UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN - 5 2012

OFFICE OF
RESEARCH AND DEVELOPMENT

The Honorable Ralph M. Hall
Chairman, Committee on Science, Space, and Technology
United States House of Representatives
Washington, DC 20515

Dear Chairman Hall:

Thank you for your letter of October 26, 2011, to Lisa P. Jackson, Administrator of the U.S. Environmental Protection Agency (EPA), in which you raised questions regarding the Agency's conduct of our study of the potential impacts of hydraulic fracturing on drinking water resources. Because the EPA's Office of Research and Development is leading the Agency's hydraulic fracturing study, your letter was referred to me.

At every step in the development of the study, we have fulfilled our commitment to Congress by using a transparent, peer-reviewed process, independent sources of information, and EPA's most rigorous quality assurance procedures. The study plan was designed with extensive stakeholder outreach efforts, opportunities for public input, and full review by EPA's Science Advisory Board (SAB).

In particular, you express concern that EPA started gathering samples without proper protocols and standards in place. I have been assured that no samples were taken prior to completion of the appropriate quality assurance steps. As the Committee can appreciate, all parties interested in the outcome of this study are eager to have timely results. Therefore, we initiated some activities to provide a foundation for the full study prior to publishing the final Study Plan on November 3, 2011. All of these initial activities were explicitly described in the draft Study Plan and supported by the SAB during its peer review. Each of these study elements is embodied in the final Study Plan. Consistent with the Study Plan, Quality Assurance Project Plans (QAPPs) have been completed and approved for every retrospective case study, and all completed QAPPs are now publicly available on EPA's website.

The responses to your specific questions are provided as an enclosure to this letter. Again, thank you for

your letter. If you have any further questions, please contact me, or your staff may contact Pamela Janifer in EPA's Office of Congressional and Intergovernmental Relations at (202) 564-6969.

Sincerely,

Paul T. Anastas

Paul T. Anastas
Assistant Administrator

Enclosure

cc: Rep. Eddie Bernice Johnson
Ranking Member
Committee on Science, Space, and Technology

Rep. Brad Miller
Ranking Member
Subcommittee on Energy
and Environment

Rep. Paul Tonko
Ranking Member
Subcommittee on Investigations
and Oversight

Enclosure

EPA Response to
Questions from the Committee on Science, Space, and Technology
October 26, 2011

1) ***Were the technical workshop presentations and abstracts used at all EPA Technical Workshops in connection with the Study provided to the SAB and made publicly available? Please describe whether and how the technical content was available to the SAB to consider in its review of the draft Study Plan. If that material was not available, please provide an explanation why.***

Response: The SAB was given the draft Study Plan and specific charge questions, and was made aware of the stakeholder engagement activities that occurred during the development of the Study Plan. Supplementary information is typically provided to the SAB, upon request, when the Board thinks it is needed to inform its review. The Agency did not receive a request from the SAB for the materials from the technical workshops. The presentations and abstracts from the technical workshops are being made publicly available except in cases where the author has requested the presentation not be published. Three of the technical workshops are currently available on EPA's web site,[1] and the remaining one is in the process of being posted.

2) ***How was the information presented during the Technical Workshops integrated into the draft and/or final Study Plan? Was material from the Technical Workshops made available to all Agency staff providing input to the study plan?***

Response: The primary use of the information presented during the technical workshops is to inform the full study. Key Agency staff responsible for the development of the study plan participated in these workshops, and the materials from each workshop are available for their use.

3) ***Has the Study been designated by EPA as a "highly influential scientific assessment" as defined by the Office of Management and Budget's January 2005 guidelines Final Information Quality Bulletin for Peer Review? If not, provide an explanation why.***

Response: The Agency has designated the 2012 and 2014 study reports as "highly influential scientific assessments." Accordingly, EPA will follow the peer review planning requirements described in the Office of Management and Budget's *Information Quality Bulletin for Peer Review.*

4) ***When will the final Study Plan be released?***

Response: The final Study Plan was released on November 3, 2011.

Characterization of Risk

1) ***Given the apparent inconsistency provided to the Committee and the SAB, please clarify how EPA identified the "most significant risks."***

Response: The Agency has not identified the most significant risks. The purpose of the study is to inform our understanding of the potential for risk through the collection and analysis of data that can be

[1] http://www.epa.gov/hfstudy/#technical.

used to evaluate the impacts of hydraulic fracturing, if any, on drinking water resources. As recommended by the SAB, the Agency used a risk-based framework to prioritize research activities.

2) ***The draft Study Plan states that "[f]ollowing guidance from the SAB, EPA uses a risk-based prioritization approach to identify research that addresses the most significant risks at each stage of the hydraulic fracturing water lifecycle."***

2a. ***How has this or any other risk characterization been used this far in Agency decisions related to the Study and in accordance with the EPA Policy for Risk Characterization or EPA Risk Characterization Handbook?***

Response: Risk characterization has not been used in any Agency decisions related to the study, nor does the study involve the conduct of a comprehensive risk assessment involving all four steps of the risk assessment paradigm (i.e., exposure assessment, hazard identification, dose-response relationship assessment, and risk characterization). The risk assessment paradigm does, however, provide a useful framework for asking scientific questions and focusing research to accomplish the stated goals of this study. The results of the study may be used to inform risk assessments, including risk characterizations, in the future. For the current study, emphasis is placed on exposure assessment and hazard identification.

2b. ***Please provide the Committee a detailed description, including supporting technical documentation, of all risk assessment activities and materials associated with the Study.***

Response: The Agency has not conducted any risk assessment activities or developed any risk assessment materials associated with the study. As stated above and in the study plan, EPA used a risk-based approach to identify high priority research, with a focus on activities to inform the exposure assessment and hazard identification steps of a potential future risk assessment process.

3) ***The SAB recommended that the Study focus on "fundamental topics that will be relevant to policy formulation and on environmental concerns related to hydraulic fracturing rather than on concerns common to all oil and gas production activities." What method is the Agency using to differentiate concerns related to hydraulic fracturing from concerns common to all oil and gas production activities?***

Response: As you state, in their review of EPA's *Research Scoping Document Related to Hydraulic Fracturing*, the SAB cautioned EPA against studying all aspects of oil and gas production. The panel recommended that the study emphasize "concerns specific to, or significantly influenced by, hydraulic fracturing rather than on concerns common to all oil and gas production activities." Following this advice, EPA focused the draft Study Plan on features of oil and gas production that are particular to – or closely associated with – hydraulic fracturing, and their potential impacts on drinking water resources.

By using the hydraulic fracturing water use lifecycle to define the scope of the research, EPA will assess the full range of potential impacts of hydraulic fracturing on drinking water resources. For the purposes of this study, the hydraulic fracturing water lifecycle consists of the following: water acquisition; chemical mixing; well injection; flowback and produced water; and wastewater treatment and waste disposal. The proposed approach of studying the potential impacts associated with the various stages of the hydraulic fracturing water cycle was fully supported by the SAB during the scientific peer review of the draft Study Plan.

Data Quality Assurance

1) ***It is our understanding that, despite the absence of a final study plan, EPA's aforementioned data collection activities indicate that EPA has already initiated the Study. These actions appear to directly contravene the assurances this Committee received only weeks ago, and make it impossible for EPA staff to determine if these activities even meet the goals of the Study. Further, without a reviewed and approved QAPP, the veracity and quality of data collected, samples obtained, and associated Study conclusions cannot be assured.***

Response: All of the initial sampling activities conducted by EPA were explicitly described in the draft Study Plan and supported by the SAB during its peer review. Each of these study elements is embodied in the final Study Plan that was made publicly available on November 3, 2011. Consistent with the Study Plan, QAPPs have been completed and approved for every retrospective case study. No samples were taken prior to the QAPP review and approval.

2) ***Have the project specific plans (the QAPPs) for the prospective and retrospective sites, as well as any other components of the study, been finalized as Dr. Anastas assured the Committee they would be?***

Response: The QAPPs have been finalized for all projects for which data sampling and analysis activities have been initiated by EPA, including the retrospective case studies. QAPPs for other activities, such as those supporting the prospective case studies, are still in the process of being finalized.

Note that the Agency's QAPPs are, by necessity, designed as dynamic documents. When rigorous science is conducted, EPA cannot assume to know the results that will be obtained during each phase of the research. Depending upon the early outcomes of individual research projects, it is often necessary to modify our initial plans before moving on to next steps. A modified QAPP will be subject to the same review and approval process as the initial version. In all instances, any such modifications have been and will be completely within the bounds of the Study Plan.

2a. ***If so, were the specific plans developed in accordance with EPA Quality and Peer Review protocols?***

Response: Yes. The approach for preparing and approving the QAPPs follows EPA requirements, as described in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, March 2001). This document is one part of the EPA quality system, which is an overall approach to assuring the quality of EPA's environmental data operations.

2b. ***Please provide copies of all project specific plans with supporting quality documentation.***

Response: The QAPPs that have been completed and approved can be found on the EPA hydraulic fracturing website.[2] Representatives of the companies that are conducting studies in parallel to ours at the retrospective case study sites have been contacted to advise them of the availability of the QAPPs.

[2] http://epa.gov/hfstudy

3) ***Will each QAPP be open for public comment and external peer review to ensure the Congressional expectation of a study "conducted through a transparent, peer-reviewed process that will ensure the validity and accuracy of the data?"***
3a. ***If so, when?***
3b. ***If not, provide an explanation.***

Response: The QAPPs will not be open for public comment and peer review. Formal peer review of QAPPs is not an expected practice in studies conducted by EPA, other government agencies, academia or the private sector. Consistent with Section 2.5 of EPA's Requirements for Quality Assurance Project Plans (EPA QA r-5)[3], the Agency's QAPPs "...shall be reviewed and approved by an authorized EPA reviewer to ensure that the QA Project Plan contains the appropriate content and level of detail. The authorized reviewer, for example, the EPA project manager with the assistance and approval of the EPA QA Manager, or by the EPA QA Manager alone, are defined by the EPA organization's Quality Management Plan. In some cases, the authority to review and approve QA Project Plans is delegated to another part of the EPA organization covered by the same Quality Management Plan."

