



United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

July 9, 2018

Memorandum

To: Ryan Zinke
Secretary of the Interior

From: Vincent DeVito
Chair Royalty Policy Committee

Subject: Royalty Policy Committee Recommendations

Recently, the Royalty Policy Committee (Committee) met in Albuquerque, NM. This was the third in-person, full Committee meeting.

During the meeting, members of the Committee's three subcommittees presented and debated 10 final recommendations, including the Committee's first ever recommendations pertaining to renewable energy. The recommendations were unanimously approved by the Committee for your consideration and are the result of a thorough, cooperative, and collaborative process.

The full Committee will meet next on September 13, 2018, in Denver, CO. In the meantime, work groups are continuing to meet to discuss potential incentives for your consideration that may increase coal production and optimize federal revenue from off-shore wind investments.

The Committee also heard public comments which will be made part of the official record. The minutes from the meeting will be posted to the Committee website at www.doi.gov/rpc.

Attachment:
Summary of Proceedings including recommendations

**ROYALTY POLICY COMMITTEE
JUNE 6, 2018 MEETING**

SUMMARY OF PROCEEDINGS

**U.S. DEPARTMENT OF THE INTERIOR
PREPARED: JUNE 2018**

I. Introduction

The U.S. Department of the Interior (DOI), hosted by Secretary of the Interior Ryan Zinke and by Chair of the Royalty Policy Committee Vincent DeVito, and with James Schindler presiding as Designated Federal Official (DFO) and Executive Director, convened the third public meeting of the re-chartered Royalty Policy Committee (RPC) on June 6, 2018 in Albuquerque, NM. Key agenda items during the meeting included:

- Report out from Fair Return and Value Subcommittee
- Receive public comments
- Report out and recommendations from Planning, Analysis, and Competitiveness Subcommittee
- Report out and recommendations from Tribal Energy Subcommittee
- Timeline review

Please note that, throughout this meeting summary, comments are provided without attribution unless made by presenters or by non-Committee members.

This meeting summary was prepared by the Department of the Interior. Interested parties are invited to contact the RPC at rpc@ios.doi.gov with any questions, comments, or concerns regarding the content of this meeting summary.

The following items are included in this meeting summary:

I. Introduction.....	1
II. Summary of Decisions and Action Items	2
A. Decisions	2
B. Action Items and Next Steps	3
III. Presentations, Key Discussions, and Committee Vote.....	3
A. Fair Return and Value Subcommittee	4
1. Oil and Gas Payor Handbook.....	4
2. Marketable Condition	5
3. Coal Benchmarks	5
4. Audit	5

B. Planning, Analysis, and Competitiveness Subcommittee	6
1. Non-Fossil and Renewables.....	6
a) Recommendation 1 – Secretarial Order	6
b) Recommendation 2 – Legislative Proposal	8
c) Recommendation 3 – Instruction Memorandum	9
d) Recommendation 4 – Secretarial Order	11
2. Offshore Oil & Gas.....	12
a) Recommendation 5 – Notice to Lessees (NTL)	12
3. Onshore Oil & Gas	13
a) Recommendation 6 – Instruction Memorandum	13
b) Recommendation 7 – Instruction Memorandum	14
c) Recommendation 8 – Guidance to NEPA Planning Staff.....	15
d) Recommendation 9 – Full Rulemaking Process	17
4. Alaska	18
5. Studies	18
C. Tribal Energy Subcommittee	19
1. TERA	19
a) Recommendation 10 – Secretarial Clarification.....	19
2. Model Congressional Statute	20
3. Taxation.....	20
IV. Public Comments	21
V. Wrap Up / Closing	35
VI. Meeting Participants	36
Appendix A: Meeting Materials	40
Appendix B: Written Public Comment	41

II. Summary of Decisions and Action Items

A. Decisions

The RPC approved the following recommendations for submission to the Secretary of the Interior (*for the full language of the recommendations, see Appendix A*):

1. A Secretarial Order should be issued to plan a wind leasing program to bring at least 20 additional gigawatts from offshore wind to the United States over the decade beginning in 2024. This goal shall be achieved by leasing at least two gigawatts annually through at least four lease sales on the United States Outer Continental Shelf (OCS) of at least five hundred megawatts each.
2. The Secretary should submit to Congress a legislative proposal to expand the Outer Continental Shelf Lands Act (OCSLA) to the U.S. Territories.
3. The BLM should issue an Instruction Memorandum (IM) or other mechanism to update and clarify solar energy right of way, acreage rent schedules, megawatt (MW) capacity fees, lease and grant renewal process, bond requirements, and application priority for projects in six Southwestern states.
4. A Secretarial Order should be issued to grandfather projects that were under construction, development, or for which an application had been accepted when

the BLM issued its 2016 Competitive Processes for Solar and Wind Energy Development rule.

5. The Bureau of Safety and Environmental Enforcement (BSEE) should issue a Notice to Lessees and Operators to add specificity regarding factors such as enhanced oil recovery (EOR), high pressure/high temperature wells (HPHT), and reservoir depths, for royalty relief for late life or challenging assets.
6. The BLM should issue an IM which directs field offices to issue categorical exclusions (CX) when Energy Policy Act of 2005 Section 390 criteria are met, unless specifically rebutted.
7. The BLM should issue an IM to update the fee-fee-fed IM to avoid unnecessary National Environmental Policy Act (NEPA) analysis of impacts to non-federal surface off-lease and analysis of horizontal wells that develop a minority of federal minerals.
8. The Department should issue guidance to NEPA planning staff that states project-specific NEPA documents should be scoped to the actual project impacts and limited to the best available information.
9. The BLM should issue a full rulemaking process to revise Onshore Orders 43 CFR 3173, 3174, and 3175 by giving due consideration to applicable API and GPA standards.
10. The Secretary should issue guidance that clarifies what items are not inherently federal functions and therefore, appropriate for tribes to manage in a Tribal Energy Resource Agreement (TERA).

B. Action Items and Next Steps

1. The Tribal Energy Subcommittee will discuss the opportunity to use categorical exclusions (CXs) on tribal lands.
2. The BLM should work with the Onshore Working Group on Onshore Orders and technical suggestions that might be needed.
3. The Planning, Analysis, and Competitiveness Subcommittee should discuss the role of the RPC in reviewing the Department's NEPA processes.
4. The next RPC meeting will be September 13 in Denver, CO. An updated calendar of meetings is available on the RPC website.

III. Presentations, Key Discussions, and Committee Vote

James Schindler, presiding as Designated Federal Official (DFO) and Executive Director, opened the meeting and welcomed participants.

Vincent DeVito, RPC Chair and Counselor to the Secretary for Energy Policy, US Department of the Interior, stated that New Mexico plays an important part in President Trump and Secretary Zinke's vision of energy dominance for the U.S. He noted that having the meeting outside of Washington, D.C. allows for those to attend who may not usually be able to participate in person in the meeting, and that this meeting had the

largest public comment signup for this committee under this administration. Additionally, he thanked the committee for their work and continued commitment.

All individuals in attendance introduced themselves. *(A full attendance list can be found in Section VI – Meeting Participants, page 36.)*

James Schindler outlined the agenda for the day, how the agenda changed based on feedback from participants of the last meeting, and the process for voting: 1) Review the recommendation under consideration, 2) RPC members voice any questions and discuss comments, 3) RPC is operating by consensus, so if any comments cannot be resolved, the issue can be sent back to subcommittee(s) for further discussion, and 4) if there are no outstanding concerns, consensus is reached and the RPC votes in favor of the recommendation. Decisions apply to both the recommendation itself and the underlying analysis for that recommendation. *(For the full language of the recommendations, see Appendix A)*

A. Fair Return and Value Subcommittee

Matthew Adams, Cloud Peak Energy and Co-director of the subcommittee, introduced the subcommittee and stated he was pleased with the amount of work the subcommittee has accomplished so far. The group continues to follow up and work on recommendations from the last meeting in February, items for future recommendations, as well as presentations for the group to raise for further consideration. Two of the work groups, Index Pricing and Marketable Condition, have been combined. There were no recommendations coming out of this subcommittee; however, subcommittee members shared updates to the RPC in the following areas:

- Oil and Gas Payor Handbook: Gabrielle Gerholt, Concho Resources
- Marketable Condition: Stella Alvarado, Anadarko Petroleum
- Coal Benchmarks: Matthew Adams, Cloud Peak Energy
- Audit: Greg Morby, Chevron

1. Oil and Gas Payor Handbook

Gabrielle Gerholt, Concho Resources, provided updates on the Oil and Gas Payor Handbook. The handbook was split into a federal and an Indian handbook, and five chapters were provided to the workgroup to provide user feedback. These handbooks are “living” handbooks, which allow for easier edits and updating. Recent changes include updated citations to current law, tables for comparison, and illustrations. *(Additional information can be found in the meeting materials in Appendix A.)*

In response to Ms. Gerholt’s presentation, an RPC member made the following comment.

- The first five chapters of the Payor Handbook are going to be published online by the Office of Natural Resource Revenue (ONRR) in October. In December, the Indian Gas Valuation chapters will be published.

2. Marketable Condition

Stella Alvarado, Andadarko Petroleum, provided updates on the Marketable Condition Workgroup. The group is discussing options for moving forward as a combined group with Index Pricing. The group is evaluating standardized tables for allowances and disallowances in order to determine costs for putting gas into marketable condition. Of these three tables, one went from simplicity to a standard allowance, a second looked at geographical locations and cost deducts for transportation, and the third looked at transportation and marketing costs that would be allowed or disallowed. Ms. Alvarado noted the group has a good platform to move forward once there are decisions regarding index pricing. *(Additional information can be found in the meeting materials in Appendix A.)*

There were no comments or questions by RPC members following Ms. Alvarado's presentation.

3. Coal Benchmarks

Matthew Adams, Cloud Peak Energy, provided updates on the Coal Benchmarks working group. The group focuses on valuation of coal under current regulations. There are areas of debate between industry/payors and ONRR when it comes to valuation of coal for royalty purposes, the largest being non-arms-length sales where coal is sold to affiliates. Mr. Adams noted the group is testing views on arms and non-arms-length valuation and the outside conversations with experts have been appreciated in keeping conversations moving forward. He noted that while they have great representation on the working group, further tribal input is desired. *(Additional information can be found in the meeting materials in Appendix A.)*

In response to Mr. Adams' presentation, RPC members asked the following question. *Responses from Mr. Adams and other subcommittee members are indicated in italics.*

- Has a decision been made on the Indian Alternate Dual Accounting, standardized average single price, and potential index pricing? *This has been discussed, but the recommendations were for federal gas only, which allowed for the tribes to decide on the best method they felt was most fitting. Currently, the group is awaiting a pending decision from the Secretary to decide on those evaluations. ONRR will also be soliciting feedback on these topics.*

4. Audit

Greg Morby, Chevron, provided updates on the Audit working group. He noted the group had a meeting in April that provided updates on the initiatives around the operations management tool (an online database of valuation guidance for internal use) as well as the appeals analyst position. The group and ONRR are monitoring progress on this issue. *(Additional information can be found in the meeting materials in Appendix A.)*

In response to Mr. Morby's presentation, RPC members asked the following questions and made the following comments. *Responses from Mr. Morby and other subcommittee members are indicated in italics.*

- The working group is in recommendation mode. The views and work from ONRR and outside have been remarkable, and both sides have been open to changes and efficiencies. While there are no recommendations, there is a lot of work for September and beyond.
- There was a recommendation previously to review the benchmark system that is currently in place. Is there an update on that recommendation or when a new proposed rule might be seen? *All rules need to go through an economic analysis, which is the step the working group is currently on. The working group is reaching out to industry and academia to provide data that can be used to supplement the economic analysis. Currently, companies can value coal based upon other companies' valuations for arms-length sales; however, a company cannot use their own arms-length sales to value non-arms-length sales of coal. The recommendation from the previous meeting was to allow companies to use third party sales to value non-arms-length sales. The working group is working with industry and academia to pull the economic analysis together.*
- The Navajo Nation has two active coal mines, so the valuation of sales is important. The non-arms-length coal extraction vs. the lesser arms-length sales is important for valuation.

