Welcome to the CLU-IN Internet Seminar

Well Construction/Operation and Subsurface Modeling Technical Workshop

Sponsored by: EPA Office of Research and Development

Delivered: July 16, 2013, 3:00 PM - 4:00 PM, EDT

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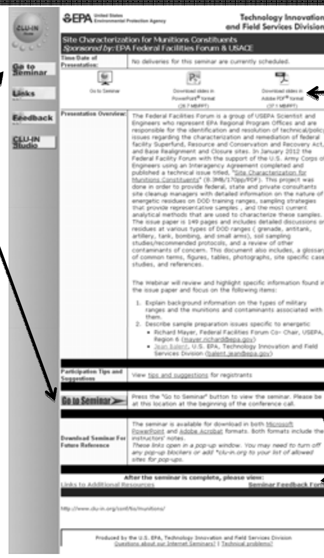

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Technology Innovation and Field Services Division

Site Characterization for Munitions Constituents
Sponsored by: EPA Federal Facilities Forum & USACE

Time/Date of Presentation:	No deliveries for this seminar are currently scheduled.

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Presentation Overview:

The Federal Facilities Forum is a group of USEPA Scientist and Engineers who represent EPA Regional Program Offices and are responsible for the identification and resolution of technical/policy issues regarding the characterization and remediation of federal facility Superfund, Resource and Conservation and Recovery Act, and Base Realignment and Closure sites. In January 2012 the Federal Facility Forum with the support of the U.S. Army Corps of Engineers using an Interagency Agreement completed and published a technical issue titled, "Site Characterization for Munitions Constituents" (8.3MB/170pp/PDF). This project was done in order to provide federal, state and private consultants site cleanup managers with detailed information on the nature of energetic residues on DOD training ranges, sampling strategies that provide representative samples , and the most current analytical methods that are used to characterize these samples. The issue paper is 149 pages and includes detailed discussions on residues at various types of DOD ranges (grenade, antitank, artillery, tank, bombing, and small arms), soil sampling studies/recommended protocols, and a review of other contaminants of concern. This document also includes, a glossary of common terms, figures, tables, photographs, site specific case studies, and references.

The Webinar will review and highlight specific information found in the issue paper and focus on the following items:

1. Explain background information on the types of military ranges and the munitions and contaminants associated with them.
2. Describe sample preparation issues specific to energetic
   - Richard Mayer, Federal Facilities Forum Co- Chair, USEPA, Region 6 (mayer.richard@epa.gov)
   - Jean Balent, U.S. EPA, Technology Innovation and Field Services Division (balent.jean@epa.gov)

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Produced by the U.S. EPA, Technology Innovation and Field Services Division
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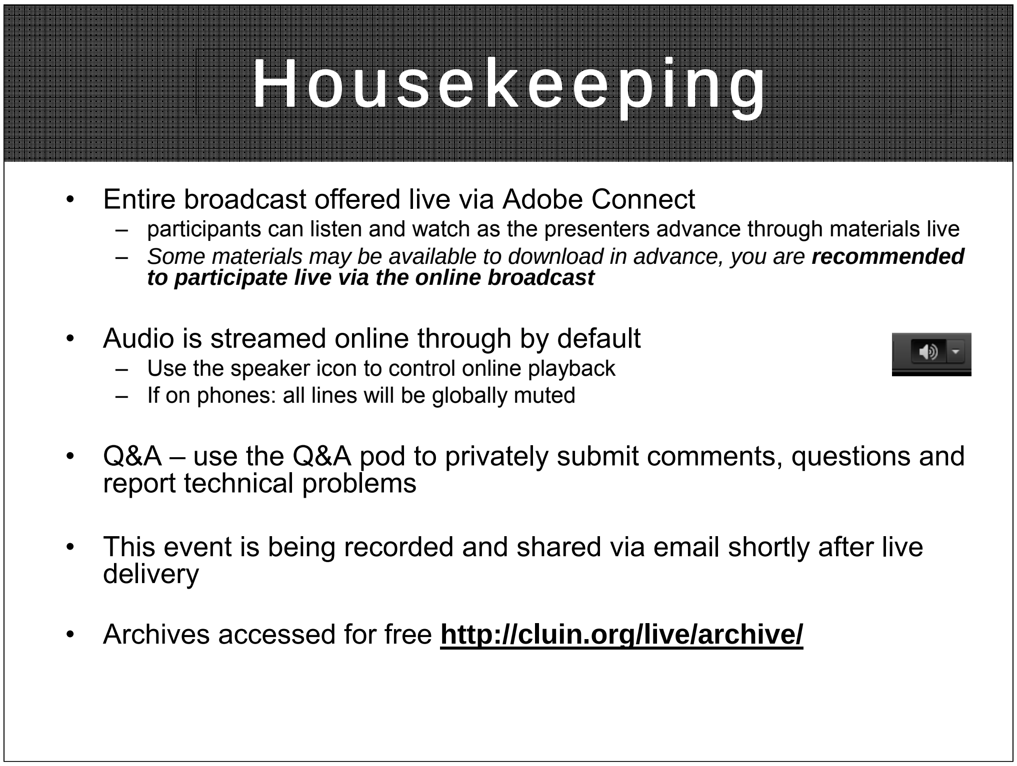