3c. ***Are all test protocols publicly available and are tests being conducted in such a way that each data point can be independently verified?***

Response: The case study QAPPs document information for field and laboratory analyses of samples. For each critical analyte, this information includes the EPA standard method or other peer reviewed, publicly available method. The QAPPs also reference the standard operating procedures that detail how the standard method is implemented in the specific laboratory. In the few instances where a standard EPA method is not available, the QAPPs describe how the method will be performed and what quality measures will be used to support the results generated. Data and supporting information for these analyses are maintained so that individual data points can be independently verified.

4) ***To what extent has the EPA engaged in any field activities (e.g. data collection, monitoring, sampling, etc.) associated with the study?***

Response: As described in both the draft and final Study Plans, a number of field activities are needed to provide a foundation for the study and final analyses. This includes baseline sampling at field sites, using scientifically sound approaches that have been shared with collaborators. We have discussed initial plans for case studies with landowners and state, local, and industry representatives. All of these activities were supported by the SAB. The data gathered will provide baseline information for the full implementation phase of the study. Our approach has been transparent, and will remain so. This work will enable us to provide timely and scientifically sound results in the 2012 and 2014 reports.

4a. ***If so, please explain why no information has been released to the public about such activities.***

Response: The Agency released information about these activities, and it is available to the public. All of these activities were laid out in the draft Study Plan, and again in the final version. Information was also provided publicly during our extensive stakeholder outreach efforts. For example, on June 23, 2011, EPA announced its selection of the five retrospective and two prospective case studies.[4] Information posted on the internet included the case study locations, key issues to be investigated, possible outcomes

[3] http://www.epa.gov/quality/qs-docs/r5-final.pdf
[4] http://epa.gov/hfstudy/casestudies.html

of the research, and criteria for case study selection. Furthermore, to support transparency and allow for independent verification of data, we have shared our initial sampling plans with cooperators who would like to conduct studies at case study locations in parallel to EPA's work. The Agency has provided sampling plans to well owner/operators associated with each of the retrospective case study locations. The sampling plans are comprised of the key sections of the site-specific QAPPs related to sampling and analysis activities. They include lists of analytes, methods of analysis, detection limits, sampling procedures, sample bottle requirements, and sample preservation techniques.

These are just a few examples of our efforts to communicate our plans and activities with all of our stakeholders since the earliest days of the development of the study plan. Our approach has been transparent and will continue to be so.

4b. ***If so, what plans or protocols were used or are being used by EPA to determine the appropriateness of these activities?***

Response: All of the activities underway were laid out in the draft Study Plan reviewed by the SAB and available for public comment. In addition, all of the activities were supported by the SAB during the peer review. The Agency's QAPPs have been completed and approved for all retrospective case studies.

4c. ***Please detail all sampling conducted to date, including timing and location as well as the laboratories and testing protocols used to analyze each of the samples.***

Response: To date, samples have been collected at the following locations on the dates indicated:

Kildeer, ND:	July 18 – 20, 2011; October 18-20
Washington County, PA:	July 25 – 28, 2011
Wise County, TX:	September 19 – 22, 2011
Raton Basin, CO:	October 3 – 7, 2011
Bradford County, PA:	October 24 – November 3, 2011

In all cases, sampling and analysis were carried out using methods described in the approved QAPPs. Specific information about the testing protocols and laboratories used can be found in the QAPPs posted on the EPA web site.

Interagency Cooperation

1) ***In relation to all executive branch activities, the President has stated that interagency coordination and review is imperative. Additionally, in a September 23, 2011 submission to this Committee, EPA Assistant Administrator Dr. Paul Anastas stated that "[a]s we proceed with our study, EPA is working closely with other agencies such as the Department of Energy (DOE), including DOE's National Energy Technology Laboratory; the Department of Interior, including the US Geological Survey and the Bureau of Land Management; the US Army Corps of Engineers; and other agencies to identify opportunities for collaboration and to leverage resources." In order to better understand the extent of interagency coordination and in an effort towards greater transparency, please provide the Committee with a detailed list of any meetings and/or communications that have taken place between EPA officials and officials in the following Federal agencies (including entities within such agencies). Please include the names and titles of relevant officials participating in any such meetings and/or***

communications and include any materials or presentations given by EPA officials relating to hydraulic fracturing activities.

1. ***U.S. Department of Energy;***
2. ***U.S. Department of Energy Secretary of Energy's Advisory Board (SEAB);***
3. ***U.S. Department of the Interior***
4. ***U.S. Department of Agriculture; and***
5. ***U.S. Army Corps of Engineers.***

Response: Table 1 includes a list of calls and in-person meetings that EPA has conducted with the agencies you mention (DOE, DOI, USDA, USACE) to exchange information among experts as we proceed with the study planning and implementation. Through these meetings, EPA has learned about work those agencies are involved in and identified opportunities for collaboration and leverage. The table below includes information about the date, location, topic and senior EPA staff in attendance for each consultation. Agendas and presentations are attached as appropriate.

Table 1 - Consultations with Federal Agencies about Potential Collaboration on EPA Hydraulic Fracturing Study

Consultation Date	*Federal Agency*[5]*, Location*	*Collaboration for Hydraulic Fracturing Study*
March 29, 2010	USACE; conference call	Conference call with UASCE
May 5, 2010	USACE; Pittsburgh, PA	Discuss Ohio River basin stream flow, water quality and potential collaboration in EPA study
June 7, 2010	All agencies; webinar	Consultation with federal partners to discuss study scope, identify data gaps, data sharing and opportunities for joint studies Documents (available online[6]): Meeting Summary, EPA Presentation
June 21, 2010	DOE; conference call	Discuss research activities; multiple DOE offices
July 14, 2010	DOI (USGS); Denver, CO	Discuss stable isotope methods and potential analysis
July 21, 2010	DOE (NETL); Morgantown, WV	Discuss ongoing research, potential collaborations, technical workshop collaboration on produced water management
August 30, 2010	DOI (USGS); conference call	Conference call with USGS personnel from around the country involved in some way with HF research and data collection
October 12, 2010	DOI (BLM); conference call	Discuss potential collaboration, data from CO and WY, input on seismic surveys
October 26-28, 2010	DOE, DOI (USGS); Baltimore, MD	Water Research Foundation Workshop with DOE, USGS, industry, states, and municipalities on hydraulic fracturing

[5] Acronyms for federal agencies: BLM = Bureau of Land Management; DOE = Department of Energy; DOI = Department of Interior;; NETL = National Energy Technology Laboratory of the Department of Energy; USGS = United States Geologic Survey; USACE = United States Army Corps of Engineers

[6] http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydroout.cfm#hydro

Consultation Date	*Federal Agency*[5]*, Location*	*Collaboration for Hydraulic Fracturing Study*
December 16, 2010	DOE; Washington, DC.	EPA-DOE Hydraulic Fracturing – Opportunities for Collaboration and Research Leveraging Senior EPA attendees: Bob Perciasepe, Deputy Administrator; Bob Sussman, Senior Policy Advisor Documents (attached): Agenda, Discussion Paper, EPA Presentation
January 3, 2011	USGS; conference call	Conference call with multiple USGS offices
January 20, 2011	All; Washington, DC.	CEQ meeting to initiate interagency review of draft study plan. Documents (attached): EPA Presentation
January 20, 2011	DOE (NETL), DOI (USGS), USACE; conference call	Interagency conference call
January 27, 2011	DOI (USGS); conference call	Discuss radiological analyses
February 23, 2011	DOE (NETL), DOI (USGS), USACE; conference call	Discuss prospective study collaboration
February 24-25, 2011 March 10-11, 2011 March 28-29, 2011 March 29-30, 2011	DOE, DOI; Arlington, VA	Technical workshops to provide an opportunity for EPA to interact with technical experts, including those from other federal agencies, to inform EPA about current practices in hydraulic fracturing and to identify research related to EPA's study Documents (available online[7]): Workshop Proceedings, individual presentations
March 24, 2011	DOI; conference call	Discuss opportunities for interagency collaboration.
April 27, 2011	DOE; conference call	Discuss opportunities for wastewater treatment research. Plan future scientist-to-scientist meeting.
May 9-11, 2011	DOE (NETL)	Meeting with DOE, academic institutions at NETL
June 9, 2011	DOE (NETL); Pittsburgh, PA	Scientist-to-scientist meeting to discuss planning for wastewater treatment research Documents (attached): Agenda
September 10, 2011	Meeting with DOI (USGS), DOE (NETL); Washington Co., PA	Prospective site meeting to discuss monitoring wells for prospective study site.

[7] http://epa.gov/hfstudy/

Meeting: Scientist to Scientist Meeting between DOE-National Energy Technology Laboratory (NETL) and EPA-Office of Research and Development, National Risk Management Research Laboratory

Location: Pittsburgh, PA DOE NETL Facility

Date: June 9, 2011 (Agenda attached)

Objective: To discuss possible collaborative efforts in Hydraulic Fracturing Drinking Water Research planning. Exchange information on current DOE in-house and DOE extramurally funded research to prevent duplication in EPA-ORDs planning process. Note that the meeting consisted of discussion only (there were no presentations given).

TENTATIVE AGENDA

Hydraulic Fracturing Research Meeting

Thursday, June 9, 2011

Bldg 58, Rm 305, 1:00-4:00 PM

1:00 – 1:10 **Introduction and Background-** NETL

1:10 - 2:00 **HF Research at EPA ORD Cincinnati** – EPA

2:00 -2:10 **NETL Produced Water Characterization Team** – NETL

2:10-2:20 **Organic Compounds** – NETL

2:20-2:40 **Microbiological Aspects** – NETL

2:40 – 3:00 **Stable Isotopes** – NETL

3:00 – 3:20 **NORM** – NETL

3:20 – 3:25 **Work with USGS** – NETL

3:25 – 3:35 **Synergies with Sequestration and NRAP Research Programs** – NETL

3:35 – 4:00 **Wrap-Up Discussions**

AGENDA

EPA – DOE Hydraulic Fracturing – Opportunities for Collaboration and Resource Leveraging
December 16, 2010
10:00 A.M. – 1:30 P.M.
EPA Ariel Rios Building North, room 3530, located at 1200 Pennsylvania Ave. NW, Washington, DC 20004

Purpose Begin an open dialogue between EPA and DOE that will focus on the design and goals of the EPA and DOE hydraulic fracturing research plans, and explore opportunities for collaboration and leveraging expertise and resources.