B. Planning, Analysis, and Competitiveness Subcommittee

Colin McKee, State of Wyoming, introduced the subcommittee. The subcommittee is divided into six working groups. There are some groups with recommendations and others only have updates as they prepare future recommendations. Mr. McKee thanked the members and alternates, as well as the Interior staff that attend calls and meetings. Subcommittee members shared updates and provided recommendations to the RPC in the following areas:

- Non-Fossil and Renewables: Marisa Mitchell, Intersect Power
- Offshore Oil & Gas: Patrick Noah, ConocoPhillips Company
- Onshore Oil & Gas: Kathleen Sgamma, Western Energy Alliance
- Alaska: John Crowther, State of Alaska
- Studies: Emily Kennedy Hague, American Petroleum Institute

1. Non-Fossil and Renewables

Marisa Mitchell, Intersect Power, discussed the working group's first three recommendations and Colin McKee introduced the fourth.

a) Recommendation 1 – Secretarial Order

A Secretarial Order should be issued to plan a wind leasing program to bring at least 20 additional gigawatts from offshore wind to the United States over the decade

beginning in 2024. This goal shall be achieved by leasing at least two gigawatts annually through at least four lease sales on the United States Outer Continental Shelf (OCS) of at least five hundred megawatts each. (For the full language of the recommendation, see Appendix A)

This recommendation relates to America's energy dominance. The Federal Government has experience with offshore wind leasing as the first generation of leases have been accomplished. This recommendation would set the stage for the next phase of offshore wind. The first generation of leases meets market demand through 2030, but planning needs to start now for the next round. The floor of 2GW/year was learned from the European experience, and creates enough competition in the supply chain to ensure the offshore wind generation is accomplished. This recommendation ensures there is a commitment by the Federal Government to lease sales so funding can be secured by developers. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Mitchell's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Mitchell and other subcommittee members are indicated in italics.*

- How was the 20GW and 2GW figure derived, was there an analysis completed? *Two gigawatts is the minimum for investment in the supply chain. This floor was set by the European example. Twenty gigawatts is the market demand going forward.*
- Twenty GW is 2GW per year for 10 years. This means all of those GW have to be successful. Why not lease more knowing that some will not proceed? *Two per year is the minimum. Ideally, it could be more. The detailed recommendation has language regarding a multi-stakeholder process to obtain input from the industry and economists to ensure the numbers are correct.*
- The second part of the recommendation focuses on stakeholder education and engagement, which is an important part of the recommendation. The detailed discussion of the recommendation includes proposed language for the secretarial order and lists specific areas for lease sales. Would you consider changing "proposed" to "possible" language for the secretarial order? *That would be acceptable.*
- The Bureau of Ocean Energy Management (BOEM) is conducting a high level assessment about the future of offshore wind. It has been published in the Federal Register and it is open to public comment through July 5.
- How does this recommendation fit in with the BOEM process? *This would be an important consideration as well as the other comments we receive.*

Given the change from "proposed" to "possible" language for the secretarial order, Mr. DeVito asked if there were any additional questions or objections to the first recommendation. Hearing none, the committee agreed to move forward with the recommendation.

b) Recommendation 2 – Amendment to OCSLA

The Secretary should submit to Congress a legislative proposal to expand the Outer Continental Shelf Lands Act (OCSLA) to the U.S. Territories. (For the full language of the recommendation, see Appendix A)

OCSLA originally omitted the Territories. As Puerto Rico is reinvesting in infrastructure following hurricanes and as Guam has received a commitment from the Department of Defense (DOD) to increase DOD presence and infrastructure on Guam, territories could benefit from energy development, particularly wind. This recommendation could help reinvest in infrastructure, including transmission resources, as well as ensure territories could utilize their energy resources. The Congressional Budget Office completed an analysis and determined there could be a \$20 million increase in federal revenues over the 2018-2027 period. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Mitchell's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Mitchell and other subcommittee members are indicated in italics.*

- Clarifying question on the language of the recommendation, would the Secretary forward a legislative amendment? As drafted, the recommendation touts the benefits without proposing the Secretary do anything. *There was an edit that did not make it to the meeting package. The Secretary does not have the authority to lease the areas in the Territories, but he can make recommendations to Congress that he is given the authority to lease off the Territories as he is off states.*
- Have territories provided input on this and what has the nature of the discussions been? *There have been several legislative moves around this activity in the past and it is understood these proposed amendments have received input from the Territories. From reading the background, both houses have supported this previously, but it would be important to get the Territories' input as the proposal moves forward.*
- How does the Federal Government engage with the Territories in seeking their input on leasing? *To date, there is no authority to lease off the Territories, but the Secretary does have trust responsibilities. In earlier iterations of this recommendation, there were active conversations with Territories but not recently. There is a DOI office of Insular Affairs that has direct engagement.*

Mr. DeVito noted the change that the action for the recommendation would be for the Secretary to submit a proposed legislative amendment. He then asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

c) **Recommendation 3 - Instruction Memorandum**

The BLM should issue an Instruction Memorandum (IM) or other mechanism to update and clarify solar energy right of way, acreage rent schedules, megawatt (MW) capacity fees, lease and grant renewal process, bond requirements, and application priority for projects in six Southwestern states. (For the full language of the recommendation, see Appendix A)

This recommendation instructs BLM to draft an instruction memorandum (IM). The six Southwestern states have ample solar resources and have been identified by BLM in the Western Solar Plan as suitable and potentially suitable for energy development. There has been a boom in solar development on private lands; however, federal land solar policies discourage solar development on public lands. America needs to be on the leading edge of technology in order to take advantage of its solar resources. Most systems today are photovoltaic systems, which have high upfront costs and low operating costs. The idea is to enter into a long term Power Purchase Agreement (PPA). The recommendation would provide clarifications and guidance on current policies to ensure that multiple-use federal lands are competitive with private lands. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Mitchell's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Mitchell and other subcommittee members are indicated in italics.*

- Does the megawatt (MW) capacity fee account for increasing capacity of technology? State lands are debating how to capture royalties for electrons rather than minerals. *The MW fee is calculated by hours in a year multiplied by net capacity factor, times the megawatt hour price, multiplied by rate of return. The net capacity factor can be re-evaluated as technology changes, and the rate of return can change. It is not tied to production, but price.*
- This recommendation is to provide guidance, as opposed to modifying the rules? *This recommendation is for BLM to clarify rules to ensure BLM has discretion to go back to original rates and make changes.*
- The conservation groups made a comment that had an alternative to eliminate the MW capacity fee, and adjustments to the acreage rent and MW capacity fee. Could you comment on that? *The MW fee is double calculating. The resource for solar is the land. The lease rate is capturing that. The fee is on par with the county fees. It provides an incentive for prioritizing solar energy across BLM lands. A full zone-wide NEPA analysis, EIS, resource studies, and consultations were completed. This would cut permitting time and build an incentive.*
- New Mexico and the Navajo Nation are looking at solar. For BLM, can you speak to leases that have been issued under the Western Solar Plan and the effect of the MW capacity fee? *The MW capacity fee is based on a PPA. BLM is looking at NV, CA, and other states and their standards for what they are changing for a fair return. Impact on BLM is access to transmission. Proponents had an application, but had to hold because of transmission. This issue needs to be solved. For the*

MW fee, it has been adjusted and BLM will look to see how NV, CA, and AZ are adjusting. There has not been an impact. Solar is not 100% comparative to oil and gas. BLM is trying to get a fair return and need a county by county appraisal, after which BLM can make adjustments. As for bonding, BLM needed a way to ensure taxpayers would not be left to clean up if a developer walked away. The solar energy zone fee is a way to recoup fees from a taxpayer funded regional mitigation plan. If a developer is working outside the zone, they would invest the money because it is a cost recovery.

- *How are bond rates set? Wind and solar is set by regulation. Coal, oil, and gas is set by statute. In the bonding, there are provisions for adjustments, but it depends on the standing of the operator. However, this is typically adjusted at the end.*
- *This recommendation does not ask for a rule change. Would a rule change come at the end? Some things can be done through an instruction memorandum, but it cannot be used for a public process. Some things require a regulatory change.*
- *Is there a time frame for the MW fee? There is a phase in. Charging a MW fee is double counting and a lease fee already accounts for use of the land. This change would get to a place for interest in federal lands.*
- *Tax payers need to get reimbursed. Please comment on that. There are regional mitigation strategies already set up for the solar energy zones. When a developer wins a bid, they pay into the mitigation fee. Developers then do not have to find their own offset lands to pay for any potential impacts of the development. There are fees developers pay back into the fund to pay back the taxpayers for the upfront investment. That fee is only for the solar energy zone lands and not the variance process lands.*
- *How does this apply to tribal lands? This does not apply to Tribal lands. It only applies to BLM land already designated through the Western Solar Plan.*
- *The current rule has a rental rate for acreage and the MW capacity rate. The recommendation is to combine the fees. Double paying is detrimental to industry. However, the recommendation may be outside what an IM can do, and that rulemaking needs to be done on this issue. BLM does have the discretion to go back and reevaluates the fees.*
- *Would you be open to adjusting the language for BLM to “reevaluate” this? In reviewing with industry, these are the five things than can be done through and IM to get federal land on par with private land. A rulemaking would take months, which would lose interest for development on federal lands. It would be good to keep the IM for now and work with BLM later to reevaluate the rule, since there are a number of things that need to be adjusted.*
- *This could be a two-step process of proceeding to day with adjusting the rule through and IM and then going back with adjustments via rulemaking later.*
- *A rulemaking would have a public process, while an IM would circumvent that. There are concerns that the recommendations are inconsistent with the regulatory requirements. Making inconsistent recommendations, even in the*

short term, circumvents the public process long term. *The public did have comment time. BLM does have the ability to change the rates, if determined to not be correct. Attorneys agreed this could be done via and IM.*

- Does BLM agree with the point that an IM can be used in this situation? *BLM agrees with the concept that some things can be changed via an IM, but not that an IM can be used for everything. BLM uses a number of vehicles for change and a full rulemaking may not be necessary. BLM would like the flexibility that if an IM is not appropriate, it can take the proper process. The solicitors would review the recommendation before it went to the Secretary and ensure an IM can be used.*

Noting the change of “an IM and/or rulemaking as appropriate” to give BLM flexibility with mechanisms for adjustment, Mr. DeVito asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

d) Recommendation 4 – Secretarial Order

A Secretarial Order should be issued to grandfather projects that were under construction, development, or for which an application had been accepted when the BLM issued its 2016 Competitive Processes for Solar and Wind Energy Development rule. (For the full language of the recommendation, see Appendix A)

Prior to the 2016 rule, operators were only subject to a capacity fee. However, the new rule instituted an additional acreage fee and changed how the capacity fee was calculated. The nature of the recommendation is to define who is subject to grandfathering when the rule went into effect in 2016. The recommendation does not increase revenue generation to DOI, but would honor the environment developers had when applying and provide assurance for developers to make development more attractive. This rule would not weaken the environmental requirements and is a narrow recommendation that affects a small amount of projects. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Mr. McKee’s presentation, RPC members asked the following questions and made the following comments. *Responses from Mr. McKee and other subcommittee members are indicated in italics.*