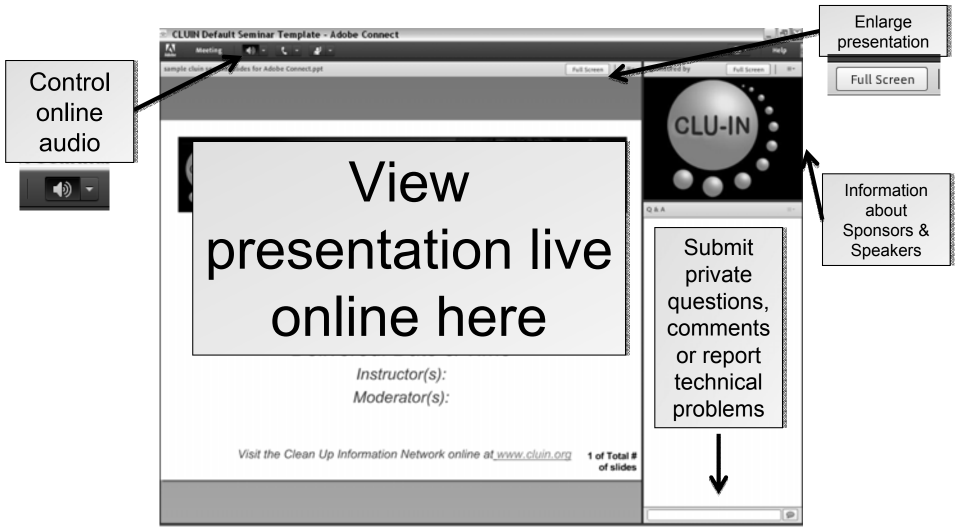
Although I'm sure that some of you have these rules memorized from previous CLU-IN events, let's run through them quickly for our new participants.

Please mute your phone lines during the seminar to minimize disruption and background noise. If you do not have a mute button, press *6 to mute #6 to unmute your lines at anytime. Also, please do NOT put this call on hold as this may bring delightful, but unwanted background music over the lines and interupt the seminar.

You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments. To submit comments/questions and report technical problems, please use the ? Icon at the top of your screen. You can move forward/backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1st and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our agenda, speaker information, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today's presentation materials.

With that, please move to slide 3.

New online broadcast screenshot



Web Conference Summary of April 16-17 and June 3, 2013 Technical Workshops on Well Construction/Operation and Subsurface Modeling

Jeanne Briskin & Steve Kraemer

July 16, 2013

Workshop Structure

Day 1:	**Well Construction/Operation**	**(April 16)**
Session 1:	Well Design and Construction to Protect Drinking Water	
Session 2:	Well Operation and Monitoring to Protect Drinking Water	
Day 2:	**Subsurface Modeling**	**(April 17)**
Session 3:	Subsurface Modeling of Fluid Migration to Identify and Understand Potential Impact on Aquifers	
Technical Follow-up Discussion		**(June 3)**
Session 1:	Subsurface Scenarios: What are we trying to model?	
Session 2:	Modeling Subsurface Scenarios: How do we do this?	

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April 16-17 Technical Workshop

•52 participants from EPA, DOE,USGS, states, industry, academia and non-governmental organizations

•14 technical presentations (5 industry, 3 DOE, 3 academia, 2 EPA , 1 USGS)

June 4 Technical Follow-up Discussion

•34 participants, (30 of whom also attended the Technical Workshop in April)

•Presentations by EPA and Lawrence Berkeley National Laboratory (LBNL)

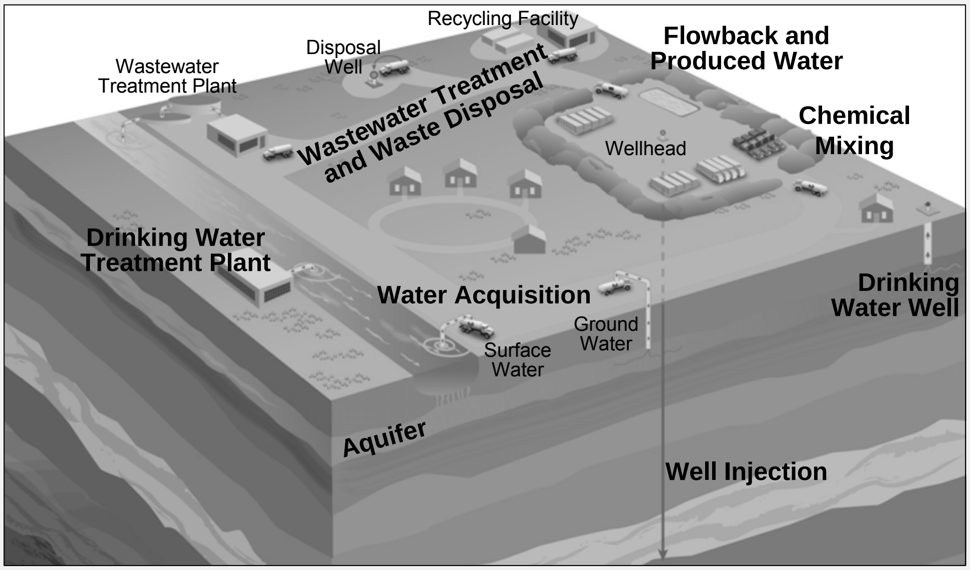
EPA Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources

Study Goals:

- Assess whether hydraulic fracturing may impact drinking water resources
- Identify driving factors that may affect the severity and frequency of impacts

For more information:
http://www.epa.gov/hfstudy

Hydraulic Fracturing Water Cycle



WATER CYCLE STAGES

Water Acquisition → Chemical Mixing → Well Injection → Flowback and Produced Water → Wastewater Treatment and Waste Disposal

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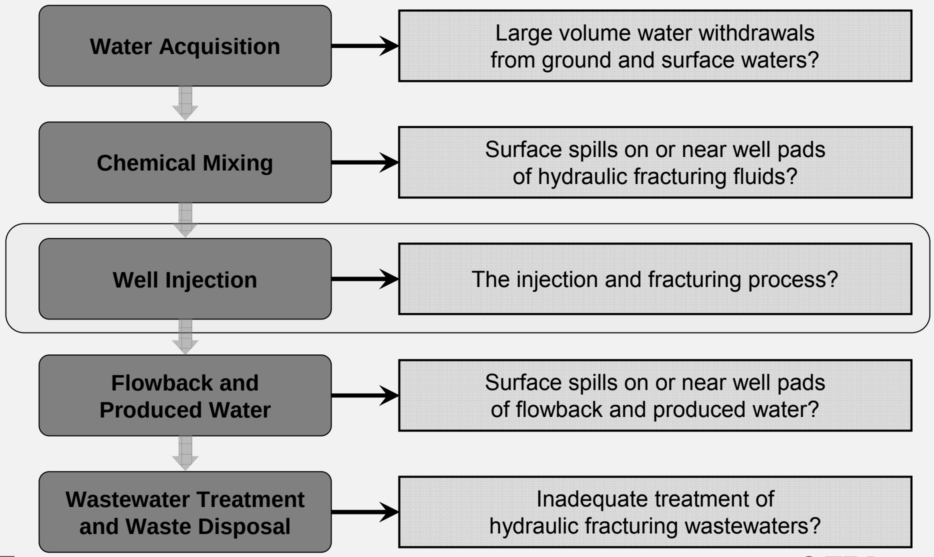
Primary Research Questions

What are the potential impacts on drinking water resources of:



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Well Injection

Secondary Research Questions

- How effective are current well construction practices at containing gases and fluids before, during, and after fracturing?
- Can subsurface migration of fluids or gases to drinking water resources occur, and what local geologic or man-made features might allow this?

Ongoing Research Projects

Literature Review
Subsurface Migration Modeling
Service Company Analysis
Retrospective Case Studies
Well File Review

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Note that Well File Review information applies to all 5 primary research questions, but that during this workshop we are focusing on these two secondary research questions.

The questions not included in slide:

Water Acquisition

How much water is used in hydraulic fracturing operations, and what are the sources of this water?

Chemical Mixing

What is currently known about the frequency, severity, and causes of spills of hydraulic fracturing fluids and additives?

What are the identities and volumes of chemicals used in hydraulic fracturing fluids, and how might this composition vary at a given site and across the country?

If spills occur, how might hydraulic fracturing chemical additives contaminate drinking water resources?

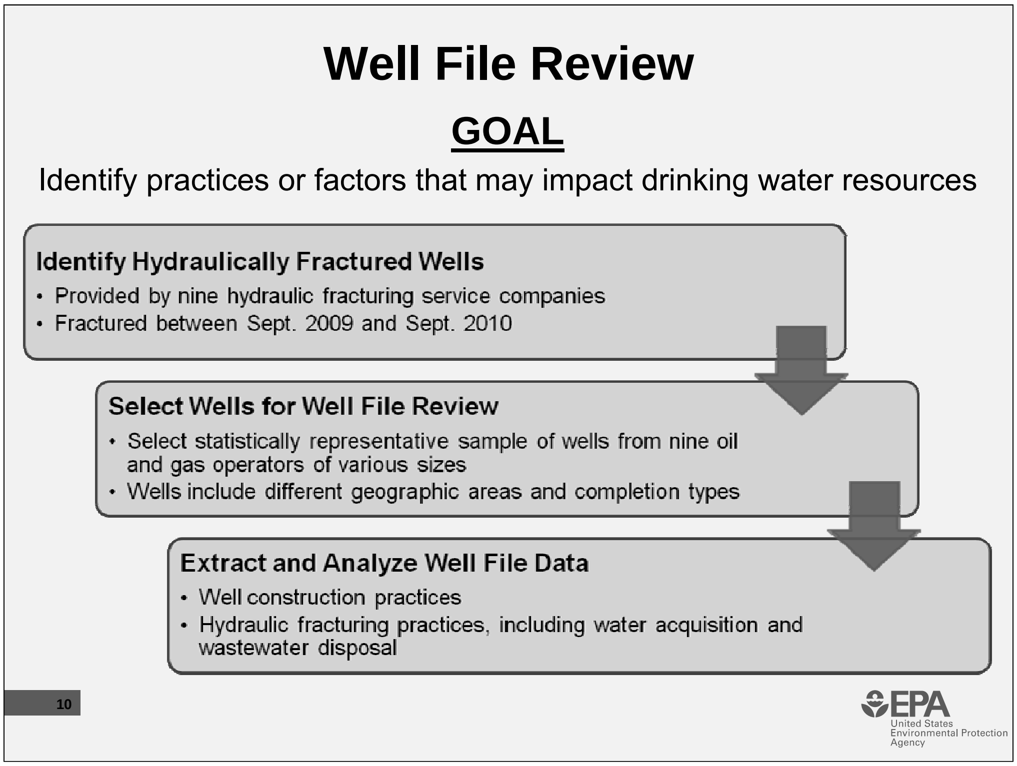
Flowback & Produced Water

What is currently known about the frequency, severity, and causes of spills of flowback and produced water?