Time	Item	Lead
10:00 - 10:10	Welcome & Introductions	Christopher Smith – DOE
10:10-10:30	EPA Programmatic Overview • Program priorities and future direction • Water regulatory framework/ Statutory authority • Programmatic and data needs/areas for collaboration	Ann Codrington Mary Smith
10:30 – 10:50	Remarks by EPA & DOE Senior Management	Cathy Zoi/David Sandalow – DOE Robert Perciasepe – EPA Robert Sussman – EPA
10:50 – 11:30	DOE Programmatic Overview and Emerging Issues • Program priorities and future direction • Existing Projects • Potential research focus areas • Identification of specific projects where collaboration is planned • Opportunities for EPA contributions – areas for DOE to conduct research with EPA input on design and execution, or areas for collaborative research	John Duda George Guthrie
11:30 – 11:45	Break	
11:45 – 12:15	EPA Hydraulic Fracturing Research Activities • ORD HF study overview • Research data gaps • Opportunities for DOE contributions - areas for EPA to conduct research with DOE input on design and execution, or areas for collaborative research	Jeanne Briskin

12:15 – 1:30	Future Collaboration • How do EPA and DOE projects "fit" together? • How can EPA and DOE provide support / coordinate in current and future projects to meet policy goals? • Establish framework to streamline communication/collaboration	All

DRAFT

Meeting Participants

Name	Title
US Department of Energy	
Cathy Zoi	Acting Under Secretary for Energy and Assistant Secretary for Energy Efficiency and Renewable Energy
David Sandalow	Assistant Secretary for Policy & International Affairs
Anthony Cugini	Director, National Energy Technology Laboratory
Christopher Smith	Deputy Assistant Secretary for Oil & Natural Gas
Robert Edwards	Deputy General Counsel for Energy Policy, General Council
Renee Stone	Senior Advisor to the Under Secretary for Energy
Holmes Hummel	Senior Policy Advisor to the Assistant Secretary for Policy & International Affairs
Ehsan Khan	Senior Technical Advisor to the Assistant Secretary for Fossil Energy
John Duda	Director, Strategic Center for Natural Gas and Oil, National Energy Technology Laboratory
Guido DeHoratiis	Director, Future Oil and Gas Resources, Office of Oil and Natural Gas
George Guthrie	Focus Area Leader, National Energy Technology Laboratory Office of Research and Development
Nancy Johnson	Program Manager, Environmental Policy & Regulations, Office of Oil and Natural Gas
Kevin Easley	Natural Gas Policy Analyst, Policy & International Affairs
Natenna Dobson	Physical Scientist, Environmental Policy & Regulations, Office of Oil and Natural Gas
US Environmental Protection Agency	
Bob Perciasepe	Deputy Administrator
Bob Sussman	Senior Policy Council to the Administrator
Fred Hauchman	Director, Office of Science Policy, Office of Research and Development
Jeanne Briskin	Hydraulic Fracturing Research Task Force Leader, Office of Science Policy, Office of Research and Development
Susan Burden	Chemist, Office of Research and Development, Office of Science Policy
Bob Puls	Hydraulic Fracturing Technical Research Lead, National Risk Management Research Laboratory/ ORD
Cynthia Dougherty	Director, Office of Ground Water & Drinking Water
Ann Codrington	Acting Director, Office of Ground Water and Drinking Water, Drinking Water Protection Division
Bruce Kobelski	Acting Chief, OGWDW, Drinking Water Protection Division, Prevention Branch
Chitra Kumar	Special Assistant, Drinking Water Protection Division
Mary Smith	Director, Office of Science and Technology, Engineering Analysis Division
Marcus Zobrist	Chief, OWM, Water Permits Division, Industrial Branch
Additional Staff	TBD
Council on Environmental Quality	
Jason Bordoff	Associate Director for Energy and Climate Change
Anhar Karimjee	Deputy Associate Director for Energy and Climate Change

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Study Plan Framework

Phases of the Hydraulic Fracturing (HF) Water Cycle

- Water acquisition
- Chemical mixing
- Well injection
- Flowback and produced water
- Water treatment and waste disposal

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Study Will Follow HF Water Cycle

Water Use in Hydraulic Fracturing Operations	Potential Drinking Water Issues
Water Acquisition	• Water availability • Impact of water withdrawal on remaining water quality
Chemical Mixing	• Accidental release to surface and ground water (e.g., on-site spills/leaks)
Well Injection	• Accidental release to ground water (e.g., well malfunction) • Fracturing fluid migration into drinking water aquifers • Formation fluid displacement into aquifers • Mobilization of subsurface formation contaminants into aquifers
Flowback & Produced Water	• Accidental release to surface and ground water • Leakage from on-site storage into drinking water resources • Improper pit maintenance and closure
Water Treatment & Waste Disposal	• Surface and/or subsurface discharge into surface and ground water • Incomplete treatment of wastewater

Scientific Questions

Water Acquisition

- **How do large volume water withdrawals from ground water and surface water impact drinking water resources?**
  - What are the impacts on water availability?
  - What are the impacts on water quality

Chemical Mixing

- **What are the possible impacts of on-site spills and/or leaks on drinking water resources?**
  - What is the composition of hydraulic fracturing fluids and what are toxic effects of the constituents?
  - What factors may influence the likelihood of contamination of drinking water resources?
  - What practices are used to contain or mitigate spills/leaks?

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Scientific Questions

Well Injection

- **How might the fracturing process lead to contamination of water resources by hydraulic fracturing chemicals or naturally occurring substances?**
  - How effective are well construction practices at containing fluids during and after fracturing?
  - What are the potential impacts of pre-existing man-made or natural pathways/features on contaminant transport?
  - What chemical/physical/biological reactions could impact the mobilization, transport, fate or toxicity of substances in the subsurface?

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Scientific Questions

Flowback and Produced Water

- **What are the possible impacts of on-site spills and/or leaks on drinking water resources?**
  - What is the composition and variability of flowback and produced water, and what are the toxic effects of these constituents?
  - What factors may influence the likelihood of contamination of drinking water resources?
  - What practices are used to contain or mitigate spills and/or leaks?

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Scientific Questions

Water Treatment and Waste Disposal

- **What are the possible impacts of inadequate treatment of flowback and produced water on drinking water resources?**
  - How effective are treatment and disposal methods?

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Qualitative Risk-Based Approach to Prioritize Research

- **Relevance:** Only work that may directly inform an assessment of the potential impacts of hydraulic fracturing on drinking water resources was considered.
- **Timing:** Work that needs to be completed before other work can be initiated received a higher priority.
- **Unique contribution:** Work already underway by others received a lower priority for investment by EPA.
- **Leverage:** Work that EPA can leverage with co-investigators received a higher priority.
- **Funding:** Work that is valuable but not affordable with the current budget was identified for consideration in later years.

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Study Plan Approaches

- Evaluation of existing data
- Laboratory-scale experimentation
- Field studies
- Fate and transport modeling

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Study Plan Framework

Phases of the Hydraulic Fracturing (HF) Water Cycle

- **Water acquisition**
- Chemical mixing
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Water Acquisition: How do large volume water withdrawals from ground and surface water impact drinking water resources?	
Secondary Question	**Research**
What are the impacts on water availability? What are the impacts on water quality?	*Analyze Existing Data* • Survey and map HF sites and water resources (e.g., use and quality) • Compare areas with HF activity to areas without *Prospective Case Studies* • Collect data on water quantity • Monitor management practices and impacts (such as availability) related to water acquisition *Scenario Evaluation* • Assess impacts of cumulative water acquisition at watershed and aquifer levels

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Study Plan Framework

Phases of the Hydraulic Fracturing (HF) Water Cycle

- Water acquisition
- **Chemical mixing**
- Well injection
- Flowback and produced water
- Water treatment and waste disposal

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Chemical Mixing: What are the possible impacts of on-site spills and/or leaks on drinking water resources?

Secondary Question	Research
What is the composition of HF fluids and what are the toxic effects of these constituents?	*Analyze Existing Data* • Analyze publically available data and data provided by 9 natural gas service companies related to the identity and quantity of chemicals used in HF • Compare chemical list with databases of known toxic chemicals Use ToxCast (or other methods) to predict hazards in cases where toxicity is unknown

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What factors may influence the likelihood of contamination of drinking water resources?	*Retrospective Case Studies* • Possibly investigate an HF site where a spill of HF fluid has been reported • Evaluate reports of spills from data provided by HF companies *Scenario Evaluation* • Use models to explore various accidental release scenarios
What are the impacts of the approaches used to contain or mitigate spills and/or leaks on drinking water resources?	*Prospective Case Studies* • Monitor and assess current chemical management practices

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Secondary Question	Research
What chemical/physical/ biological processes could impact the fate and transport of substances in the subsurface?	*Laboratory Studies* • Identify relevant reactions between HF fluid additives and naturally occurring substances • Determine degradation products of HF fluid additives Determine important properties (e.g., temperature and pressure) of gas-bearing formations, solid residues, and fracturing conditions that may lead to drinking water contamination
What are the toxic effects of potential subsurface water contaminants?	• Compare list of naturally occurring substances with databases of known toxic chemicals Predict hazards in cases where toxicity is unknown

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Study Plan Framework

Phases of the Hydraulic Fracturing (HF) Water Cycle

- Water acquisition
- Chemical mixing
- **Well injection**
- Flowback and produced water
- Water treatment and waste disposal

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Flowback and Produced Water: What are the possible impacts of on-site spills and/or leaks on drinking water resources?	
Secondary Question	**Research**
What is the composition, quantity, and variability of flowback and produced water and what are the toxic effects of these constituents?	*Analysis of Existing Data* • Analyze data on flowback and produced water provided by follow up to data from 9 natural gas service companies *Prospective Case Studies* Sample flowback and produced water periodically after injection is completed

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What factors may influence the likelihood of contamination of drinking water resources?	*Retrospective Case Studies* • May investigate a case study where a spill of flowback and produced water has been reported *Scenario Evaluation* • Investigate scenarios involving migration of contaminants up the borehole Use models to explore various accidental surface release scenarios
What are the impacts of the approaches used to contain or mitigate spills and/or leaks on drinking water resources?	*Prospective Case Studies* Monitor on-site management of flowback and produced waste

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Study Plan Framework

Phases of the Hydraulic Fracturing (HF) Water Cycle

- Water acquisition
- Chemical mixing
- Well injection
- **Flowback and produced water**
- Water treatment and waste disposal

22

Well Injection: What are the possible impacts of the fracturing process on drinking water resources?