- BLM has looked at grandfathering and the administration landed at a two-year period for reduction. That timeframe would make allow for adjustments. BLM does not have a problem with this moving forward.
- The recommendation is for projects underway. Is the intent to grandfather projects that had an application or more under construction? *The intent is that projects under development or those that submitted a right of way application and are going through the permitting process would have the option of being grandfathered.*

- Does the recommendation provide certainty for projects being developed now or the future? *Future projects as well. There would be some assurance for developers that they would be able to work under the regulations that were in place when they applied. It is understood that changes occur over time, but this would be a big change for the environment for projects.*

In order to clarify what a project “under development” means, the language of the recommendation was changed to include projects “for which an application had been accepted by the Bureau of Land Management” prior to the rule taking effect. Mr. DeVito asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

2. Offshore Oil & Gas

Patrick Noah, ConocoPhillips Company, discussed the recommendation coming out of the offshore working group.

a) Recommendation 5 – Notice to Lessees (NTL)

The Bureau of Safety and Environmental Enforcement (BSEE) should issue a Notice to Lessees and Operators to add specificity regarding factors such as enhanced oil recovery (EOR), high pressure/high temperature wells (HPHT), and reservoir depths, for royalty relief for late life or challenging assets. (For the full language of the recommendation, see Appendix A)

This recommendation is a notice to lessees that would help provide royalty relief for challenging or late life projects. The recommendation is for DOI to consider specific criteria in hopes the process for approval for royalty relief would be used more widely by lessees. While there is a process for royalty relief, few apply for it and even few receive the relief. The most recent approval in the Gulf of Mexico was 17 years ago. This recommendation would not create a new standard or lower the bar, but would help make the process more usable and more effective, which would help encourage investment that might not otherwise happen. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Mr. Noah’s presentation, RPC members asked the following questions and made the following comments. *Responses from Mr. Noah and other subcommittee members are indicated in italics.*

- One might argue that royalty relief would not be appropriate given the public comments. The question is should public policy support the higher cost projects that would not otherwise be economic? If policy should be neutral, then one could argue against relief on principle. *The current process was a policy decision made years ago. Developers are being told that production should occur on public lands, rather than abandonment or investment not made. There should be a priority for change.*

- If the cost is born by private companies and not the public, why is that a concern? *Royalty relief favors higher cost operations. At a different time and place, we may want to open a discussion on royalty relief more generally.*
- The study in the materials was from 2015, and oil prices have gone up since then. Has that changed the economics of the analysis? *The output was based upon a tool developed in 2015, but the numbers used were from 2017.*
- The purpose of these tools is to not have resources stranded. Can this be elaborated on? *The law says BSEE can grant relief for development based on the project's economic need. Companies need to submit an application in order for that to be done. It has not been utilized in the Gulf, but needs to be based on the project's economic need, drilling needs, and other parameters.*
- The recommendation is an expansion of the previous recommendation and based on deep water.

Mr. DeVito asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

3. Onshore Oil & Gas

Kathleen Sgamma, Western Energy Alliance, presented four recommendations on behalf of the onshore working group. The group looked at increasing royalties and determined that an increased rate would lead to less revenue, since developers would be driven from development on federal lands. The group focused on how to increase competitiveness of federal lands and deliver increased revenue. These recommendations build upon and provide more specificity to recommendations made at the Houston RPC meeting.

a) Recommendation 6 - Instruction Memorandum

The BLM should issue an IM which directs field offices to issue categorical exclusions (CX) when Energy Policy Act of 2005 Section 390 criteria are met, unless specifically rebutted. (for the full language of the recommendation, see Appendix A)

Timeframes for the Application for Permit to Drill (APD) have become lengthy (260 days on average) due to redundant NEPA analysis completed by BLM. BLM should issue guidance that CXs must be used when a company meets any of the statutory Section 390 criteria. Section 390 CXs are mandated by the EPA Act 2005 and should not be discretionary. The use of CXs would reduce APD processing time, avoiding redundant NEPA analysis and allow analysis on non-CX activities. Ms. Sgamma also noted that BLM has issued an IM concerning these CXs. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Sgamma's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Sgamma and other subcommittee members are indicated in italics.*

- This recommendation is limited to federal and not Indian leases. Indian country has been dealing with delays for years, and this recommendation should be a discussion for the Tribal Energy Subcommittee.
- Section 390 is a high bar for rebuttable presumption, but not mandatory. There may be instances where the bar is met, but companies do not apply, which makes this mandatory language uncomfortable. *Statutory might be better because that was the intent.*
- Recommendations for NEPA are outside the committee's charter and am having difficulty assessing when it is in our scope and not. *CXs fall under the streamline the Department's processes to increase competitiveness. NEPA decreases federal competitiveness, which is why the group looked at policies to help increase revenues from federal lands. Processes within the Department is in the charter; however, getting into the environmental side of NEPA is not.*
- When the processes become limited or streamlined, that raises concerns for the public. Environmental concerns may be beyond the scope of the committee, but studies have shown CXs have impacts when not followed. Public participation is challenging when talking about a process. *When looking at a CX, NEPA has been done and there is still a chance for public involvement. This recommendation does not get rid of the public comment, but does say it will not take up to 15 years. Further, it does not get rid of NEPA, but we do want to increase revenue on public lands. More to the point, the initial charter is for the public to receive the full value of resources. If the public does not get that value because of delays, that is a part of the charter. To counter that, that depends on what your idea of value is.*
- Examining the scope of the charter and what falls within and outside the scope of the committee should have further discussion.

New language of "unless specifically rebutted" was inserted at the end of the recommendation after "are met." Noting the change of "unless specifically rebutted," Mr. DeVito asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

b) Recommendation 7 - Instruction Memorandum

The BLM should issue an IM to update the fee-fee-fed IM to avoid unnecessary National Environmental Policy Act (NEPA) analysis of impacts to nonfederal surface off-lease and analysis of horizontal wells that develop a minority of federal minerals. (For the full language of the recommendation, see Appendix A)

NEPA analysis need not consider impacts from nonfederal actions that would occur independently of a federal authorization, such as when multi-well pad is sited on off-lease, nonfederal surface to access nonfederal minerals. BLM should establish clear guidance for analyzing impacts of horizontal wells that develop a minority mineral interest. BLM should not conduct unnecessary analysis of impacts from nonfederal actions that would occur regardless of whether BLM approves an APD. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Sgamma's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Sgamma and other subcommittee members are indicated in italics.*

- *BLM is updating its 2009 guidance and is consistent with this recommendation on how BLM can use its discretion for fee-fee-fed.*
- *Is there specific data on delays and impacts concerning the issue of federal nexus? There is no specific data, but North Dakota has looked at delays for nonfederal wells. North Dakota has 32% of its Balkan units impacted where the surface location is on state lands, but the federal minerals are accessed via a well pad. The state normally issue multi-well pad permits in 25 days, but most are taking 250 days or more. These wells roll into NEPA and environmental analysis, which leads to permitting delays. When developers respace wells, the Federal Government gets no royalties from that.*
- *Is it 50% or less, or more generally? More generally. It is not meant to be too prescriptive.*

Mr. DeVito asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

c) Recommendation 8 - Guidance to NEPA Planning Staff

The Department should issue guidance to NEPA planning staff that states project-specific NEPA documents should be scoped to the actual project impacts and limited to the best available information. (For the full language of the recommendation, see Appendix A)

NEPA analysis can take three to five years for small projects, and up to ten years for large projects. The RPC has evaluated reducing NEPA and other approval timelines to encourage more development, increasing royalty revenue. To implement Secretarial Order 3355 (one-year time frame and 150 pages) NEPA documents should focus on actual, not speculative, impacts beyond the scope of the project. Tiering to existing environmental analysis should be used wherever possible. NEPA documents should also be scoped to best available information. Processing of NEPA documents should not be put on hold while waiting for new research to be completed. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Sgamma's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Sgamma and other subcommittee members are indicated in italics.*

- There is a broad scope NEPA done on lands against Navajo lands, and there are tiered projects done under that NEPA analysis. Is this recommendation for a tiered scope? Concerning methane spikes, small projects would be ok, but cumulative projects may have an effect. Is this covered? *There is an RMP or larger programmatic document that has high level modeling. Individual NEPA documents show the contribution of the project and complete an analysis of project impacts given what the models say for development. That could show how the project is mitigating those impacts.*
- Is there a mechanism if something comes up not in the Programmatic Environmental Impact Statement (PEIS)? *In the NEPA document, there are four tiers for reasonably foreseeable development: a CX, Determined NEPA Adequacy (DNA) (already studied and impacts are within the foreseeable impacts), EA (Environmental Assessment) (NEPA analysis completed but new information for FONSI), or Environmental Impact Statement (EIS).*
- If it was not foreseeable in five years, is there a new way to insert information into the CX? *Not in the CX, but in the EA or EIS.*
- What would this recommendation change or add? *Companies are having to do research projects, rather than using the best available science. For example, companies are asked to complete multiple air models or complete wildlife surveys which are outside what the project impacts, which lengthens the NEPA process. This recommendation suggests use what is in front of the department at the time and within the project scope. There are times a PEIS is needed, but if it is a limited project, it should be scoped accordingly. The recommendation is meant to help DOI meet the time and page goals for NEPA. It helps reinforce the orders for limited time and pages for NEPA analysis.*
- The recommendation sounds like, for individual projects, companies do not have to study the impacts to all of a state, but limits the impacts to what the project will impact.
- If a project is requested to do a study and they do not think it is within scope, what is the relief? *There is a process for the right official to review and check for scope. Generally, on the plan level, the plan will be put out to the public and they can comment if it is within or outside of scope based on purpose and need.*
- There needs to be a conversation on how NEPA should be completed for areas with multiple jurisdiction, ex. Navajo lands next to federal or other Indian lands.
- There should be further discussion regarding NEPA.

Paragraphs from the background section were moved to the analysis section, which was left blank in the full subcommittee recommendation packet. Mr. DeVito asked if there

were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

d) Recommendation 9 - Full Rulemaking Process

The BLM should issue a full rulemaking process to revise Onshore Orders 43 CFR 3173, 3174, and 3175 by giving due consideration to applicable API and GPA standards. (For the full language of the recommendation, see Appendix A)

The rulemaking should fix the retroactive aspects of the existing rule that threaten existing unitization and commingling agreements. The simplest and most equitable means of modifying the regulations would be to adopt the American Petroleum Institute (API) and Gas Processors Association Midstream (GPA) standards in their entirety. All variances, commingling agreements, and off-site measurement agreements approved prior to the effective dates of the new rules should be honored. BLM should consider a provision in the rule to define “economically marginal” that would establish when commingling of production is allowed from a property. *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Sgamma’s presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Sgamma and other subcommittee members are indicated in italics.*

- These recommendations encompass a 17-point document that included concerns, changes, problems considered, etc. It was an extensive study put together and given to BLM.
- Why are the API and GPA standards appropriate? *API and GPA are industry groups where companies, manufacturers, and regulators come together and make standards for each items that measures oil and gas. The groups have been around 30-40 years, meet multiple times a year, and have reviews every 5 years to ensure the standards are still relevant. If they are not relevant, they are revised.*
- The rule speaks to 2016 rules that were scientifically unsound. Could someone speak to that? *One rule was for multipoint proving and it was impossible technically to complete that proving.*
- There were rules in 2016 and comments about if it was appropriate to defer to industry standards. *Several rules were changed as they were impractical for the value they provide. There are items that BLM agrees need to change. The best way to meet the revision is to rely on documents that have been built upon decades. Once standards are put forward, studies are completed and money invested to ensure the equipment can meet standards.*
- BLM agrees there needs to be a change but cannot agree to adopt the standards that are out there. These are technical, site specific rules. There needs to be a discussion between BLM and the subgroup on the concerns and changes that need to be made. There is probably more agreement than not in changes BLM

can make to reduce the burden. Industry has been worked with for developing these standards, but more detailed conversations are needed.

