04-13 Environmentally Friendly Drilling Workshop held at the American Association of Drilling Engineers Conference, Houston, TX.
2011-03-15 Managing the Eagle Ford Development Workshop held in San Antonio, TX.

2009 – 2010

2010-11-16 EFD – Managing Fayetteville Shale Play Development Workshop held at the University of Arkansas, Fayetteville, AR.

2010-10-14 EFD/BMP – Opportunities and Obstacles to Reducing the Environmental Footprint of Natural Gas Development in the Uintah Basin. Workshop held in Vernal, UT.
2010-09-23 EFD Europe Kick-Off Forum held in Florence, Italy
2010-08-24 PTTC-EFD Workshop/Forum held in Pittsburgh, PA.
2010-07-08 *Water Management Technologies & Regulatory Requirements for Different Locations and Environments,* Workshop presented at the 2010 Summer Meeting of the IOGA of New York, Findley Lake, NY.
2010-06-07 *The Eagle Ford Shale,* 16th International Symposium on Society and Resource Management in Corpus Christi, TX.
2010-05-06 Panel Discussion, Natural Gas Solutions Summit, Aspen, CO.
2010-05-05 Panel Discussion, Offshore Technology Conference, Houston, TX.
2009-11-12 *The EFD University/National Laboratory Alliance*, Oak Ridge, TN, Special workshop with employees from the Oak Ridge National Laboratory.
2009-10-14 *Best Practices for Community and Environmental Protection*, Rifle CO, Over 160 participants from academia, industry, environmental organizations, regulators, landowners and others

Exhibits

2013

2013/1018 *Energy Day,* Houston, TX. (exhibited Virtual Rig Site at RPSEA booth)
2013/08/12-14 *Unconventional Resources Technology Conference and Exhibition*, Denver, CO.
2013/04/20 Co-sponsored and participated in the Texas GLO ZBeach Clean-Up Day at Matagorda Beach, TX.

2012

2012/10/17-18 *Texas Energy Alliance Conference,* Houston, TX.

2011

2011/10/15 *Energy Day*, Houston, TX.
2011/09/24-28 *Groundwater Protection Council Annual Forum,* Atlanta, GA.
2011/05/17-18 *East Texas Energy Expo i*n Center, TX.

2010 – 2009

2010/06/07-10 *16th International Symposium on Society and Resource Management,* Corpus Christi, TX.
2010/05/20 *IADC Onshore Drilling Conference & Exhibition,* Omni Houston Hotel Westside, Houston, TX.
2010/01/26-27 *IADC Health, Safety, Environment & Training Conference & Exhibition,* Omni Houston Hotel Westside, Houston, TX.

Awards

2009-10-05: ***Environmental Partnership/Chairman's Stewardship Award***, Interstate Oil and Gas Compact Commission.