Secondary Question	Research
How effective are well construction and operation practices at containing fluids during and after fracturing?	*Analysis of Existing Data* • Analyze a selection of well files provided by 9 natural gas service companies *Retrospective Case Studies* • Investigate the cause(s) of reported drinking water contamination, including testing mechanical well integrity • Evaluate data from state files *Prospective Case Studies* • Conduct tests to assess mechanical well integrity before and after fracturing *Scenario Evaluation* Test various scenarios involving well failure that may result in drinking water contamination

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Study Plan Framework

Phases of the Hydraulic Fracturing (HF) Water Cycle

- Water acquisition
- Chemical mixing
- Well injection
- Flowback and produced water
- **Water treatment and waste disposal**

24

What are the potential impacts of pre-existing man-made or natural pathways/features on contaminant transport?	*Retrospective Case Studies* • Investigate the cause(s) of reported drinking water contamination *Prospective Case Studies* • Identify the impacts of natural and artificial pathways on contaminant transport *Scenario Evaluation* Test scenarios where faults or fractures intersect natural and artificial pathways

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Water Treatment and Waste Disposal: What are the possible impacts of inadequate treatment of flowback and produced water on drinking water resources?

Secondary Question	**Research**
How effective are treatment and disposal methods?	*Analysis of Existing Data* • Assess data on direct treatment, pre-treatment, and treatment for reuse of HF wastewaters • Evaluate current management practices for treatment of chloride and bromide *Prospective Case Studies* Monitor treatment and disposal/reuse of hydraulic fracturing wastewaters

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Appendix

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Outline of EPAStudy Plan

1. Introduction and Purpose of Study
2. Process for Study Plan Development
3. Overview of Unconventional Natural Gas Production
4. The Hydraulic Fracturing Water Lifecycle
5. Approach
6. **Proposed Research**
7. Case Studies (nominated case studies in Appendix F)
8. Characterization of Toxicity and Health Effects
9. Environmental Justice
10. Additional Areas Not Included in this Plan
11. Appendices
    - See especially Appendix C - List of Research Questions and Proposed Research

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Opportunities to Collaborate with DOE

1. Holistic look at organics in flowback/produced water. attempt to identify and quantify all organic species present. This information is necessary for the development and evaluation of treatment technologies. Work in progress.	EPA would like to compare results from this effort with replies from service companies regarding identification of fracing chemicals used. Could also be important information for all case studies.
2. Determination of the microbial ecology in flowback/produced water pits. flowback pits become septic in summer months often resulting in the objectionable odors. NETL will determine what organisms are present in septic pits and link those organisms to chemical transformations observed during the storage of produced/flowback water. NETL will then work with Dow Chemical (Microbial Control Division) to develop biocides that selectively limit the activity of objectionable organisms.	EPA has no planned research in this specific area but results can be important to other efforts.. Microbial ecologists in NRMRL-Cinn. may also have interest in this research. Suggest coordination with NETL scientist and NRMRL microbial ecologists. Perhaps some efforts along these lines could be incorporated into some case studies where the opportunity presents itself.
3. Evaluation of NORM in Marcellus Flowback/Produced Water. develop analytical methods for NORM in high-salt brines and apply these methods to Marcellus flowback/produced water. Work to begin October 2010.	EPA is very interested in this project and recommends coordination with Amy Bergdale (EPA Region 3) and Ron Wilhelm (OAR) who are actively pursuing information and research on NORM and TENORM issues. I would also be addressed in some of the case studies.

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Opportunities to Collaborate with DOE

4. Determine the isotopic signature of Marcellus Flowback/Produced Water. Determine if stable isotopes can be used to identify Marcellus Flowback/Produced Water when commingled with surface waters or shallow groundwater (surface spill or casing leak scenarios). Work to begin October 2010.	EPA is very interested in this project. We expect to use isotopic analyses to distinguish the nature of methane but also to identify potential mixing of fracture zone fluids with overlying USDWs.
5. Marcellus Test Site. Range Resources has offered eight well locations (to be drilled in 2012) as possible test sites. NETL is selecting one site in western PA and one site in north central PA. The development schedule will enable background monitoring for one year prior to the commencement of any drilling activities. Monitoring will continue through development and into early production. Input was solicited from state and Federal agencies pertaining to parameters that should be monitored at the site. The input was compiled into a spreadsheet containing more than 100 suggestions. Work in progress.	This project is identified as a potential prospective case study in the EPA HF Study Plan draft. EPA would like to collaborate on this project with DOE and assist with those portions related to potential impacts on drinking water resources.

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Work Underway at DOE

6.ALL Consulting, Tulsa, OK –Develop a modeling system to allow operators and regulators to plan all aspects of water management associated with shale gas development, including water supply, transport, storage, use, recycling, and disposal. This system will be used to plan, manage, forecast, track permit,, and onitor compliance	Helpful to improve BMPs associated with shale gas development.
7. General Electrical Company, Niskayuna, NY –Develop a low-cost, mobile process to treat the total dissolved solids (TDSs) in the flowback water from hydraulic fracturing operations. Develop both a flowback water pretreatment process and a membrane-based partial demineralization process to yield an effluent suitable for reuse as hydraulic fracturing water	EPA is very interested in treatment options for produced and flowback waters.
8. West Virginia University, Morgantown, WV – Develop and demonstrate treatment for the 'frac' water returns from Marcellus Shale wells, including a pretreatment filter coupled with a combination of one or more treatment elements.	EPA is very interested in treatment options for produced and flowback waters.

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Work Underway at DOE

9. University of Arkansas, Fayetteville, AR – Develop a water management decision-support system by modifying and integrating a state-of-the-art water resource simulation model with a modern enterprise geographic information system (GIS). This will provide a science-based tool to support development of energy resources in the Fayetteville Shale region of Arkansas.	Similar comments as found below in 10 and 11
10. Ground Water Protection Research Foundation, Oklahoma City, OK –Develop new hydraulic fracturing module as an add-on to the well known Risk-Based Data Management System, to assist regulators and operators to enhance protective measures for source water and streamline the well-permitting process.	While no similar effort is envisioned for the EPA Study, this is an important effort to get more states up to speed and decrease the variability in the application of rules, regs, guidance for all phases of HF operations.
11. Geological Survey of Alabama, Tuscaloosa, AL – Analyze and develop strategies for water management in the CBM reservoirs of the Black Warrior basin. Develop a large, high-quality database and GIS to provide a basis for more efficient development of CBM and identification of beneficial uses of produced water.	This study is related to studies planned in the Ohio River Basin and the Susquehanna River Basin. Lessons learned, methods, database structure and GIS techniques in the Black Warrior Basin may be transferable to PA.

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Work Underway at DOE

12. Altela Inc., Albuquerque, NM –Demonstrate that the AltelaRain technology can be successfully deployed in a cost-effective manner to treat the produced and flowback water from Marcellus Shale, and that it can operate within state and federal regulatory requirements.	EPA has no planned research in this area but results can be important in investigating the significance of bromide in flowback waters entering waste water treatment plants.
13. University of Pittsburgh, Pittsburgh, PA – Evaluate the potential to combine and treat two waste streams (flowback water and acid mine drainage) for reuse as a frac fluid, and develop novel viscosity modifiers for water high in total dissolved solids.	EPA would be interested in knowing if the novel viscosity modifiers are benign regarding environmental/health risk.
14. Texas Engineering Experiment Station, College Station, TX –Identify an efficient and cost-effective pretreatment method for use in processes to treat and reuse field-produced brine and fracture flowback waters. Develop and demonstrate a mobile, multi-functional technology specifically for pretreatment of brine.	EPA has no planned research in this area but results can be important in investigating the significance of bromide in flowback waters entering waste water treatment plants.

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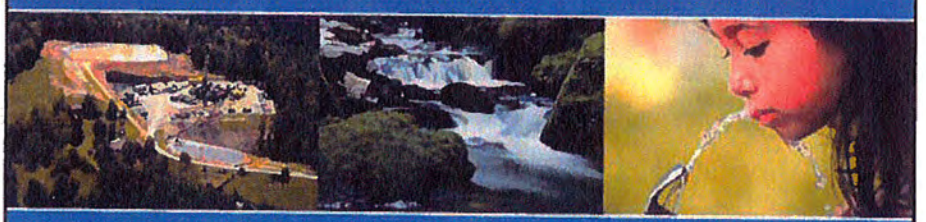
Draft Hydraulic Fracturing Study Plan

Interagency Review

January 20, 2011



Office of Research and Development

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EPA
United States Environmental Protection Agency

Overview

- Direction from Congress
- How the Study Plan was developed
- Overview of Study Plan approach
- Key research proposed
- Next steps and schedule

2

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Purpose of Study Plan

- In its FY2010 Appropriations Committee Conference Report, Congress directed EPA to study the relationship between hydraulic fracturing and drinking water, using:

- Best available science
- Independent sources of information
- Transparent, peer-reviewed process
- Consultation with others

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How the Study Plan was Developed

- SAB suggestions
- Stakeholder input
- Literature review
- Input from experts across EPA

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Science Advisory Board Recommendations