- Was there any consideration on tribes? Reopening rules that have already been established could have an effect on tribal lands. *That was not looked at specifically. Reopening the rule would go through full public comment, which could affect Tribal rules. There are sections that could be opened to public comment.*
- Is the intent to look at the standards and adopt those that are appropriate or adopt them in their entirety? *Those that are appropriate.*
- Tribes need consultation to know how the adopted rule impacts the Navajo Nation. *If the rule was reopened, it would automatically go to tribal consultation.*
- That may be correct regarding consultation, but tribes haven't seen that with this administration. Not necessarily with DOI, but with other departments.
- It was suggested to not put qualifiers, since that may leave people out. *If it is reopened, the tribes will be fully consulted. When someone is left out, it is usually the tribes. This is the tribal experience over time.*
- There has been permitting backlogs related to flaring. This should be followed up on by BLM.

The language of the recommendation was changed to “revise” rather than “rewrite” the onshore orders and “giving due consideration” to API and GPA standards was inserted. Mr. DeVito asked if there were any additional questions or objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

4. Alaska

John Crowther, State of Alaska, provided an update on the Alaska working group. DOI has begun the NEPA scoping process for leasing in the 1002 Area and robust involvement from the state and local stakeholders is expected. Alaska continues to be an important new exploration opportunity for federal production for the National Petroleum Reserve. DOI needs to ensure appropriate acreage is available and permitting is coordinated and efficient. There may be a future recommendation regarding the reserve. The OCS 5-year planning process continues in Alaska, including planning for a 2019 lease sale in the Beaufort Sea area. Federal royalty valuation for OCS transportation costs and other factors should take into consideration the Alaska context to promote production. A recommendation may be brought in the future.

There were no comments or questions by RPC members following Mr. Crowther's presentation.

5. Studies

Emily Hague, American Petroleum Institute, provided an update for the studies working group. The group is focusing on working with BOEM and BLM subject matter experts to analyze modeling within DOI. The working group will review existing assumptions and

how the bureaus review and update the assumptions to stay in line with current economic conditions. Additionally, the group will explore how the models are used within DOI to inform policy decisions, as well as identify gaps or additional factors that should be included in the models.

In response to Ms. Hague's presentation, RPC members asked the following questions and made the following comments.

- BOEM is moving forward with the studies from the previous recommendation and the goal for the larger study is to have results by the end of the year to inform the following lease sale. The focused study will likely be available sooner than that.

C. Tribal Energy Subcommittee

President Russell Begaye, Navajo Nation, introduced the subcommittee, thanked the members for their work in the previous months, and stated there would be one recommendation brought forward. Additional recommendations will be brought forward at a later time.

Subcommittee members shared updates and provided recommendations to the RPC in the following areas:

- TERA: Bidtah Becker, Navajo Nation Office of Natural Resources
- Model Congressional Statute: Prof. Monte Mills, University of Montana School of Law
- Taxation: Chairman Mark Fox, Mandan, Hidatsa, and Arikara Nation

1. TERA

Bidtah Becker introduced the recommendation coming out of the TERA working group.

a) Recommendation 10 – Secretarial Clarification

The Secretary should issue guidance that clarifies what items are not inherently federal functions and therefore, appropriate for tribes to manage in a Tribal Energy Resource Agreement (TERA). (For the full language of the recommendation, see Appendix A)

Tribes are authorized to enter into a TERA, as authorized under the 2005 Energy Policy Act. This authorizes a tribe to develop and approve their own leases, business agreements, and rights-of-way for a range of activities related to the development of energy resources, without requiring secretarial approval for each agreement, ROW, or lease. No tribe has yet to successfully enter into a TERA; however, six tribes have requested pre-application meetings. What is an "inherently federal function" is undefined, which is a hurdle for development. The recommendation identifies seven areas for DOI to consider and issue guidance as "not inherently Federal functions." *(Additional information can be found in the meeting materials in Appendix A)*

In response to Ms. Becker's presentation, RPC members asked the following questions and made the following comments. *Responses from Ms. Becker and other subcommittee members are indicated in italics.*

- Would there be unintended consequences? *The issue is what is inherently federal and implementing the regulations of the 2005 EPA Act. These are functions under a TERA, so legacy issues would not be affected. This recommendation would clarify "inherently federal functions" and what the tribes can move forward on. On a practical matter, when funding gets low, implementing certain programs becomes challenging. We addressed that and did not want other concerns to be brought into this recommendation.*

Mr. DeVito asked if there were any objections to the recommendation. Hearing none, the committee agreed to move forward with the recommendation.

2. Model Congressional Statute

Monte Mills provided an update from the Model Congressional Statute working group. The group would like to have more participants in the group, especially tribal participation. The working group is developing language beyond the Houston recommendations.

There were no comments or questions by RPC members following Mr. Mills' presentation.

3. Taxation

Chairman Mark Fox provided updates on the Taxation working group. Fort Berthold represents 2% of all oil and gas production in the U.S., and there are several issues which affect this production. A delay in rules has created a backlog for notices to proceed (which can take longer than 260 days), which then delays decisions regarding whether flaring is avoidable or not, and ultimately effects royalties. A big concern is how ONRR makes a determination on allowable transportation costs.

The Tribal Energy subcommittee has taken the position that tribal energy development is being impacted by dual taxation, an issue brought up in Houston. There is disagreement on how income derived from tribal lands should be taxed in order for energy development there to be competitive. An internal rule stating property taxes are to not diminish tribal and trust royalties could resolve the issue. The \$2 billion from this lost from dual taxation could be spent on developing lands, infrastructure, and regulation. It has been noted that RPC may not be the appropriate forum to resolve this issue; however, an appropriate forum should be found.

There were no comments or questions by RPC members following Mr. Fox's presentation.

IV. Public Comments

Various members of the public took the opportunity to provide public comment during the RPC meeting.

Athena Christodoulou, NMSEA

Close your eyes. Imagine a world in which people forgot about gravity and they walk off cliffs. And they believe there is a finite boundary to the world and it is flat. Or that we can burn fossil fuels without suffering the consequences. Open your eyes. You have now come to the United States, a once great country who is now flamboyantly combusting fossil fuels at the expense of our future, your future, our kids' future. We must transition from fossil fuels. As to the flat earthers, my son has encountered flat earthers in college. As to people walking off buildings, people walked off buildings when Superman first came out. So let's get real, scientists have confirmed. My first job was teaching thermal nuclear power for the Navy. I am a retired commander, environmental engineer, and mom. What you do here in this committee will have future ramifications. Think very deeply about anything that encourages fossil fuel extraction. I use fossil fuels to heat my home and water. I used to use it to drive my cars. I'm part of the problem. Don't make it worse. Don't make it too cheap. We have to transition as fast as we can. Your committees can make the difference. Ditch the fossil fuels in our personal lives, economy, and everywhere. Thank you.

Editor's note: Additional detail is provided in Appendix B, which contains Ms. Christodoulou's full public comment.

Mark Fox, Chairman of Mandan, Hidatsa, and Arikara Nation

We are located in western North Dakota, in the heart of the Balkan and Three Forks play. We've been involved for 10 years in oil and gas development. Native name is Sage Man. It is an honor to be here this morning. Not only among the RPC and the things we are doing here, but also with the amazing and great tribes and in their homeland. Happy to be here and to walk Sandia Peak last night. I have 16,000 members to represent. Basic message to bring to committee, as I also sit on the tribal subcommittee, is the same message we've shared with the Whitehouse, this administration, with Congress, and our own state. Thirty percent of non-renewable resources in the United States are in Indian country. If the goal is development of that 30%, it has to be done in a particular way. It can't be forced or compromised on tribes. Things have to be done in a particular way in order for Tribes, such as ours, to endorse that development. Two factors of that particular way – rule of law, rule of energy development within our boundaries. Tribes have to have primacy. Anything that we pass, the policies that was, regulations we adopt need to defer to tribal laws. We know how to take care and protect our lands. We know how to maximize our lands on behalf of our nation and individual members. That has to be a part of the construction of the laws from federal down to reservation lands. A very important part of that is, although tribal lands are federal lands they are held in trust. Tribal lands are not federal public lands. They are trust lands. They are starkly

different. Second point, we have to be primary beneficiaries of that extraction of the valuable minerals in our lands, in the form of royalties, in the form of support and control of our development. We have a sovereignty model at the Three Affiliated Tribes. We aren't going to sit back and collect a few taxes in royalties. We want to be involved in the billions of revenues. We will partner with industry, but we are going to put ourselves as to benefit from that. There are other things I will comment on later, but that is an important part in Indian Country. We are at the table for a reason and that 30% is why we are here. Thank you.

Editor's note: Additional detail is provided in Appendix B, which contains Mr. Fox's full public comment.

Sister Joan Brown, MN Interfaith Power & Light

When I was inviting some people of faith to come to this royalty hearing, they asked me "who was the royalty?" This got me to thinking about the disparity of special interest royalty that seems to be focused on accumulating wealth at the cost of the common good. Our school children, future generations and the effects of greed in relationship to climate justice. I'm a Franciscan Sister, so these concerns are rooted deeply in me and I work with New Mexico Interfaith Power and Light. There are many people of faith concerned with this hearing, concerned about our oil and gas in the state and how it's done. They seek the common good and fairness for the people of New Mexico. New Mexico is almost last in poverty decade after decade. There are extractive industries in our state that is making millions and billions of dollars and is having no effect or coming to us as the common good. St. Thomas Aquinas said the common good is the goal of law and government. Today you are sitting here as representatives of law and government. The goal is the common good. James Madison also said this and it is in many religions as well. Contemporary Catholic teachings believe that the common good is the good of all people and the whole person. The human person cannot find fulfilment apart from the fact the he or she exists with others and for others. The goal of society is to obtain the common good. Pope Francis in his encyclical *Care of Our Common Home* would add our sister mother earth to this and that all creatures have a part of this common good. So, today we wear white as an SOS. SOS's are major alerts to grave danger or to save someone from death. Today, our SOS is warm because we face death on several levels. In our religious terms, we might say this SOS is about saving our souls. These are soul choices that you are making today. SOS for our sister mother earth, who cries as we lose our souls to a mentality of extraction to the point of extinction and climate change. SOS the children cry as they seek a properly funded education from resources that are being stolen from their future. SOS we cry to save our souls because the sickness and greed is wiping out what it means to be brothers and sisters here and in our country. The Old Testament Book of Amos states, you have my judgment to sell the righteous for silver and the needy for a pair of sandals [or fancy shoes]. You trample on the heads of the poor and you push the needy and common good out of the way. Please, answer this SOS that we the people of New Mexico faith have today with ethical and moral decisions for the common good.

Editor's note: Additional detail is provided in Appendix B, which contains Ms. Brown's full public comment.