What is the composition of hydraulic fracturing wastewaters, and what factors might influence this composition?

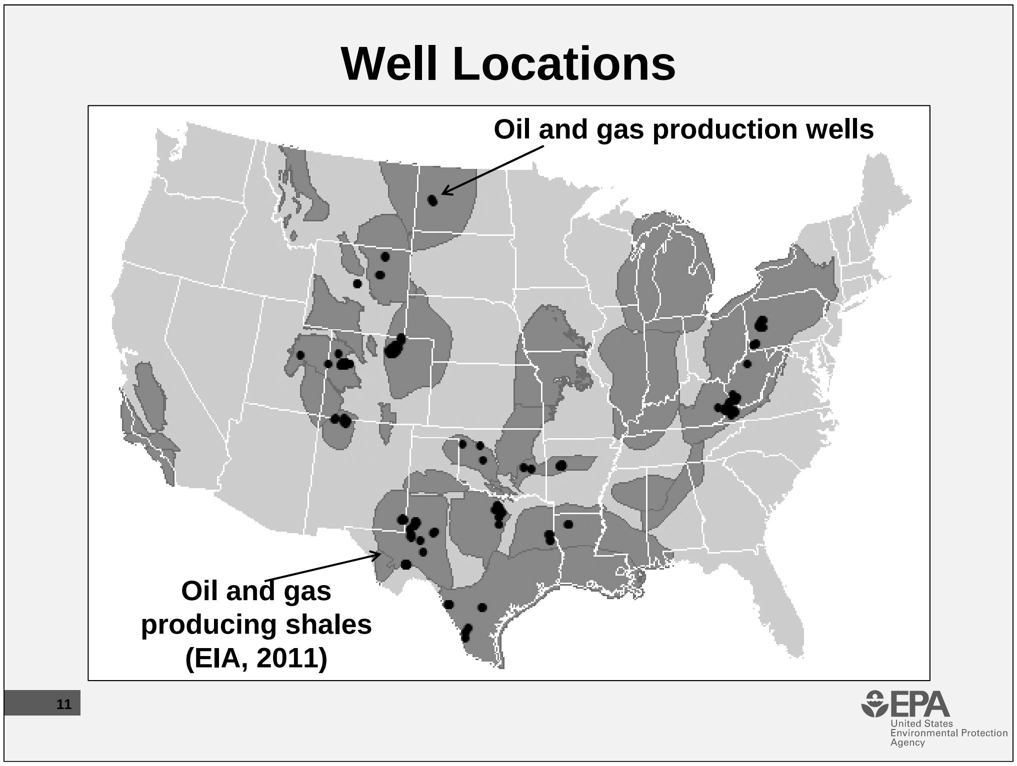
Wastewater Treatment & Waste Disposal

What are the common treatment and disposal methods for hydraulic fracturing wastewaters, and where are these methods practice?



To best represent actual occurrences of hydraulic fracturing, without the bias of selecting sites where allegations of a problem took place, EPA requested files from nine different operators whose wells were hydraulically fractured on-shore between August 2009 and September 2010 in the lower 48 states. These operators and their requested wells were selected using a stratified random process, designed to sample diversity in geography and operator size.

EPA used the list of wells supplied by nine hydraulic fracturing service companies from which to draw the wells subject to the well file review.



This map shows the locations of the wells whose files EPA requested. The black dots are the symbols representing each well. Note that many of the dots overlap due to the scale of the illustration.

The teal shaded areas are the mapped basins with significant shale gas, per the U.S. Energy Information Agency

Information Requested

- Geologic maps and cross sections
- Daily drilling and completion records
- Mud logs
- Open hole logs, such as porosity and resistivity logs
- Description of well casings installed
- Cased hole logs, such as cement evaluation logs
- Pressure testing results of installed casing
- Up-to-date wellbore diagram
- Pre- and post-hydraulic fracturing reports, including volumes/additives used
- Source(s) of water used
- Chemical analyses of fluids (used in treatment, water zones, offset locations, flowback)
- Microseismic monitoring results
- Spill/incident reports

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This is a summary of the information EPA requested from nine operators.

Session 1: Well Design and Construction to Protect Drinking Water

Participants considered three questions:

1. What current techniques are designed to prevent leaks through production well tubulars and fluid movement along the wellbore?
2. What factors are typically used to ensure adequate confinement of fluids that can move?

3a. How are ground water resources identified and documented prior to and during production well installation?

3b. What is the breadth of approaches?