June 2010

- Direct initial research to sources and pathways of potential impacts on water resources, esp. drinking water sources
- Eventually investigate the impact on water resources more generally
- Endorsed use of lifecycle framework
- Include 5-10 in-depth case studies at locations representing the full range of regional variability
- Use a risk-based research prioritization approach
- Engage stakeholders throughout the research process

5

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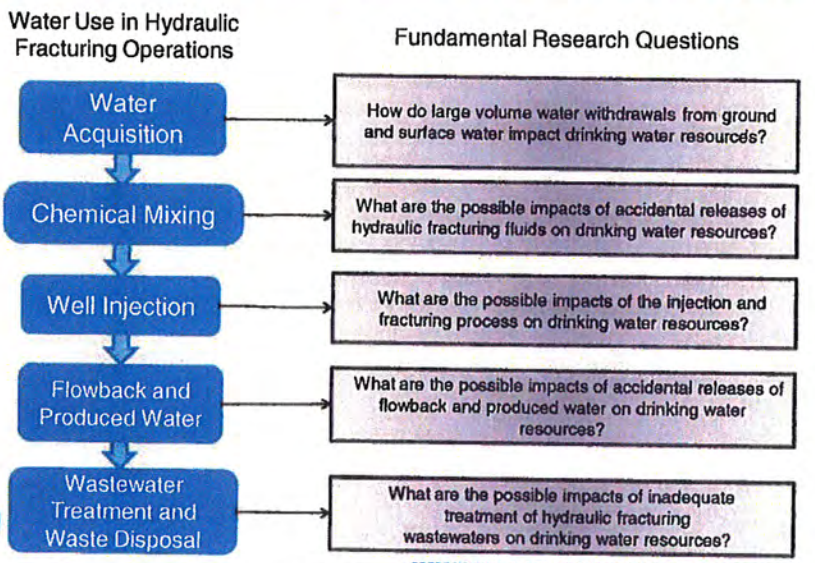
Study Will Follow HF Water Cycle



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Research Approaches

- Literature reviews
- Data gathering and analysis
- Laboratory investigations
- Field investigations and case studies

Appendix C summarizes specific research areas

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Qualitative Risk-Based Approach to Prioritize Research

- **Relevance:** Only work that may directly inform an assessment of the potential impacts of hydraulic fracturing on drinking water resources was considered.
- **Timing:** Work that needs to be completed before other work can be initiated received a higher priority.
- **Unique contribution:** Work already underway by others received a lower priority for investment by EPA.
- **Leverage:** Work that EPA can leverage with co-investigators received a higher priority.
- **Funding:** Work that is valuable but not affordable with the current budget was identified for consideration in later years.

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DRAFT Retrospective Case Study Candidates- SUBJECT TO CHANGE

Location	Areas to be Investigated	Potential Outcomes
Bakken Shale – Killdeer and Dunn County, ND	• Production well failure during hydraulic fracturing • Suspected drinking water aquifer contamination • Possible soil and surface water contamination	• extent of contamination of drinking water resources • sources of well failure
Barnett Shale – Wise and Denton Counties, TX	• Possible drinking water well contamination • Spills and runoff leading to suspected drinking water well contamination	• source of contamination in private water well • information about the likelihood of transport of contaminants via spills, leaks, runoff
Marcellus Shale – Bradford and Susquehanna Counties (Dimock), PA	• Ground water and drinking water well contamination • Suspected surface water contamination from a spill of fracturing fluids • Methane contamination of multiple drinking water wells	• source of contamination in drinking water well • source of methane in private wells
Raton Basin – Los Animas County, CO	• Potential drinking water well contamination (methane and other contaminants) in an area with intense concentration of gas wells in shallow surficial aquifer (coalbed methane)	• source of methane contamination • presence/source of contamination in drinking water wells
Marcellus Shale – Wetzel County, WV; Green and Washington Counties, PA	• Changes in water quality in drinking water, suspected contamination • Stray gas in wells, spills	• extent of impact to surface and ground water from surface spill • source of contaminants in drinking water

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DRAFT Prospective Case Study Candidates – SUBJECT TO CHANGE

- Barnett Shale – Flower Mound / Bartonville, TX
- Marcellus Shale – PA in a location yet to be determined

- Bakken Shale – Berthold Indian Reservation, ND
- Niobrara Shale – Laramie County, WY

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Focus for Review

1. For each stage of the hydraulic fracturing water cycle, consider:
   - Is the background information provided in Chapter 6 accurate and sufficiently thorough for the intended purpose of the Study? If additional information or changes are needed, please provide as necessary.
   - Are the proposed research activities appropriate and sufficient for answering the key scientific questions? If not, what changes would you recommend?
   - Do you have any recommendations regarding the conduct and selection of the retrospective and prospective case studies? (see Chapter 7 and Appendices F and G in particular)
   - Are the proposed research activities clearly described? If not, please provide clarifying text.

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Focus for Review

2. Are there particular opportunities for EPA to collaborate with your Agency? If so, please provide the name of a key contact person.

Your input requested no later than noon 1/28

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Timing

- 2012: Report of Preliminary Results
  (includes research completed and reviewed no later than March 2012)
  - Data analysis
  - Modeling
  - Retrospective case studies
- 2014: Report of Further Results
  - Data analysis
  - Prospective case studies

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EPA United States Environmental Protection Agency

Next Steps

• Jan 20-28	CEQ / Interagency Review
• Jan 31-Feb 3	Revise Study Plan
• Feb 4	Submit to SAB
• March 7- 8	SAB mtg (≥ 4 weeks after submittal) Initial comments from SAB within 2 weeks of meeting
• Late March/ Early April	Begin research upon receipt of initial SAB comments

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Appendices

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EPA United States Environmental Protection Agency

Outline of Study Plan

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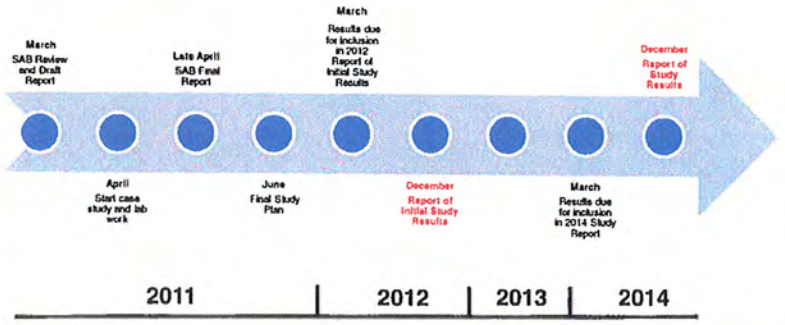
Timing for Research Results and Reports



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Science Advisory Board Review Panel

Dzombak, David A.	Chair	Carnegie Mellon University	Pittsburgh	PA
Alexeeff, George		California Environmental Protection Agency	Oakland	CA
Ballestero, Tom		University of New Hampshire	Durham	NH
Benjamin, Mark		University of Washington	Seattle	WA
Bostadol, Michel		Temple University	Philadelphia	PA
Boyer, Elizabeth		Pennsylvania State University	University Park	PA
Bunnett, David		Texas A&M University	College Station	TX
Davis, Thomas L.		Colorado School of Mines	Golden	CO
Dunn-Norman, Shari		Missouri University of Science and Technology	Rolla	MO
Giesy, John P.		University of Saskatchewan	Saskatoon	Saskatchewan
Griffiths, Jeffrey		Tufts University	Boston	MA
Gschwend, Philip		Massachusetts Institute of Technology	Cambridge	MA
Hammack, Richard W.		U.S. Department of Energy	Pittsburgh	PA
Harris, Cynthia M.		Florida A&M University	Tallahassee	FL
Kim, Nancy K.		Health Research, Inc.	Troy	NY
Lee, Cindy M.		Clemson University	Anderson	SC
Patten, Duncan		Montana State University	Bozeman	MT
Randtke, Stephen		University of Kansas	Lawrence	KS
Reible, Danny		University of Texas	Austin	TX
Schroepel, Connie		Mohawk Valley Water Authority	Utica	NY
Thyne, Geoffery		University of Wyoming	Laramie	WY
VanBriesen, Jeanne		Carnegie Mellon University	Pittsburgh	PA
Vidic, Radisav		University of Pittsburgh	Pittsburgh	PA

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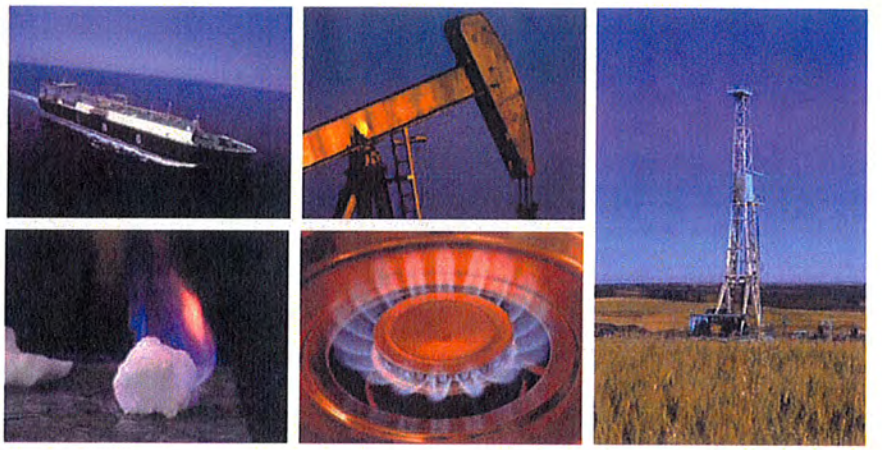
U.S. DEPARTMENT OF ENERGY