Rev. Erika Simka, Mennonites and NM Interfaith Power and Light

I'm the pastor the Albuquerque Mennonite church. Mennonites are known for many things, including our impeccable fashion and our outstanding jams and jellies. We are also known for the national and international stores known as Ten Thousand Villages. Ten Thousand Villages was founded by Mennonites concerned about loving one's neighbor through responsible and appropriate compensation in exchange for goods. Mennonites and generally people of all faith affirming the dignity of all creation and people. One way to communicate value is through fair financial compensation. A good deal for all must be a good deal for all. The bottom line should be, when we are motivated by love for our neighbors, as taught by every major world religion, and if you are not religious, it is taught by Mr. Rodgers, loving neighbors broadly defined as people and creation near and far means neighbor comes before money. However tempting a good deal might be, conscious demands fair compensation. As communities depend on royalties, it is a matter of fair trade. To pay appropriate amounts, a fair share back to communities. Public lands must benefit the public. To paraphrase a quote by James Baldwin, we are responsible to and for each other. We are responsible to the future and not to the bank. Thank you.

Camilla Fibelman, Sierra Club

I'm the director of the Rio Grande chapter of the Sierra Club. We have over 30 thousand supporters in New Mexico and west Texas. I was thinking about the idea that might be unruly. Raphael might be the most unruly. We are here in defense of the rules. Sierra Club believes strongly in the role of the public to participate. We thank the committee for a public forum to work on an important issue. Our biggest issue is in the committee composition. It doesn't include members of the community to look out for taxpayers. It doesn't include people who are concerned about the implications of climate change, but also what the royalty impacts are for states like New Mexico. New Mexico pays in federal royalties than any other state in the country. This is a big issue for us and has a lot of implications for people like my son. I'd like to give three examples of rule makings that we participated in in good faith. The first was an attempt to review the coal extraction off public lands royalty rates. Many of us traveled up to Farmington, we studied the issue, and looked at the question of resale of coal from one company to another related company to keep royalty rates low. Which seems unfair and doesn't seem like a good business practice. Or that it's fair to the people who live in the state where the land is or to the federal treasury. We've paid close attention to the BLM and EPA methane rules, and view those rules to be complementary. To have oil and gas extracted and wasted is not fair from a royalty standpoint. There are no royalties paid on the wasted natural gas extracted off public lands. That doesn't seem fair, especially since there are 11 local companies that do methane mitigation. There was an ironic article in the Farmington Times a few years ago. The local oil and gas association said

the rules are terrible and will put us out of business. The next featured speaker said they would install methane capture technology on to your facility for free and split the profits. In states like Colorado, industry is willing to do this. It hasn't but anyone out of business or slowed production. It has led to fair payment of royalties on something that belongs to all of us. You might say these are rules from the last administration. Elections matter. Rules are changing. The data and background that is used to justify rolling these rules back doesn't make sense. It says we want to measure impact methane on U.S. rather than globally. That isn't how global warming gasses work. They don't respect federal boundaries. There are costs to all of us, climate related refugee situations and more. I tried to think about your role and what you might think of me as I was standing here talking. I know that you feel like you are playing an important role for our country. That you think you keep the lights on, that you are keeping our water warm, that you are keeping people employed. And we are grateful for that. We need to be able to have a conversation. I don't want to be part of divisive country. I'm concerned about what it will mean if there aren't enough natural resources for him in the future. If we can't get together and talk without finding ourselves in silos that we don't really exist in, we probably have a lot more in common than we think, we can come up with solutions. I hope you will leave today knowing that we care and we know you care. We hope the committee will represent a more balanced approach to looking at royalty revenue for our country. Thank you.

Dan Bucks, Former MT Director of Revenue

Good morning, my name is Dan Bucks, former Montana Director of Revenue and former Executive Director of the Multistate Tax Commission. I'm in awe of the people who spoke before me. I appreciate what they said. I also appreciated opportunity to speak previously with the coal working group. Nonetheless, I would request this committee to reconsider through a meaningful public process the recommendations approved on February 28. Those recommendations, the product of closed subcommittees, were publicly released only a few days prior to the meeting, preventing thorough analysis and submittal of written comments by the public before action was taken. Further, time for public input at the meeting was inadequate for any detailed input to the committee. Improvements made for this meeting don't remedy problems of action at the last meeting. There are serious issues this committee did not consider regarding the February recommendations. I will be attaching an analyses prepared since that meeting for four of these recommendations for issues not considered for which there wasn't time given the short notice on the posting of the proposals. Without an adequate public process, February actions are simply illegitimate and should be reconsidered. As to new items, the PAC subcommittee proposal to repeal onshore oil and gas measurement orders and replace them with industry procedures is unacceptable industry control over government decision making. Delegating Interior's authority to private industry groups whose decision making is neither accountable to nor open to the public is bad public policy and legally questionable. Government agency presence in the industry standards program does not cure the delegation of authority problem and still leaves public who owns the oil and gas in the dark and out in the cold. The committee should remember

that excessive industry influence has played a major role in the recurring scandals of fraud and abuse regarding federal minerals, even as recently as a decade ago. Proposals to expand industry influence over mineral policy will justifiably be greeted with public mistrust and resistance. The justification for the proposal makes sweeping assertions that the existing order are burdensome and threaten unitization and commingling agreements. Yet, there is no empirical evidence presented in the materials to support these assertions. There is not even a description of or link to industry standards to be adopted under this proposal. Without a clear public record and reasonable basis being established for this proposal, it should not be approved at this time. I would also note that the proposal to allow for rate relief in certain offshore oil situations, and this is also done in onshore situations. This whole idea of rate relief for otherwise non-economic production is a policy decision that ought to be more carefully analyzed and reconsidered. It isn't clear that this is an acceptable idea in free market terms. Thank you very much.

Editor's note: Additional detail is provided in Appendix B, which contains Mr. Bucks' full public comment.

Toni & George Loesig, Citizen

Nothing we can say that can be said as well as what has already be said. Put us down as ditto.

Don Schreiber, NM Rancher

I'm uncomfortable with this speaking position. I feel like I'm talking to part of the people and excluding the rest, and we wouldn't want to do that. I'm a rancher from Rio Arriba County. I'd like to recognize Chairman Begaye, Chairman DeVito, President Fox. For a show of hands, who lives, as their residence, with an oil and gas well that is leaking, venting, or flaring? Daniel, Sam, George, President Fox, am I missing someone else. I believe that makes an obvious statement, and I could stop there, about where these impacts land. Because, I also raise my hand as a rural rancher. However, I have prepared remarks, which I will leave. I'll abbreviate to say, I met Mr. DeVito in his office in Washington, D.C. in April. I took with me County Manager Tomas Campos and a formal tribal official from Utah, Sam Dee who I call my brother. Manager Campos has 8,000 wells in Rio Arriba County, which is one of the most productive oil and natural gas areas. Sam Dee, there are over 700 wells in his very small community of Montezuma Creek, Utah. My wife and I have 122 wells in or around our property in northwest Rio Arriba County. I can see 10 wells from ranch house. We went to the chairman's office, to Mr. DeVito's office, to offer our help and assistance, so that RPC and he can do his job as the special council for energy, appointed by President Trump, could have the benefit of what is like for us who live with oil and gas on a daily basis. To what it looks to us when federal energy policy hits the ground. Mr. DeVito did not accept our offer of assistance, and today we have more of this administration's talk of ignoring the impacts of oil and gas and these policies as they hit the ground. And that is the ground that we live on. That April meeting did not go as I had hoped. At one point he said, "now, don't take this

personally.” I interrupted him to say, “Mr. DeVito, whatever you are going to say, how can we not take it personally?” Manager Compos is unable to get even a simple audit or an accounting of the oil and gas produce in his county. He doesn’t even know the royalties and taxes that should be paid. He is trying to ensure his county’s basic services, like law enforcement, hospitals, schools, and the health of its citizens are met. Those services are already pushed to the brink before any talk of cutting royalties or selling leases for repentance. Sam Dee, who once lived in a healthy community now lives in monoculture of oil and gas. He doesn’t know what royalties should be paid. He doesn’t know what comes back to him to help replace his culture that has been destroyed along with his environment. Today we make our offer again. Let our collective voices be heard in this committee. Hear what we have to say. Thank you.

Editor’s note: Additional detail is provided in Appendix B, which contains Mr. Schreiber’s full public comment.

Cory Kief, Crosby Tugs, LLC

Hello and good morning. It’s nice to be out here in New Mexico. I’ve never been here before. I’ve traveled the world and seen a lot of things in my life. It’s wonderful to come out here and see such a nice landscape. It’s really beautiful here. I work for a tugboat company and dredging company in Louisiana. The biggest impression that folks get is you are talking about big business and its public companies and its board of directors. We are a family company. I’m also the president of the South Central Industrial Association, which represents companies that are owned by families. Families have their life investment into these companies. I appreciate everything that you all have to say over here today. But we depend on oil and gas for a living and have been doing that since the 40s, 50s, and 60s. Some people have jobs, careers. This is our way of life. We have millions in assets that are rotting. Thousands of people out of jobs. And it is because of the environment that we are facing these days in the oil and gas sector. I mentioned before that I’d been all over. North Sea, Persian Gulf, Atlantic Ocean, Pacific Ocean. This isn’t something that isn’t just going on in the U.S. We need the oil and gas industry. It’s our way of life. We are looking at production levels and see that production levels are low. Looking at drilling and see that drilling isn’t where it should be. Looking at leasing and see that is too low too. I’ll take my tugboat hat off for a minute and put my dredging hat on. We invested in to dredging because the state of Louisiana has a coastal and restoration plan, which his directly affected by the amount of royalties paid. We have GOMESA, which is a piece carved out of royalties for our state that goes to coastal protection and restoration. If you connect these dots, we love are marshes, estuaries, wildlife, hunting and fishing. We treasure these things. We also treasure oil and gas. We are living proof that these things can exist hand and hand if they are handled the right way. I have friends and clients in oil and gas. They say they won’t come online for production. There won’t be enough drilling. There won’t be enough leases sold. There won’t be enough revenue raised to do all the things we are talking about if they don’t get some relief. If you look worldwide and globally and understand how that competition...I’m being cut off so that is it. Thank you for listening.

John Bradberry, State of Louisiana

Good morning. Committee members, thank you in advance for listening to what I have to say. I'm the executive assistant to the Governor of Louisiana for coastal activities, and I chair the Coastal Protection and Restoration Authority. Ladies and gentleman of the committee, we have a coastal crisis going on in Louisiana. Since the early 1930s, we have lost 2,000 square miles of wetland. That is equivalent to size of Delaware. We slowed it down in the past decade. Slowed it to about a football field every hundred minutes. If you include the end zones, that is 25 acres a day of wetland we are losing. Since Hurricane Katrina in 2005, we've aggressively adjusted our situation to the point where the federal government came in after Katrina and invested \$14.5 billion in protection infrastructure in and around southeast Louisiana. They told us that, if they are going to make this investment, that means you have to have a plan to protect south east Louisiana and the entire coast. So, we developed a 50-year, \$50 billion master plan. We don't have \$50 billion today, but we do have revenue flow streams that can help us get to the \$50 billion mark. One of the flow streams is GOMESA, the Gulf of Mexico Energy Security Act. That flow stream is based on royalty rates. There are discussions going on about whether the royalty rates should be reduced or adjusted. From our perspective, if you reduce that royalty rate, then we see less revenue. Which translates to less projects we can do, which translates to less protection and restoration of our ecosystem that we have in place. We also realize that if you reduce rates, you increase activity, you increase production. We are in a quandary. If we support royalty rate reduction, what does that do to our revenue stream? And if you increase it, what does that do to the economic stability that drives our state? We have a keen interest in the discussions and recommendations developed by this committee that relates to royalty rate adjustments. We currently have a study in motion that hopefully helps us rationalize what happens to our flow streams if you increase or decrease royalty rates and the corresponding activity that might take place relative to that increase or decrease. When we are done with the study, we will turn it over to the committee for consideration. We ask, as you go through and rationalize the effects that it has on production and activity levels, that you keep GOMASA flow stream in mind, that you keep the state of Louisiana in mind, and the viability of our coast in mind. Thank you very much for listening.