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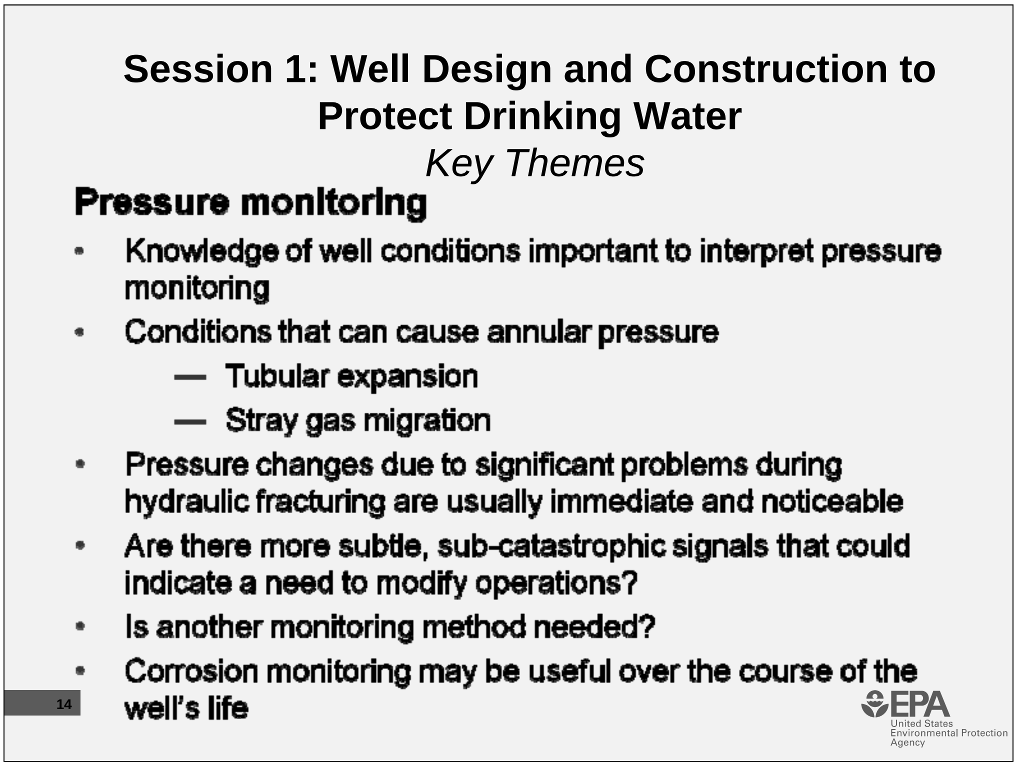

•Any pressure on an annulus not related to reservoir conditions indicates that some type of failure occurred- Nathan noted that, “The important point here is that annulus pressure can be attributable to a number of things and warrants investigation to understand its origin.”

Session 1: Well Design and Construction to Protect Drinking Water

Key Themes

Diagnostics to assess well integrity

- Regulations vary and companies use different tools, such as:
    - — Mechanical inspection logs, caliper logs, sonic and/or magnetic flux, and pressure-testing the casing
- Important to understand current condition of older wells before hydraulic fracturing

Well life cycle

- Wells are often subjected to multiple pressure changes throughout lifespan and operators need to plan for this when designing the well

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Session 1: Well Design and Construction to Protect Drinking Water

Key Themes

Cementing

- Different criteria for each well
- Cementing of annular spaces can be a means to enhance barrier functioning
- Cement displaced to the surface eliminates the potential to monitor annular pressure

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Session 1: Well Design and Construction to Protect Drinking Water

Key Themes

Cementing, *cont.*

- When refracturing in a new zone, examine the initial completion and work to ensure zonal isolation
- Cement bond log evaluations have potentially subjective interpretations
- Foamed cement formulations are difficult to evaluate using cement bond logs

Alternative technologies

- Emerging and future technologies
  - — High-strength resin used for small fractures are not affected by water, acids, or bases

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Session 1: Well Design and Construction to Protect Drinking Water

Key Themes

Definition of protected water

- Definition of “protected” or “useable” groundwater varies by state

Options for identifying ground water resources

- Petrophysical evaluation
- Talk with local geologists or water well drillers and verify with samples and logging
- Water resource board data
- Resistivity logs

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Session 1: Well Design and Construction to Protect Drinking Water

Key Themes

Variability of water quality and need for better data

- Local water quality can vary significantly between locations
- Data on water quality often limited
  - — Well drilling records may contain information on physical location, depth, and some lithology

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Session 2: Well Operation and Monitoring to Protect Drinking Water

Questions for Consideration

Participants considered two questions:

1. What testing is conducted to verify issues do not exist prior to, during and after hydraulic fracturing?

2a. What testing or monitoring techniques ensure adequate confinement?

2b. What is the breadth of approaches?

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Session 2: Well Operation and Monitoring to Protect Drinking Water

Key Themes

Options for testing to verify that issues do not exist

- Pressure testing of casing
- Collection of subsurface data
- Diagnostic fracture injection tests (DFIT) to determine reservoir pressure and formation permeability
- Nearby water wells, accounting for representativeness and variability
- Research locations of preexisting water wells at county court house

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Session 2: Well Operation and Monitoring to Protect Drinking Water

Key Themes

Options for testing/monitoring to ensure adequate confinement

- Collect cores samples to access permeability
- Test rock mechanics
- Model geology of each play
- Use radioactive tracers to identify vertical fracture growth
- Collect baseline ground water quality data
- Install pressure monitors above fractures
- Conduct microseismic monitoring
- Quality control/quality assurance

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Subsurface Migration Modeling

- Technical workshop included informational presentations, the posing of workshop questions to participants, and open discussions
- Modeling work done by Lawrence Berkeley National Laboratory (LBNL) in consultation with the EPA