Oil and Natural Gas



EPA – DOE Collaboration Meeting

16 December 2010

Collaboration between DOE and EPA

Oil and Natural Gas

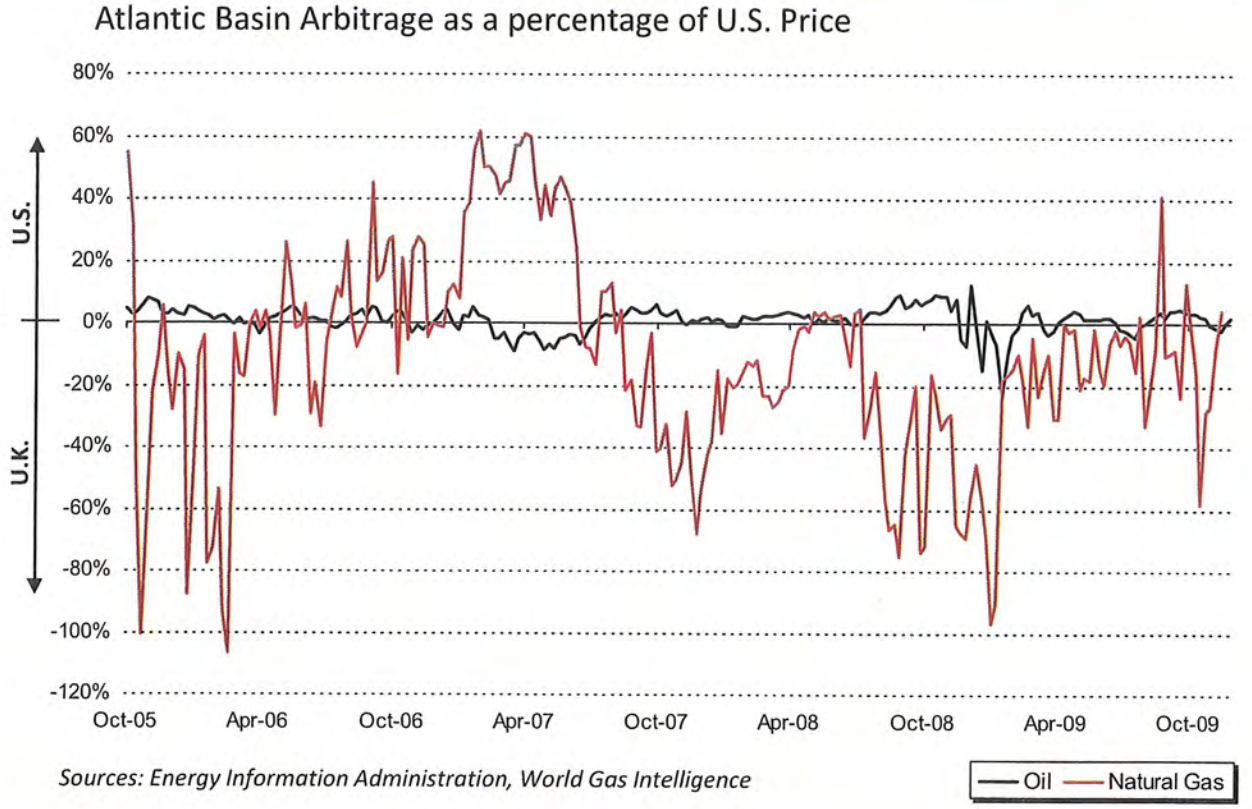
OBJECTIVES

- Establish effective communication between DOE and EPA on programs, R&D, and initiatives in the area of oil and gas.
- Discuss approaches to addressing the challenges facing the development of shale gas.
- Ensure consistent messaging from DOE and EPA on the EPA Hydraulic Fracturing study and on DOE initiatives to address challenges in developing shale gas resources.
- Familiarize DOE with the EPA Hydraulic Fracturing study and ensure that DOE has the opportunity to help guide the design and execution of the study as appropriate.
- Familiarize EPA with the DOE R&D program and solicit input on the design of future programs.

"We've got, I think, broad agreement that ***we've got terrific natural gas resources in this country. Are we doing everything we can to develop those?*** *There's a lot of agreement around the need to make sure that electric cars are developed here in the United States, that we don't fall behind other countries. Are there things that we can do to encourage that? And there's already been bipartisan interest on those issues."*

President Obama
3 November 2010

Oil Markets are Global, but Gas Markets are Fundamentally Domestic

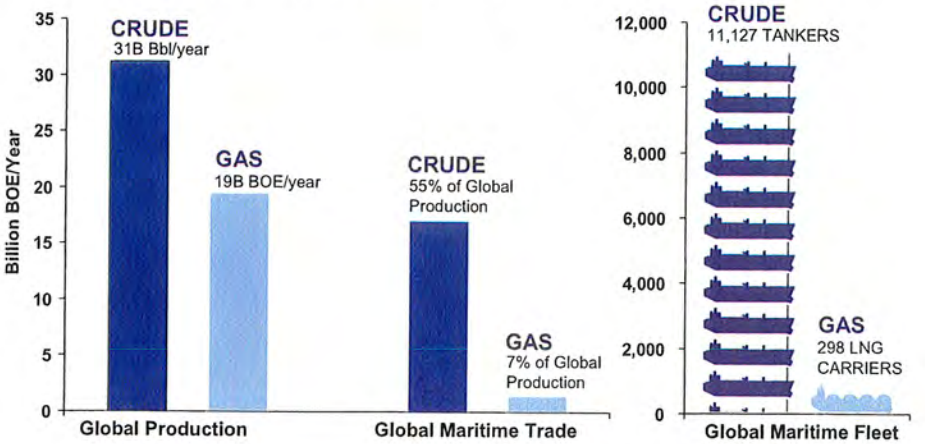


Oil is a fungible commodity for which regional demand centers are strongly linked, whereas the forces that move gas prices are uniquely local.

The global gas market is large – over 19 billion barrels equivalent per year – but global LNG shipping fleet is far to small to close arbitrages (diagram below.)

Regional gas markets move more independently than regional oil markets. Increasing domestic natural gas production capacity can reduce the price that American consumers pay for energy.

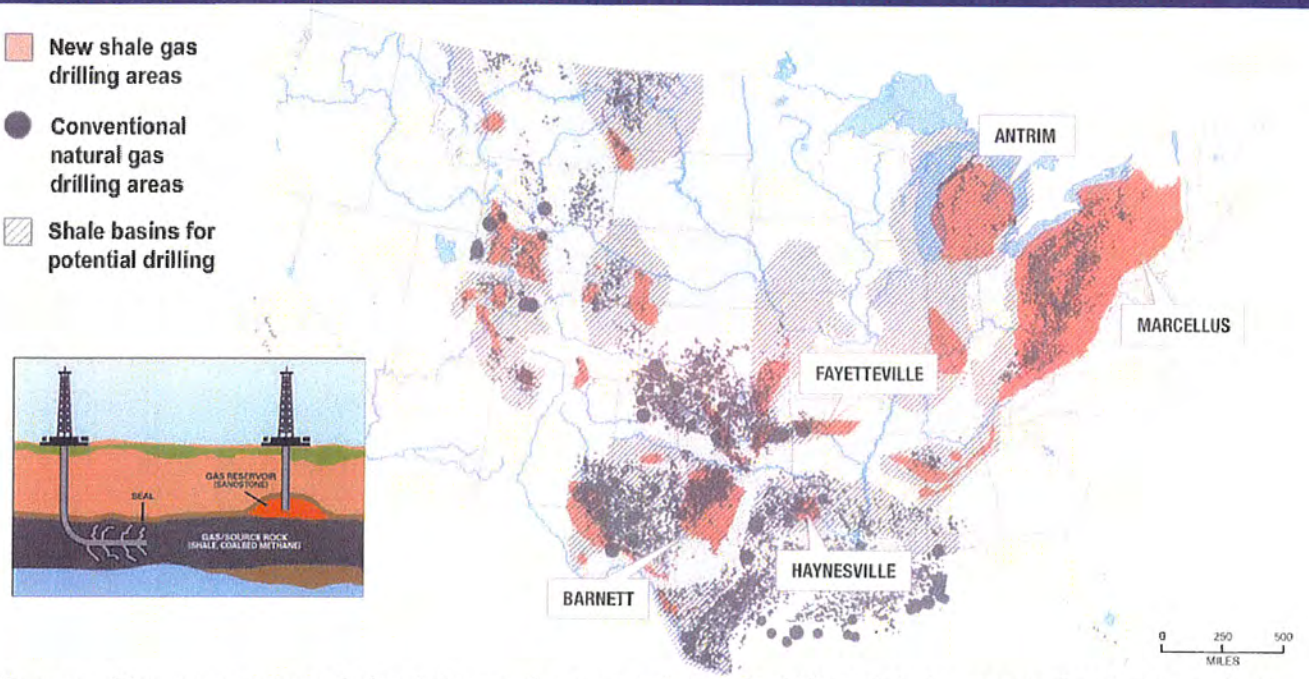
Increasing the domestic gas resource base builds **security of supply** and reduces our economy's vulnerability to **international price fluctuations.**



Sources: EIA, BP Statistical Review of World Energy, June 2009, Pacific L.A. Marine Terminal LLC, GIIGNEL

Future Domestic Natural Gas Resources will Rely Heavily on Shale

Oil and Natural Gas



Communities are concerned about **the environmental sustainability of shale gas production** to include

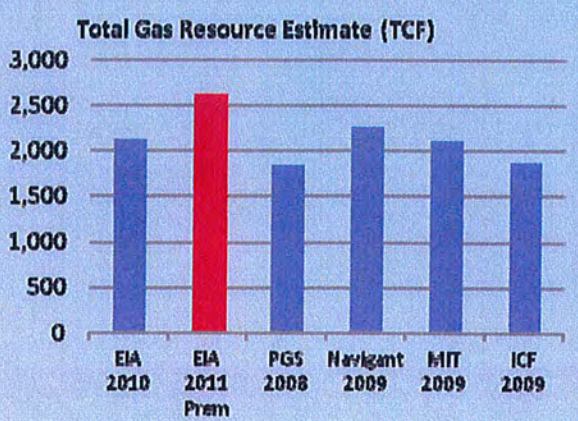
- Water availability and protection of groundwater
- Hydraulic fracturing (safety of chemicals, induced micro-seismicity)
- Impact of increased exploration and production activity on communities – minimization of drilling footprint

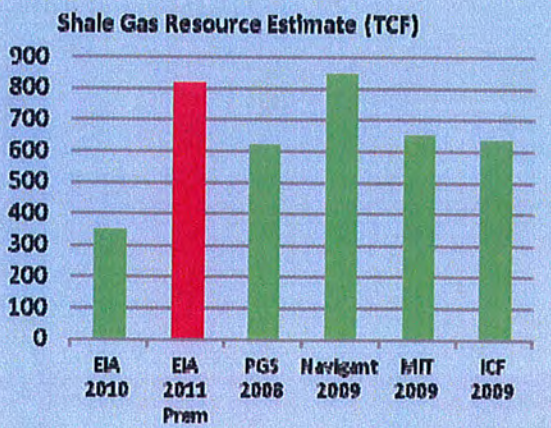
As with the deepwater, **communities are largely reliant on a limited body of safety/sustainability R&D which has been funded by the same companies that profit from the development of the resource.** The Nation will be increasingly reliant shale resources as the demand for natural gas in the United States increases. There is a role for the public sector in ensuring that the appropriate R&D is conducted to protect our communities and our economy.