Pamela Eaton, The Wilderness Society

I am with the Wilderness Society and based in Denver, part of energy and climate team. As you are considering your mission, I really hope that you will listen to the broad voices here and talk about and listen to the values they are bringing to the table. I hope you will consider expanding this table to include more of the voices you are hearing today. I also think a good start to listening to those voices is to reject the three recommendations from the onshore working group to limit BLM's environmental review and public participation in oil and gas permitting under the National Environmental Policy Act. Individually and together, these recommendations could shield thousands of decisions about oil and gas permitting from public participation and review. These

recommendations are part of a troubling process and we've heard people talk about that today. A troubling pattern of excluding the public from decisions about oil and gas development and cutting out the people most affected. We urge you to reject those NEPA-related recommendations. I believe those recommendations are outside scope of charter of this group. Which is to ensure the public receives the full value of the natural resources produced from federal lands and to provide advice on the collection of revenues derived from the development of energy and mineral resources on federal and Indian Lands. These recommendations about the scope of environmental review are not within that charter. The Department of the Interior has justified the exclusion of environmental public representation in part that it deals with royalties and not the environment. Yet, this is second time recommendations limiting the scope of environmental review and public participation have been brought forward to this committee and really try to constrain the implementation of NEPA. We recommend that you expand the membership of this committee to include a broader and more diverse set of public interest representatives in your ongoing deliberations. There are a lot of volunteers in the room who would be willing to do that. The Wilderness Society did submit a letter with partners outlining our concerns about this recommendation and about the royalty relief prior to this meeting and hope you will consider these recommendations and reject these proposals at your meeting today. It would be a good start that these people's views are considered by this committee. Thank you.

Editor's note: Additional detail is provided in Appendix B, which contains Ms. Eaton's full public comment.

Delora Hesuse, Allottee, Libbrook & Nageezi Area

Thank you for letting me speak today. I am an allotment owner in the Gallup formation. I'm here today to speak on behalf of family, extended family, and community in support of oil and gas. We are in support of the continued development of our current leases. We got the opportunity to lease our allotment. We want to set the record straight and ask these environmental groups to stop speaking on our behalf against oil and gas. We did not ask these groups to do so. I do not appreciate the representatives telling me how to live and what to wear. This is how I feel. I want you to know that this is what they have been doing to us allottees when this thing first started. Oil and gas provides financial, stable, and current employment and income for our families. BLM does a good job of keeping us informed about ensuring the regulations are followed when leasing and the APBs. Oil and gas companies have done a good job keeping me and my family, and other allottees updated and are available to answer questions when we have them. My family and I frequently get updates via telephone or in-person from the oil and gas producers that have leased our minerals, formerly WPX. Our health and water hasn't been affected by oil and gas development. I have taken a well pad tour by WPX Energy tour and they explained how it works and what it does. I know for a fact that safety is the producers number one concern when developing our minerals. Our roads have improved due to the oil and gas activities, to this huge benefit and we are thankful for it. Our leases are Indian allotted leases, not Navajo Nation leases. We own these leases,

not the tribe. People need to respect that these leases are ours and we have a right to lease or not. And we said yes. I want to also state that new when making these laws within the Department of the Interior, please think of us, think of us allottees when doing so. Thank you for hearing me out and listening.

Cherie Harms, Leonardite Products, ND

I'm with a small mining company based in Williston, North Dakota. We mine leonardite, which is an oxidized lignite. We are not associated with coal. We are not used for energy. Our primary customers are fertilizer companies. We operate mining on private surface land with a 1964 lease. Since 2010, we've wanted to resolve this matter and BLM said talk to ONRR and suggested we talk to BLM. So, we've been going back and forth for a few years now. I'm very encouraged by this policy meeting because I think that we can reach a solution if we could examine the benchmarks and the processing allowances that are being applied to leonardite. Which, admittedly is a square peg that does not fit in a round hole. So I appreciate this and I know we are all under time, so thank you very much.

Editor's note: Additional detail is provided in Appendix B, which contains Ms. Harms' full public comment.

Amy Warner, Enterprise Offshore Drilling

I'm VVP for Human Resources for Enterprise Offshore Drilling. I wanted to use this opportunity to tell our story and talk about job creation as a result of the oil and gas industry. We were founded in January 2017. We started with five employees. Today we have over 400 employees. Our employees live along the Gulf Coast, primarily in Louisiana, Mississippi, and a few in Alabama, Florida, Texas, and one guy that drives down from Nebraska for his hitch. We bought 10 jack up rigs in January 2017. Today we have two of those working. We also manage two others, meaning we staff them and conduct the drilling operations for a partner of ours. We are also on a TLP in deeper water. We are working on reactivating, and that rig should be going to work by the beginning of July. Talking economics, when we put a jack up drilling rig to work, that creates 65 direct jobs. The cost of that from a wage and benefits standpoint is \$7.6 million a year and that generates \$1.8 million in tax revenue, including federal income tax, state income tax, and FICA. If you look at our average salaries, they are double the median income in the communities our employees live. So, you can just imagine the economic impact within those communities and employees being able to make good salaries, provide for their families, and put that money right back small, rural towns that they live in.

Samuel Sage, Counselor Chapter

[speaking Navajo] Anyone understand that? That's how we won the war, World War II. My father, Corporal Andy Sage of the United States Marine Corps and Navajo code talker. I'll repeat his words, "you go abroad defending your country and then come back and have to fight your government for your homeland because they keep taking and

taking and leave you nothing.” Why are you all considering the little amount of royalties that my relatives, that myself, receive. This whole thing is nothing about greed. Just one person getting all the money. Industry and government keep taking from our land. Homeland that is rightfully ours, with nothing return. All the BLM land that is leased around us, our community of councilors gets nothing. We are left with all the impacts, the negative ones. Today our community members are suffering from illness and cancers. Our own tribal government has even failed to step forward to assist us. So we, the community members, have formed our own health impact assessment committee. We are having to do our own assessment to find out all the impacts that we rightly know comes from the industry. All the destruction. We do understand that in '66 the Nixon declared within our area an energy sacrifice zone. Why? You put us out on this reservation and now you are taking everything from under it. I think this meeting has been located in the wrong place. The makeup of the committee, wrong people. I tell my senator that he has been bought and paid for by industry, and it is rightfully true. Some of our elderlies do receive royalty payments. Those royalty payments that they spend coming here to Albuquerque, 130 miles from where we are at, just to make appointments. So, all we are asking is, instead of decreasing royalty payments, think of increasing since you are taking it from our land. Thank you.

George Waritz, Tri Chapter Council

Chapter president and tri council chairperson. Back in the 1800s, the government came in, got all the Navajos together, drew lines, and said this your land. They put us on reservation. Back before then, there were no boundaries. We roamed all over. The government comes back in and is taking. What’s wrong there? I know we had allotments out there. Few people benefit. I’m an elected leader. I’m a community leader. People come up to me and say, “How are we going to fix our roads? Where is the public safety? Where’s the hospitals? Where’s the nearest grocery store? 2013, close to \$13 million was taken out from the councilors area. 2014, \$14-15 million was taken for oil and gas production. None of that money has come back to the community to help with infrastructure. We have families that don’t have electricity and running water still. Our roads are bad. There is no money coming back. There is a little going to the state, coming back to help the nation, but that money stays in Wounded Rock. None of it is coming back. I’m telling you, somehow, we need to get that money back to communities, especially the Navajo nation. We are separate from the Navajo Nation, we share boundaries. We’ve come together as three communities, call ourselves a tri-chapter to address these issues. Not only oil and gas wells, but they are also mining in that area. They are running all over us, no respect from companies. That is what we need from oil and gas production. I say again, listen. Come out. You need to be out there to see what is going on. Thank you for your time.

Daniel Tso, Tri Chapter – Allotment Heir

[speaking Navajo]. In that aspect, I ask this group to listen to the minority members. Let their words enter your ears and affect your brains. To keep the royalty rates as is, leave it alone. We are in the heart of abject poverty. We are a very marginalized community.

The royalty monies that come to the residents end up in Farmington, Rio Rancho, Albuquerque. Why? Because there is no infrastructure. If and should a major environmental event occur, there is not even facilities to deal with that. When a well is drilled, 200 truckloads go in on what was formerly community roads, just school bus rounds. School buses have to give usage when you have 200 truckloads of water coming in. And who knows how much sand and how much chemicals. We are learned in high school science that for every action there is an equal and opposite reaction. Guess what? Two hundred truckloads of produced water. And by the industry's own admission, when one barrel of oil is produced 250 barrels of water is also produced. Allotment owners aren't being paid for that loss of water. The other is mother earth is the safest place for this oil. It is encapsulated and held onto. Why are we doing fracking, post-haste, and letting the hazardous methane, hydrogen sulfides, and associated gases come up? We have a citizen science group. We have air monitors. On May 2, we had a dangerous event. It is documented on a national air quality infrastructure website. There are health and safety impacts. The environmental justice issues are huge. Keep the royalty rates the same. Thank you.

Sherry Begaye

[Speaking Navajo]. Thank you for the opportunity to voice my concerns and comment. As I stand before you in many facets – allottee, mom, employee of the Navajo Nation Department of Health, and an elected official. There are several things I wanted to bring out. First thing is the health issues. As a health care worker, I've seen increases in cancer in our area. There is an increase in asthma, respiratory diseases, lupus, all of those things affecting our people now. If you can take a trip back with me, when I was small I used to wake up in the morning, sun comes up, air was clean and crisp. When it rained, it rained so much, the arroyos filled with water. Trees were high. Grass was really growing. We had an abundance of vegetation and water. Now, people wake up to egg smelling air. Which is not something that you want to wake up with. Headaches, sinuses, all those things. So, it affects the environment. The steel horses that are out there. It affects air, water, and vegetation. The law of nature is off by so many months now. We are seeing radon and lead increase in the home. These are what we are finding now. There is a saying in Navajo: what you take out, you put something back. You replace it with something. Last thing, practice courtesy. If you want to come into my backyard and do something within my land, my area, and my property. Tell me about it. Let me know. Fill me in. There is such a thing as informed consent. Thank you very much.