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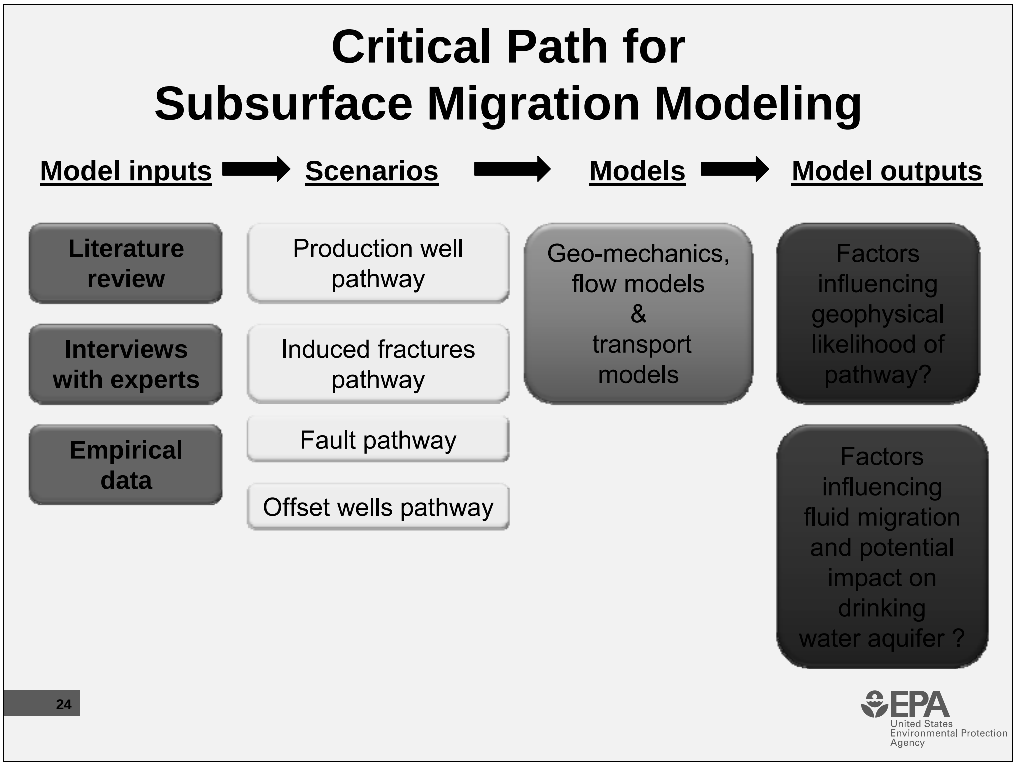
The discussion of the EPA subsurface modeling project occurred during a half-day technical workshop on April 17 in Research Triangle Park, North Carolina (referenced as Session 3) and then a full day followup session on June 3 in Arlington, Virginia.

At each technical workshop, we had a series of informational presentations, the posing of questions to be considered by workshop participants, and then open discussions.

The modeling work in this project is being conducted by the Lawrence Berkeley National Laboratory in consultation with the EPA.



The critical path for subsurface migration modeling includes conceptual design of the potential failure scenarios or pathways connecting the unconventional oil and gas reservoir with a drinking water aquifer, the selection and parameterization of the computational models representing linked geo-mechanics and flow and transport, and the analysis of model outputs for impact. We are investigating an envelope of potential failures along two separate and concurrent research tracks: (1) an investigation of factors influencing the geophysical likelihood of a pathway; and (2) an investigation of factors influencing fluid migration (gases such as methane, and liquids such as brines) given a pathway.

The LBNL ream review the literature and data and interviewed experts in academia and industry to nominate a finite number of potential failure scenarios. These included the production well as a potential pathway; offset wells, including nearby abandoned oil and gas wells, as a potential pathway, induced fractures in the overburden as a potential pathway; and reactivated nearby faults as a potential pathway.

Session 3: Subsurface Modeling

Questions for Consideration

Participants considered four questions:

1. What additional potential failure scenarios not covered in the EPA study progress report should be investigated?
2. What are the most important parameters and appropriate level of complexity for a model that studies the severity of the potential impact of hydraulic fracturing on drinking water resources?
3. What are the advantages and disadvantages of different modeling approaches?
4. What well performance data (e.g., microseismic testing, pressure, tracer or other) are available to EPA that would be useful to build and evaluate the model?

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Session 3: Subsurface Modeling

Key Themes

Additional potential failure scenarios

- Consider the tight sandstone and or coal bed methane conceptual model
- Consider the “no failure” scenario to provide confidence in the computational model

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Regarding the question about additional potential failure scenarios, it was suggested by a number of participants that EPA should recognize that the current conceptual model is “shale” centric, and that the tight sands and coal bed methane scenarios should also be considered, given that they have the potential for the HF stimulation to occur in closer proximity and with smaller separation distances to drinking water aquifers and wells.

It was also suggested that EPA should include the “no failure” scenario. This would provide confidence that the computational model represents the pre-fracturing condition without significant leakage of methane gas or brine, and that the stimulated well with intact cement performs as expected.