Domestic shale gas resources are significant

Estimates of shale gas resources continue to increase.

EIA predicts that shale gas will make up 35% of domestic production by 2035



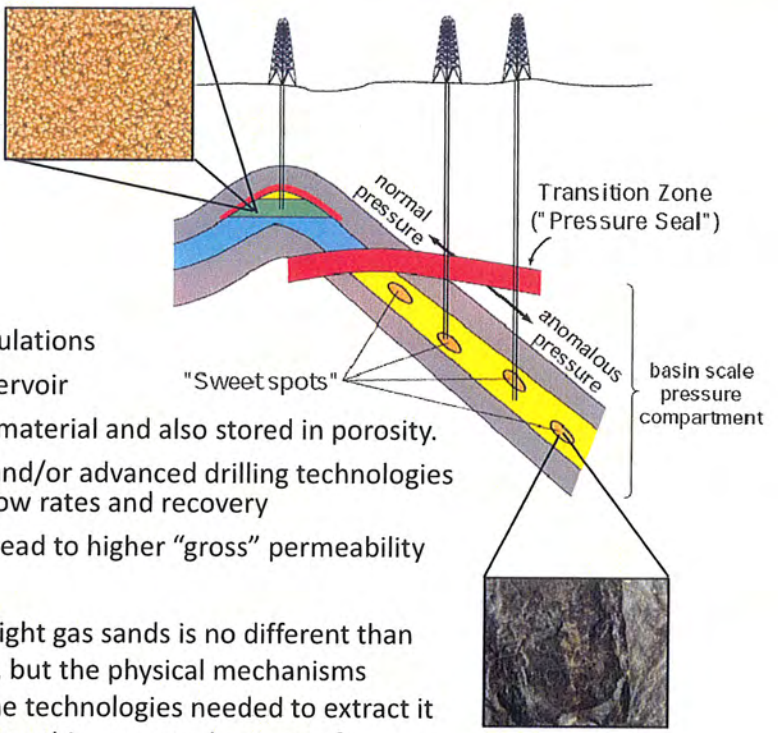


What is Shale Gas?

Oil and Natural Gas

"Conventional"

- Conventional trap and seal reservoir
- High permeability sandstones or carbonates
- Gas stored in porosity only

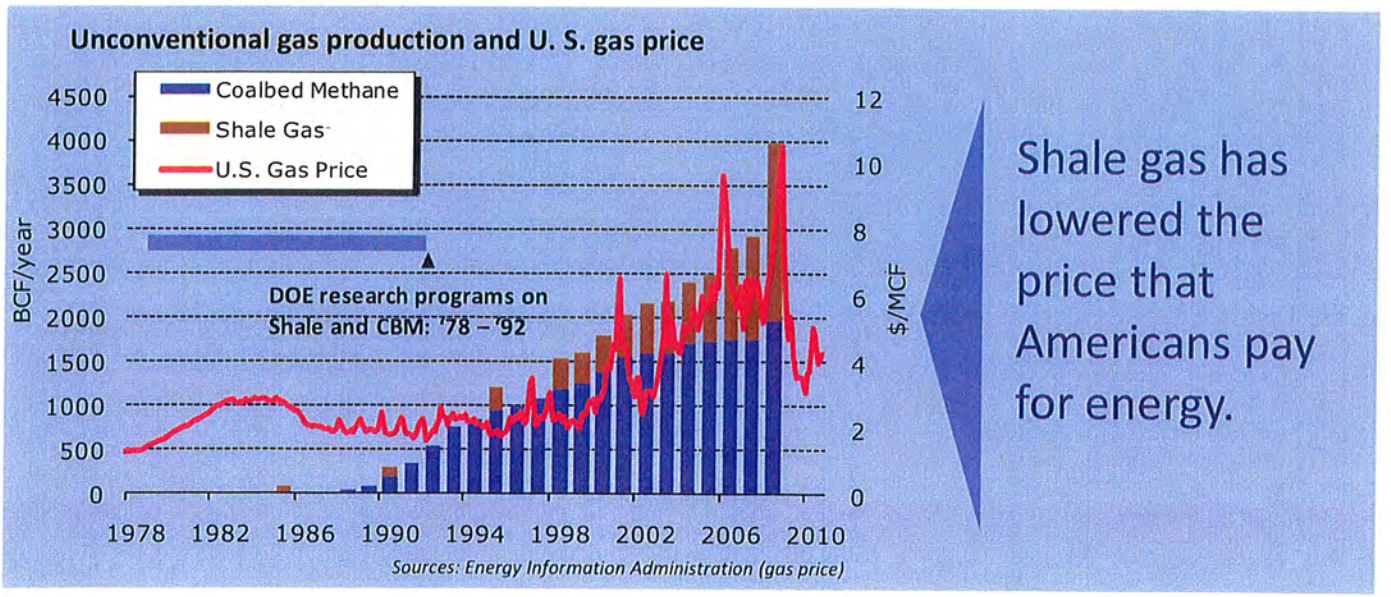


"Un-Conventional"

- Low matrix permeability
- Regionally continuous gas accumulations
- Shale is both source rock and reservoir
- Methane is adsorbed on organic material and also stored in porosity.
- Significant reservoir stimulation and/or advanced drilling technologies required to establish economic flow rates and recovery
- Variance in natural fractures can lead to higher "gross" permeability zones (sweet spots)

The natural gas stored in shales and tight gas sands is no different than that found in conventional reservoirs, but the physical mechanisms trapping the gas in these rocks and the technologies needed to extract it are different. Companies have turned to this resource because of a combination of factors:

- Improved and lower-cost drilling and fracturing technologies
- Improved understanding of the rocks and how the gas is trapped and stored,
- Favorable gas prices, and
- Lack of lower-cost alternatives for replacing reserves.



Technical Challenges

Oil and Natural Gas

OFFSHORE (DEEPWATER)

Technically complexity w/ less complex regulatory environment

ONSHORE (SHALE)

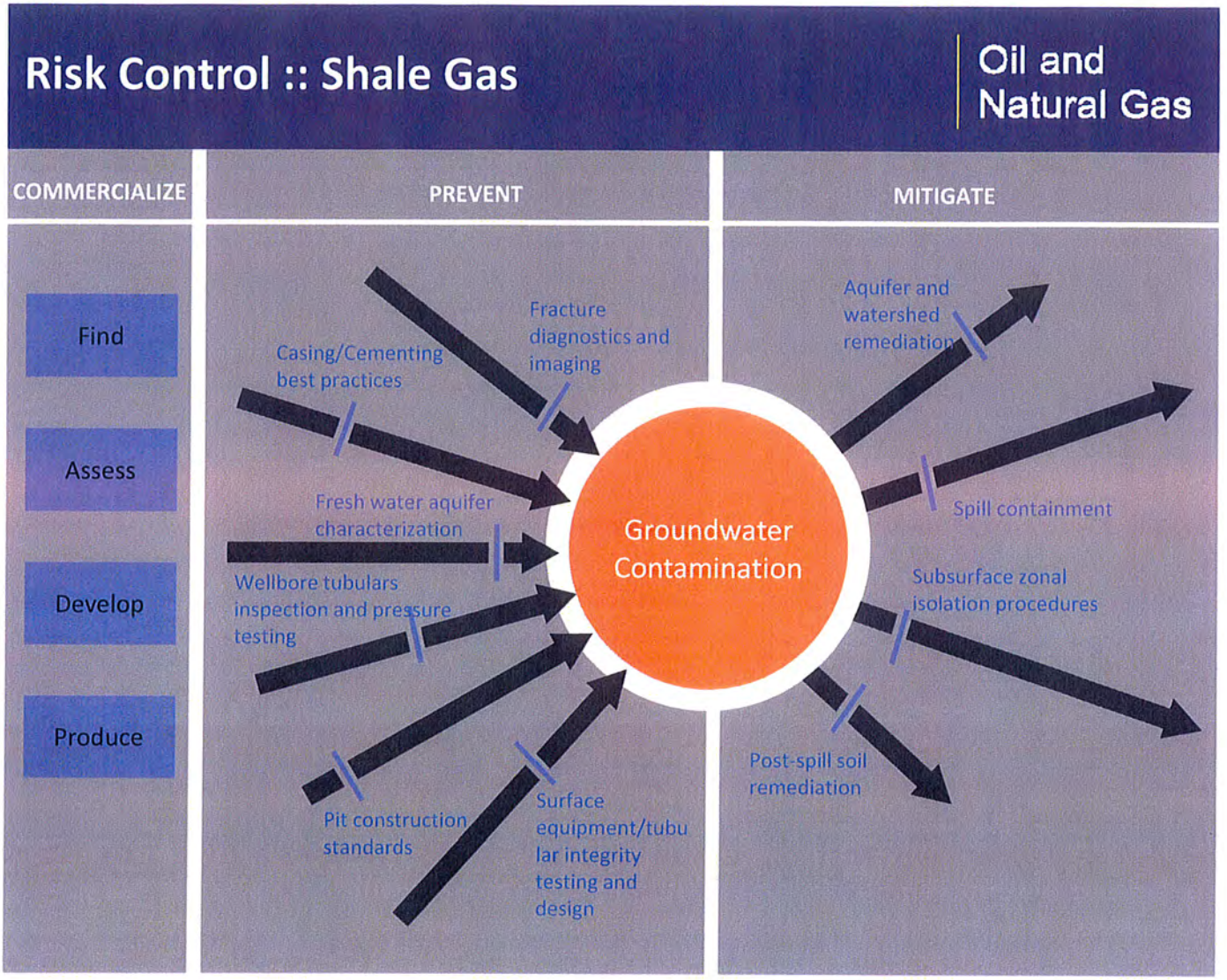
Some technical complexity but w/ a highly complex regulatory environment