Donna House, Member of the Navajo Nation

Botanist consultant in biological and cultural diversity for last 30 years. I'm honored to be here with the President of our Navajo Nation, Mr. Begaye, and Becker, who is head of our natural resources. I have worked on the Navajo as a botanist in the early years and I have spent a good deal of my life living and working on the Colorado Plateau. I have worked for BLM before FLIPMA and before wilderness was established. People who live there are Navajo people or other tribes that have lived on there for thousands of years. That has history. We have lived with oil and gas and mining of coal for more

than 50 years. People that live next to oil and gas have not only lived with the pollution, but we have. Our whole generations. There have been no health studies from Indian health services or industry to look at the impacts of our culture or to the health of the people they have mined and drilled near. To look at the water or all the elements is important. It should be part of your analysis when you do a royalty. We have royalties that have been in existence for 100 years and still in bottom 12.5. We have abandoned mines. We have oil rigs that have been abandoned. Pollution is there. Who pays for it? If BLM's role is to constantly give breaks to big industry, that is a big issue. If that isn't being used to clean up? Where is the royalty? You don't take any analysis. I have looked at the people and their background. I don't believe that equity is here. You are not looking at impacts that exist. There is data out there that you need to look at and consider as part of this committee. You aren't communicating with people that are the experts. You aren't transparent to the public. This is our money. As a tribal member and as a citizen of the U.S., I've been there and have known the ecological life I have lived in the area I'm from. I've seen ecological poverty being developed by industry. I've seen the human poverty being developed by industry. This hasn't changed and it has to. Our people depend on the environment for culture, for medicines, for sacred sites. And that needs to be a part of your calculations when you start doing royalties. NEPA is being bypassed. Oh my God, the Endangered Species Act. That is important as a citizen and tax payer. Thank you.

Dan Fine, San Juan Basin, NMT

I'm speaking to the committee just briefly without any affiliation to a group or advocacy organization. I served in Bush administration and the Naval petroleum reserve section of DOE and DOD. I've studied reserves of petroleum in that period and got into the history of this committee. Twenty years ago, you were very active in terms of royalty relief when the price of oil went to \$10/barrel in 1998. And when the threat of that, because gas follows oil, the loss of \$1 million barrels a day of marginal oil, called stripper oil. I'm calling attention to what I see coming. I'm representing the sentiment of San Juan basin. New Mexico is two petroleum states. One is in the south and southeast, Permian and Delaware basin. Second has been around for 102 years and is San Juan basin. For tribal members, the San Juan includes Southern Ute, Navajo, and Apache. I'm calling attention to get into record that maybe in your forth meeting, someone can look at history and the future. President Trump has two tools for oil and gas industry. You are one of them. And you are the chief component in the next 2-5 years. The second is uranium coal. He is following a different strategy. Royalty rate will have no effect. He is using, for the first time since the 70s, the Defense Production Act to allow for uranium relief and for coal before shutdowns occur. The note to the committee is to look at something you may have missed and that is oil and gas makes little sense in next 20 years. For natural gas, if you look at royalty rate impacts on oil and gas basins, what should be price sensitive? Should this committee be price sensitive in terms of natural gas? As I speak of San Juan basin, the owners are small, some big players, mostly small going back to 50s. The last price for natural gas, indexed, was \$1.72 for 1,000 cubic feet. This price of gas in last 10 days has made small producers at the edge of shutting down or abandoning wells. This

is the life of the basin. This commission has a historic value. You were the first, in memory, to come west of the Mississippi where the national government owns and operates lands. Can you look at the basins themselves? One operator since 1956 with 1,300 gas wells, all gas in the basin no oil, he said go to Albuquerque and tell them I can drill if you give us at 10% royalty reduction. That's all I have.

Terry Sloan, Southwest Native Cultures

Thank you, Mr. Chair, oil committee members for being here to listen to us. I'd like to recognize president Russell Begaye, chapter president Juarito, chapter official Sam Sage and Daniel Tso who made beautiful statements for us today. In a time of climate change, the worldwide concern for mother earth and her environment is looking to protect our one and only home, mother earth. And not finding a cheaper way for large companies to drill, strip, and mine here. We should be looking at renewable energy development, which is where the rest of the world is headed...a responsible addressing of mother earth, and our needs, and your needs. Through my organization, Southwest Native Cultures, I am an accredited member of the United Nations. I'd like to make a quote from the United Nations Declaration on the Rights of Indigenous Peoples, a doctrine that says prior informed consent. It is also beginning to be a human rights doctrine at same time. Thank you for listening to that consent, possibly. I'd take that to heart and go out and listen to us. There are over 900 tribes in the United States, not just the 507 federally acknowledged tribes. Please listen to us. I also believe that free, prior, and informed consent also applies to all of us here, not just the tribes. Looking at the future for energy needs, the United States is falling behind. It may take some time for us to catch up. As we all know there are pushes towards renewables throughout the whole country. Look at Paris accord and how that has taken effect, and how Europe, Canada, and others are looking to reduce carbon emissions to make that 2% change. We could invest in our renewable energy future. We can invest in our renewable energy infrastructure that can create and sustain jobs. Solar power plants need to be operated like coal plants, and that means jobs. High level engineering jobs and high-level jobs to maintain it. The Royalty Policy Committee should keep an open mind to protect mother earth and her inhabitants, but not by making it cheaper to raid her resources. Thank you.

Ryan Alexander, Taxpayers for Common Sense

Thank you for extending the time. Since 1995, TCS has released research and analysis documenting millions lost in taxpayer revenue, due to an opaque royalty system that under values our natural resources. The Royalty Policy Committee has a unique opportunity to address the long-standing problems plaguing our system and help get taxpayers what we are due. I'll turn to a few places the committee should focus. Ninety percent of the natural gas vented or flared on federal lands in the last decade did not incur a royalty. With the newly proposed BLM rule to address the royalty treatment of lost gas could make matters worse. We urge the committee to fully examine the issue of methane waste and taxpayer losses. Appropriately valuing our resources is a great concern to TCS. Last year, ONRR repealed the valuation rules, resulting in reduced

royalty collection. At the last meeting, this committee endorsed recommendations that exclusively represent the industry's objections to the rule. We urge the committee to revisit this issue. At the Houston meeting, I raised concerns about the committee's decision to reduce royalty rates and were pleased to see that DOI had not pursued lower rates. We urge the committee to instead apply an 18.75% rate across all offshore and onshore leases. At the end of fiscal year 2017, half of all onshore acres leased for oil and gas production and some 70% of all offshore oil and gas leases sat idle. Allowing companies to hold onto land prevents their use for other economically viable purposes, including oil and gas development. RPC should examine how BLM could alter its rental pricing practices to better encourage oil and gas development. We are not opposed to another review of the oil and gas measurement standards. More justification is needed to explain why a review is necessary when current standards are based on a 2007 RPC recommendation that included extensive recommendation to the API and GSA standards. The committee must demonstrate a need for a review before automatically reverting industry standards. Finally, the committee's new recommendation on DOI's royalty relief process should examine how new technology could factor into the justification for royalty relief makes sense. It is imperative that any reviews of the process or subsequent changes should not lower standards for granting royalty relief. We hope going forward the committee will be able to address these and many other issues and the royalty policies associated with them.

Editor's note: Additional detail is provided in Appendix B, which contains Ms. Alexander's full public comment

Jayne Hein, NYU

I am the policy director for the Institute of Policy Integrity at the NYU School of Law. The Royalty Policy Committee is not following its charter, which directs it to ensure that the public receives the full value of all natural resources from federal lands. Instead, the committee seems to do the opposite. It is myopically focused on advancing the interests of fossil fuel companies at the expense of the public and our federal public natural resources. In one example, in sessions led by coal executives, the committee has focused on reinstating the coal valuation loophole in order to avoid paying royalties that are owed to the public. Royalties are a significant source of revenues for the treasury and states with mineral productions, which receive a share of federal royalties. They support schools, infrastructure projects, environmental protection, and more. Numerous studies show that increasing federal royalty rates would earn more income for the public. I understand today you intend to discuss Interior may be able to skirt the legal requirements of the National Environmental Policy Act, or NEPA, in order to accelerate drilling and exclude public participation. As well as whether to encourage more discretionary royalty rate reduction for late stage or challenging leases. These moves would open the door to environmental damage, government giveaways, and industry self-dealing. The government should not be in the business of propping up uneconomic mining and drilling and providing undue concessions to industry. As you heard in other comments today, where is the representation of the public interest on

this committee? Publicly owned lands in the United States contain many of the country's most iconic natural areas, as well as a wealth of natural resources. These taxpayer owned assets are on the verge of being given away for a fraction of their true value with the encouragement and cover of this committee. Ultimately, the committee's focus on energy dominance has translated into proposals that would reduce royalty payments, provide inefficient royalty rate reductions, and pave the way for drilling in our most sensitive public lands without properly compensating the American people for the use of their resources. This is not government by the people and for the people. It is self-dealing in plain sight. Thank you.

Editor's note: Additional detail is provided in Appendix B, which contains Ms. Hein's full public comment.

V. Wrap Up / Closing

Mr. Schindler reviewed the next steps and requested that written comments continue to be submitted ahead of the next committee meeting for the committee to review and address the comments. He also announced the meeting summary would be available online in 30 days, and the next RPC meeting will be September 13 in Denver, CO. There are three meetings scheduled for 2019, with a possible fourth. Mr. Schindler reminded everyone that comments can be submitted to rpc@ios.doi.gov and should be submitted by the end of Friday, June 8, 2018. Changes to recommendations will be posted online on the RPC website.

VI. Meeting Participants

Chairman

Vincent DeVito, DOI

Designated Federal Officer and Executive Director

James Schindler, DOI

Ex-Officio

Mike Nedd, BLM

Jim James, BIA

John Mehlhoff, ONRR

Kevin Karl, BSEE

Ex-Officio (Alternate)

Renee Orr, BOEM

Timothy Spisak, BLM

States

Colin McKee, WY

John Crowther, AK

John Andrews, UT

States (Alternate)

Lynn Helms, ND

Mark Edwards, New Mexico Legislative Council Service

Shawn Thomas, Montana DNRC

Tribal

President Russell Begaye, Navajo Nation

Councilman Christopher Adam Red, Southern Ute Indian Tribe

Tribal (Alternate)

Bidtah Becker, Navajo Nation

Academia/Public Interest

Roderick Eggert, CO School of Mines

Monte Mills, University of Montana Law

Van Romero, NM Institute of Mining

Daniel Rusz, Wood Mackenzie

Industry

Patrick Noah, ConocoPhillips

Stella Alvarado, Anadarko Petroleum Corporation

Matthew Adams, Cloud Peak
Marisa Mitchell, Intersect Power

Industry (Alternate)

Greg Morby, Chevron
Kathleen Sgamma, Western Energy Alliance
Gabrielle Gerholt, Concho Resources

Royalty Policy Committee Staff

Jennifer Malcolm, ONNR

Facilitation Team

Rachel Milner Gillers, Facilitator
Erica Wales, Facilitator

Members of the Public in Attendance

Mark Fox, Chairman of Mandan, Hidatsa, and Arikaran Nation
Juan Massey
Jim Steward, ONRR
John Barder, ONRR
Bonnie Robson, ONRR
Tim LaPointe
Josh Campbell, DOI
George Warito, Tri-Chapter Council
Don Hyde, PDA
David Curtis, Anadarko
Athena Christedoulou, NMSEA
Robert Satces, STRAC
Dan Bucks, Former Montana Director of Revenue
George, Citizen
Kelsie Micelson, Western Energy Project
Matt Kirby
Cory Kief, Crosby Tugs LLC
Amy Warner, Enterprise Offshore
Johnny Bradberry, State of Louisiana
Pamela Eaton, The Wilderness Society
Emily Hague, API
??, Crosby Tugs
Jonathan Wilson, Castex Energy
Krista Red, STRAC
Alex Thompson, Wilderness Society
Lisa Winn, XTO
David Rico, TGLC
Paula Metzner, Wilderness Society

Donna Hause, Member of the Navajo Nation
Adam Zornes, Enterprise Offshore
Cherie Harms, Leonardite Products
Samuel Sage, Counselor Chapter
Sherry Begaye, Torreon Chapter Officer
Albert Begaye, Torreon Chapter
Daniel Tso, Torreon Chapter
Barb Romero, Congressman Steve Pearce
Veronica Muestus, SUIT/STRAC
Camilla Feibelman, Sierra
Sr. Joan Brown, NM Interfaith Power and Light
Pamela King, E&E News
Sadie, Devils Spring Ranch
Susanne Schreiber, Devils Spring Ranch
Travis Suazo, Public Service Commission of NM
Leo Hoskins, NMOPUA
Cathy Newby, Drum