Session 3: Subsurface Modeling

Key Themes

Appropriate level of complexity and important model parameters

- Include appropriate level of complexity in models to represent essence of geophysical processes and geological heterogeneities (e.g., discrete vs. continuum approaches for representing fractures)
- Include industry experience and data to help define the range and uncertainty of parameters

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Another key theme concerned the appropriate level of model complexity and the data to support. Model complexity includes both conceptual model uncertainty and parameter uncertainty. For example, how should we represent fractures in the models; using discrete fracture methods? or multiple interacting continuum methods? And which method is appropriate at which spatial scale of resolution?

It was suggested that EPA could benefit from industry experience and data to help define the range and uncertainty associated with various parameters used in the computer modeling study.

Session 3: Subsurface Modeling

Key Themes

Appropriate level of complexity and important model parameters

Examples

- Detailed description of fault deformations and permeability changes
- Conductivity value of debonded or delaminated concrete
- Realistic parameters for reservoirs including layering, K_v/K_h, natural fracturing and stress numbers
- Regional variations
- Spatial and temporal resolution
- Distance from adjacent wells
- Heterogeneity of mechanical properties
- Fluid system and proppant transport
- Attenuation of fracturing fluid constituents

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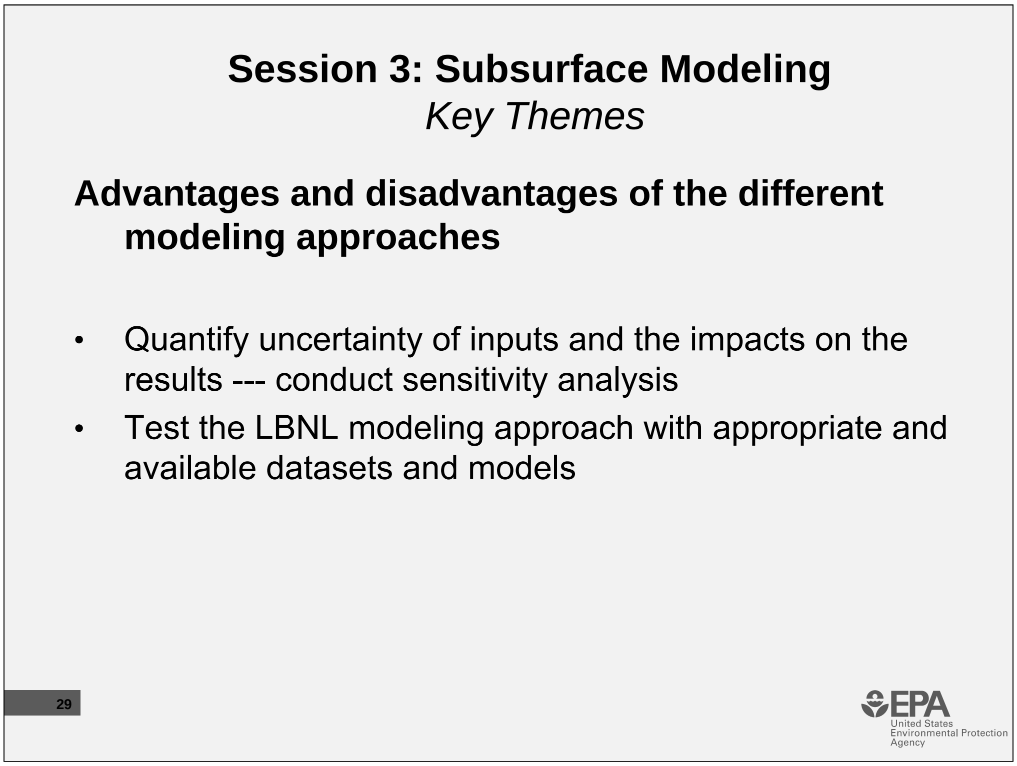
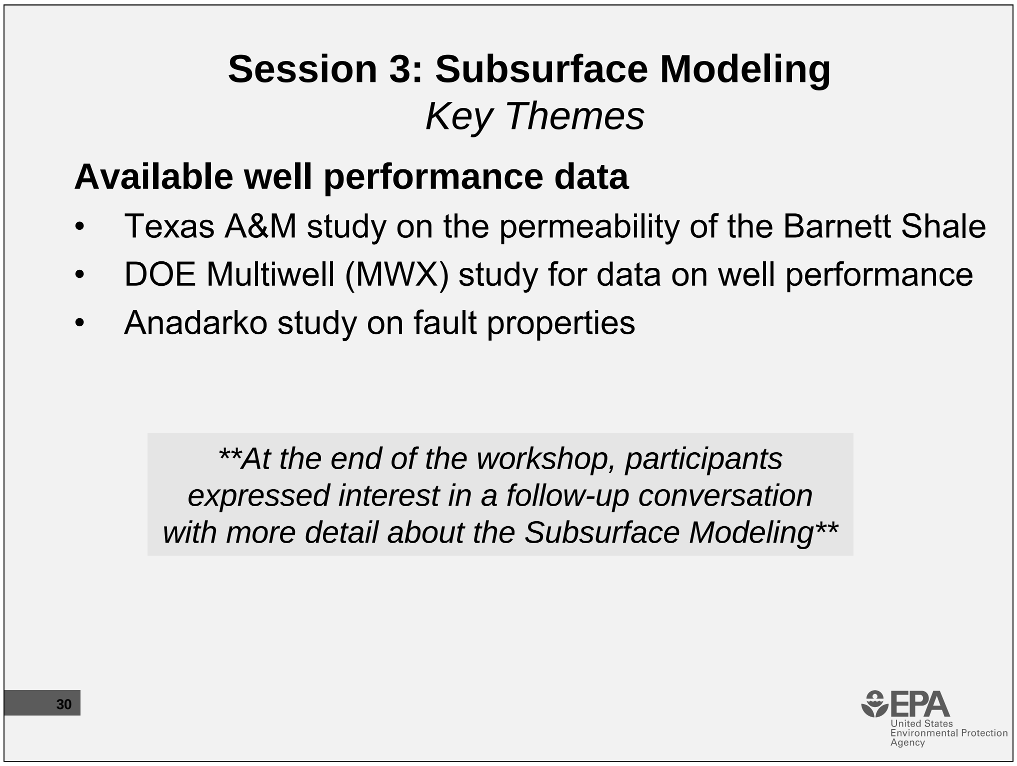
Workshop participants nominated examples of important model parameters to consider, including these examples.