Technical Challenges

- **Implementing cost effective and environmentally benign water management practices (supply, handling, treatment, and disposal)**
  - Ensure that fresh makeup water supplies are acquired in an environmentally benign manner
  - Minimize the volume of fresh water required through recycling of fracturing water
  - Ensure drilling and completion standards protect drinking water sources
  - Design water supply/handling systems (impoundments, pits, tankage, transport, pumps, pipelines, etc.) that are both cost efficient and environmentally benign
  - Cost-effectively clean flowback or produced water for re-use or surface disposal
- **Understanding the impact of drilling, completion, fracturing, and field development decisions on long-term productivity and recovery in each unique shale play**
  - How to more accurately estimate the long-term economically recoverable resource in plays where production data is limited
  - How to determine the optimal arrangement and spacing of horizontal wellbores
  - How to drill and complete wells on multi-well pads in ways that optimize well performance and recovery

Public Outreach Challenges

- Addressing the varied state regulatory requirements.
- Finding ways to promote regulations that are science-based and reflect true costs and benefits
- Finding ways to support an informed debate in an environment of misinformation
- Induced seismicity from fluid injection Hydraulic fractures extending to near-surface water supply



Current research program: Current efforts center around a number of water management and treatment projects in both the traditional program and in the Section 999 consortium-administered program.

Future program: Future projects should focus on environmental sustainability and risk prevention/mitigation, with a continued emphasis on water management.

1) Quantification of risks: Conduct applied research to evaluate risk of low probability/potentially high impact events such as induced microseismicity and contamination of groundwater via hydraulic fracturing. Evaluate the suitability of current regulations and standards (groundwater protection requirements, green chemicals, cementing and casing standards, hydraulic fracturing best practices) to prevent negative events from happening and mitigate them if and when they should occur.

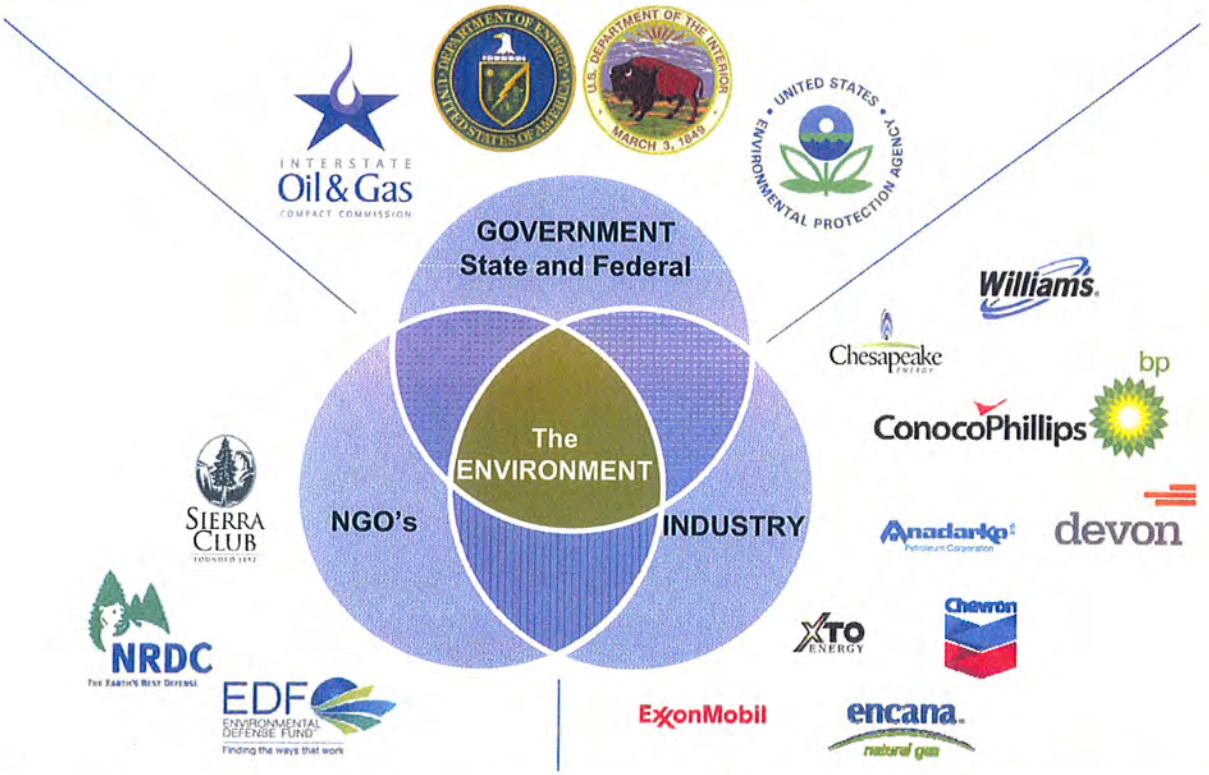
2) Development of best practices: Based on the results of the research above, work with industry, state officials and environmental companies to create a standard for the environmentally sustainable production of shale gas that establishes a baseline for state regulators. This to include: minimizing the footprint of exploration and production activities, collaborating with communities, effectively reusing/treating water used in fracturing operations, and field testing of new or improved subsurface zonal isolation methods.

3) Conduct research on watershed mitigation techniques: Develop improved methods to remediate contaminated watersheds, to include techniques for pumping and treating impacted aquifers, quick response spill containment.

What can we do now?

"...we've got terrific natural gas resources in this country. Are we doing everything we can to develop those?

Oil and Natural Gas



1) Lead the Debate	2) Work w/ Industry and NGO's to identify "quick wins"	3) Quantify risks through objective research
Fractured regulatory environment + shrill debate = lack of public confidence	There is a significant overlap in the interests of industry, NGO's and government	We can't address/mitigate the risks until we understand them

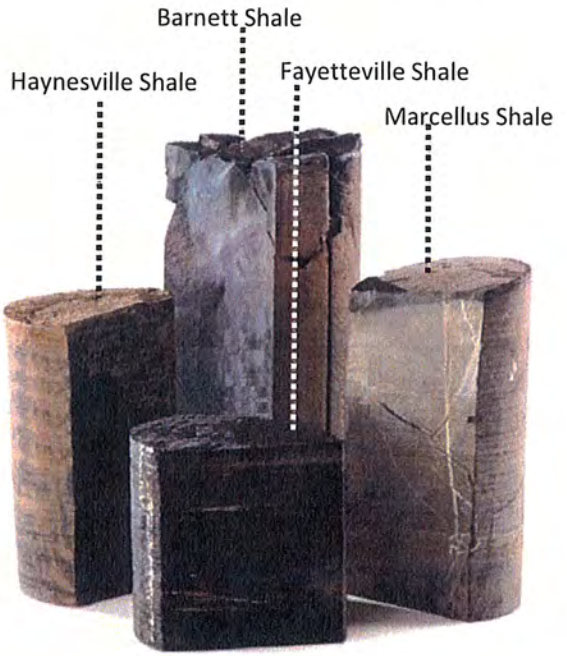
PUBLIC CONCERNS

- **Water use**: each shale gas well may require from 4 to 5 million gallons of water. This is an incremental demand on a constrained resource that can be problematic in some regions.
- **Completions through drinking water zones**: Appropriate standards for cementing and casing must be established in order to ensure that drinking water supplies are protected.
- **Hydraulic fracturing**: Communities have expressed concern about the use (and disclosure) of chemicals as well as the risk of induced micro-seismicity.
- **Reuse/treatment of contaminated water**: Flowback and produced water must be captured, treated, reused, and eventually returned to the environment.
- **Community impact**: Shale gas operations are moving into closer proximity to urban populations, and into regions which have neither an established culture of oil & gas production nor a developed regulatory regime.
- **Air quality**: Vehicles, compressors, fugitive emissions, and other sources of pollutants associated with shale gas production all have the potential to negatively impact local air quality.

DOE Projects and Capabilities

Oil and Natural Gas

- Developing and demonstrating novel processes for economically treating hydraulic fracturing flowback water and produced water from shale wells in a manner that will allow it to be reused or disposed of safely.
- Developing and field testing methods for improving the efficiency of shale development, enabling wells to produce more gas with less of an environmental footprint.
- Acquiring, validating and analyzing, research-quality field data, and publishing publicly available assessments of underdeveloped shale resources and the technologies need for their development.



- Designing and implementing field assessments that seek to provide scientifically collected data and objective analyses related to the environmental impacts of natural gas development, including the beneficial use of produced water and the improvements likely with the use of low-impact technologies.

EPA
United States Environmental Protection Agency

Hydraulic Fracturing Research: Opportunities to Collaborate with DOE

December 16, 2010

Office of Research and Development

EPA
United States Environmental Protection Agency

Overview

- Purpose of EPA's study plan
- Overview of study plan approach
- Scientific questions to be addressed
- EPA's prioritization approach
- Opportunities to collaborate with DOE

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Focus of EPA Research: Congressional Request

- In its FY2010 Appropriations Committee Conference Report, Congress directed EPA to study the relationship between hydraulic fracturing and drinking water, using:

- Best available science
- Independent sources of information
- Transparent, peer-reviewed process
- Consultation with others

3

SAB Recommendations June 2010

- Direct initial research to sources and pathways of potential impacts of hydraulic fracturing on water resources, esp. potential drinking water sources.
- Eventually investigate the impact on water resources more generally
- Engage stakeholders throughout the research process
- Include 5-10 in-depth case studies at locations selected to represent the full range of regional variability of hydraulic fracturing across the nation
- Use a risk-based research prioritization approach

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