During the discussion of the advantages and disadvantages of the different modeling approaches, a key theme emerged recognizing the importance of quantifying the uncertainty of input parameters and the resulting uncertainty of model outputs. A formal sensitivity analysis was suggested.

It was also recognized that insights would be gained in terms of model validation if the LBNL simulations could be benchmarked against other well accepted computational models.



During the discussion of potential well performance data sets that might be available to EPA, a few were nominated, including:

The Texas A&M study on the permeability of the Barnett Shale.

The DOE multiwell performance data in the tights sands of the Piceance Basin in Colorado.

The Anadarko study on fault properties.

At the end of this half-day workshop participants expressed interest in a followup technical workshop on subsurface modeling.

Technical Follow-up Discussion on Subsurface Modeling

Session 1 Presentation by EPA*: "Subsurface Scenarios: What are we trying to model?"*

- How and why EPA selected current modeling scenarios, including the level of model complexity
- The important parameters and ranges of values were presented for each scenario.
- The LBNL publication plan was reviewed.

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A full-day followup technical workshop was held on June 3 in Arlington Virginia. The workshop followed a similar structure with introduction presentations, review of the questions for the participants to consider, and facilitated discussions.

The workshop had two sessions. The first session was initiated by an EPA presentation on the subsurface scenarios and how and why EPA selected the current set of modeling scenarios. Also presented was the EPA approach to keep the scenarios as simple as possible but realistic enough to capture the essence of the problem being addressed. Each scenario was presented with the associated range of parameter values for flow properties of subdomains (aquifer, overburden, shale, fractures and faults, wells and boreholes, and geomechanical property sets). The LBNL publication plan was reviewed as a series of 10 journal manuscripts that cover modeling foundations, physics of pathways, and gas migration and fluid transport.

Technical Follow-up Discussion on Subsurface Modeling

Session 2 Presentation by Lawrence Berkeley National Lab*:*
"Modeling Subsurface Scenarios: How Do We Do This?"

- Description of fundamental equations and capabilities of TOUGH+ codes, including new equation-of-state (EOS) modules, and dynamic linking to geomechanics codes
- Mesh generation process for complex 3D geometries
- Verification and application examples were presented.

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Technical Follow-up Discussion on Subsurface Modeling

Questions for Consideration

Participants considered five questions:

1. What pros and cons of the scenarios do the participants see?
2. What other, different scenarios would participants recommend we consider?
3. What scenarios does industry typically model?
4. Are there different models/approaches EPA should consider?
5. How does industry conduct modeling to address subsurface scenarios?

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Technical Follow-up Discussion on Subsurface Modeling

Key Themes

Revisited the issue of model complexity

- In addition to exploring physical possibility of pathways, should consider evidence from geology
- We should consider the representation of geological heterogeneities in the models

Definition of protected water

- The separation distance between reservoir and aquifer is dependant on the definition of drinking water, which varies by state

Revisited the issue of additional scenarios

- Tight sands and coal bed methanes

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The issue of model complexity was revisited, and several participants agree that the study should not just filter the pathways for physical possibility, but should also look to geological realities of whether the pathway is known to exist.

Another participant noted that shale units and overburden units are heterogeneous with perhaps thousands of deformed horizontal layers, and those should be considered in the geologic conceptual model.

Several participants noted that there are differences between state definitions of freshwater/drinking water and the federal definition of underground sources of drinking water (USDWs). It was stated that this could be important because, if the USDW definition is used, there might be a vertical separation distance of only a few hundred feet or less between the hydraulic fracturing level and the drinking water source, and this scenario is not reflected in EPA's study.

A participant asked whether tight sandstone formations and coalbed methane (CBM) were modeled, stating that CBM was potentially the highest risk scenario (injecting directly in or in close proximity to aquifers). This is related to how the study defines protected drinking water.

Technical Follow-up Discussion on Subsurface Modeling

Key Themes

Description for Public

- Accurately portray scenarios for non-technical audiences, especially graphics

Units of Measurement

- Report results in common oilfield units (barrels/day, psi) in addition to international units

Next Steps

- Case Studies Workshop July 30, 2013
- Technical Roundtables will reconvene in the Fall 2013
- Information on technical workshop series: http://www.epa.gov/hfstudy/techwork13.html
- Federal register request for information: https://federalregister.gov/a/2013-10154

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