Members of the Public Participating Remotely

Aaron Weiss, Center for Western Priorities
Alan Kovski, Bloomberg
Amy Lunt, ONRR
Ariel Hill-Davis, Industrial Minerals Association North America
Ashley Morgan, Massie Partners
Ben Lefebvre, Politico
Brandon, None
Brian Schubiner, Tax Payers for Common Sense
Chris Greissing, IMANA
Chris Knight, Argus Media
Chris Mentasti, ONRR
Cindy Gossberg, ONRR
Diego Flores, Latham & Watkins LLP
EA Kim,CP
Eli Lewine, DAO
Elizabeth Klein, State Energy & Environmental Impact Center
Elizabeth Miller, Independent Journalist
Gina Liles, ONRR
Glenn Fischer, US Government Accountability Office
Helen Virene, ONRR
Herb Black, ONRR
Jason St. John, Cloud Peak Energy
Jay Cammon, BP
Jayni Hein, Institute for Policy Integrity at NYU School of Law
Jen Byers, Freelance Journalist

Jennifer Roth, Latham & Watkins
Jeremy Norton, Devon Energy
Jodi Petersen
John Fredericks, Legal Counsel for the Three Affiliated Tribes
Kimberly Jackson, ONRR
Kimberly Leefatt, Latham & Watkins
Liz Trotter, TG Results
Lori Leblanc, LMOGA
Lori Millstid, Ana Darko
Manuel Lozanos, State of New Mexico
Maroya Faied, ONRR
Mary Ellen Kustin, Center for American Progress
Mary Tharin, CA Dept of Justice
Matt Harlan, J. Connor Consulting
Matt Tabbert, US Government Accountability Office
Megan Hessee, ONRR
Meghan Trujillo, Office of Natural Resource Revenue
Michael Marchetti, ONRR
Mike Matthews, State of Wyoming
Nicolette Nye, NOIA
Peter Christnacht, ONRR
Robert Malandri, ONRR
Ryan Alexander, Taxpayers for Common Sense
Ryan Schubiner, Taxpayers for Common Sense
Samantha Seikkula, Latham & Watkins
Sara
Sarah Morris, ASK Productions
Seth Israel, Intersect Power
Shannon Anderson, Powder River Basin Resource Council
Sharon Clute, Eland Energy
Steve Feldgus, House Natural Resources Committee
Suzanne Cunningham, US Senate Committee on Energy & Natural Resources
Travis Annatoyn, Democracy Forward
Vijay Champ, EDP

Appendix A: Meeting Materials

Appendix B: Written Public Comment

Royalty Policy Committee Meeting
U.S. Department of the Interior
Sheraton Albuquerque Airport Hotel
2910 Yale Blvd SE, Albuquerque, NM 87106

June 6, 2018, 9:00am-5:00pm (MDT)

Domestic Conference Line: 1-888-469-0854 Passcode: 9724702

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AGENDA

Chair: Vincent DeVito, Chair, RPC

DFO: James Schindler, Executive Director, RPC

Meeting Goals:

- Report out from Fair Return and Value subcommittee
- Receive public comments
- Report out and recommendations from Planning, Analysis, and Competitiveness subcommittee
- Report out and recommendations from Tribal Energy subcommittee
- Timeline review

Meeting Materials:

- Agenda
- Fair Return and Value subcommittee presentation
- Tribal Affairs subcommittee recommendations and presentation
- Planning, Analysis, and Competitiveness subcommittee recommendations and presentation
- FY2018-FY2019 Timeline

8:30am–9:00am, Registration

9:00am-9:15am, Welcome and Overview

Call to Order

James Schindler, Designated Federal Officer / Executive Director

Welcome and Introductions

Vincent DeVito, Chair, RPC

All Committee Members

Agenda Review

James Schindler, Designated Federal Officer / Executive Director

**9:15am-10:00am, Fair Return and Value Subcommittee Presentation
(No Recommendations)**

- Co-Director's Introduction: Matthew Adams, Cloud Peak Energy
- Oil and Gas Payor Handbook: Gabrielle Gerholt, Concho Resources
- Index Pricing: Pat Noah, ConocoPhillips Company
- Marketable Conditions: Stella Alvarado, Anadarko Petroleum
- Coal Benchmarks: Matthew Adams, Cloud Peak Energy
- Audit: Greg Morby, Chevron

10:00am-10:30am, Opportunity for Public Comment

10:30am-10:45am, Break

**10:45am-12:00pm, Planning, Analysis, and Competitiveness Subcommittee
Presentation, Discussion, and Voting**

- Co-Director's Introduction: Colin McKee, State of Wyoming
- Non-Fossil and Renewables: Marisa Mitchell, Intersect Power
- Offshore Oil & Gas: Patrick Noah, ConocoPhillips Company

12:00pm-1:15pm, Break for Lunch

1:15pm-2:45pm, Planning, Analysis, and Competitiveness Subcommittee, Cont.

- Onshore Oil & Gas: Kathleen Sgamma, Western Energy Alliance
- Alaska: John Crowther, State of Alaska
- Coal: Matthew Adams, Cloud Peak Energy
- Studies: Emily Kennedy Hague, American Petroleum Institute

2:45pm-3:00pm, Break

3:00pm-4:30pm, Tribal Energy Subcommittee Presentation, Discussion, and Voting

- Co-Director's Introduction: President Russell Begaye, Navajo Nation
- TERA: Bidtah Becker, Navajo Nation Office of Natural Resources
- Model Congressional Statute: Prof. Monte Mills, University of Montana School of Law
- Taxation: Jackson Brossy, Navajo Nation Washington Office

4:30pm-5:00pm, Wrap-up, Timeline, Conclusion and Next Steps, Adjourn

**Planning, Analysis, and
Competitiveness
Subcommittee
Recommendations**

Subcommittee Proposing Recommendation: Non-Fossil Working Group (PAC)

Recommendation: ENSURING A CONSISTENT OFFSHORE WIND SUPPLY

The Secretary shall plan a wind leasing program to bring at least twenty additional gigawatts from offshore wind to the United States over the decade beginning in 2024. This goal shall be achieved by leasing at least two gigawatts annually through at least four lease sales on the United States Outer Continental Shelf (OCS) of at least five hundred megawatts each.

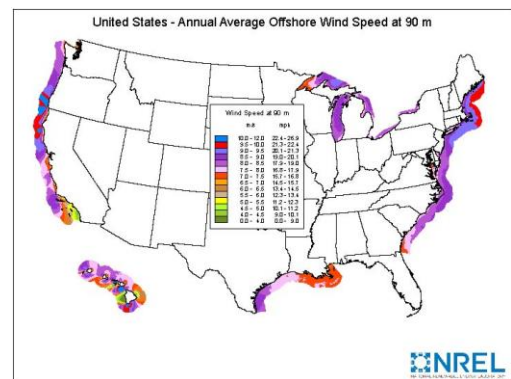
STAKEHOLDER EDUCATION – Prior to beginning the program, the Secretary shall establish a stakeholder education and engagement process to ensure the leasing program is an open and transparent procedure that allows all stakeholders with interests in the OCS an opportunity to comment and engage prior to the leasing process. Stakeholders include, but are not limited to, States and Territories, the Department of Defense, commercial and recreational fishing, United States Coast Guard, maritime transportation industry, and offshore oil and gas. This process shall be a supplement to the regular public review and participation periods related to the environmental reviews related to offshore energy development.

Nature of change: Secretarial Order

Background:

America’s energy future demands an aggressive “All of the Above” energy strategy in the OCS. This includes the responsible development of offshore wind power to support the energy needs of our coastal communities. This development will spur investments in local economies -- creating job growth and avoiding the need to export hard-earned energy dollars outside the region.

So far the federal government, forward-thinking state leaders, industry pioneers, and engaged stakeholders are focusing on



this immense energy resource. The first handful of leases offered by BOEM has put in place leases for the first generation offshore wind, which is generally enough to meet the market demand (supported by state policies) through roughly 2030. However, that market demand is expected to grow, requiring the next generation of leasing and a commitment to a broader plan and the next generation of investment.

Harnessing and engaging this industry requires a significant commitment from the agencies responsible for leasing and opening the OCS. There should be no doubt about the amazing resource available in the US both in the Atlantic, Gulf Mexico, the Pacific Coasts and our Nation's territories.

Experience from Europe has shown that an industrial commitment of two gigawatts of development is necessary to establish a significant and competitive supply chain for the offshore wind industry. In order to ensure that the benefits and opportunity for development is spread across the US OCS the Secretary shall conduct at least one sale in each of these four areas annually:

1. North Atlantic, from Maine to New Jersey;
2. South Atlantic, from Maryland to Florida;
3. Gulf of Mexico and Atlantic Territories, from Florida to Texas, including the territories of Puerto Rico and United States Virgin Islands;
4. Pacific, from Washington to California, including Alaska and Hawaii, and the territories of Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

Analysis:

This level of federal commitment, planning and investment of resources by the Federal Government, will spur follow on investment from States, industries, and researchers nationwide. Too often major energy projects, particularly in new areas, suffer from a "chicken and the egg" syndrome. For offshore wind this means no leasing, without power contracts, but no power

Point of Contact: Tim Charters, tcharters@noia.org; Randall Luthi, rluthi@noia.org

contracts without leasing. By ensuring that the Federal Government is making an active effort to plan, prepare and initiate leasing of areas of the OCS, the Department of the Interior creates an important benefit of signaling that the Federal resources are open and available for investment and development.

Considering that a single lease can take as long as 5 years to prepare and plan prior to an actual lease sale, initiating a plan now to begin in 2024 puts us right on schedule for kick starting an American energy future with offshore wind all over the US OCS.

Possible Language of Secretarial Order:

Subject: Supporting and Augmenting the Federal Offshore Wind Leasing Program by Establishing a Consistent and Significant Leasing Program

Sec. 1. Purpose. This Order is intended to ensure that the United States establishes an adequate leasing system allowing the United States to establish a competitive supply chain in the offshore wind industry.

In administering millions of acres of the Federal OCS, the Bureau of Ocean Energy Management (BOEM) has a responsibility to make federal wind resources available for leasing in an effective and timely fashion.

The Outer Continental Shelf Lands Act (OCSLA) states that “the outer Continental Shelf is a vital national resource reserve held by the Federal Government for the public, which should be made available for expeditious and orderly development, subject to environmental safeguards, in a manner which is consistent with the maintenance of competition and other national needs.”

The law makes it clear that Federal wind resources offshore should be made available for the benefit of citizens of the United States.

In issuing this Order, I am taking action as a responsible public steward to strengthen American energy security and create American jobs.

Point of Contact: Tim Charters, tcharters@noia.org; Randall Luthi, rluthi@noia.org

Sec. 2. Authorities. This Order is issued under the authority of section 2 of reorganization Plan No. 3 of 1950, 64 Stat. 1262, as amended. Other statutory authorities for this Order include, but are not limited to, the following:

- (a) Outer Continental Shelf Lands Act 40 U.S.C. §§ 1332.

Sec. 3. Directive. Consistent with principles of responsible public stewardship entrusted to this office, with due consideration of the critical importance of American energy security, job creation, conservation stewardship, and the economies of affected states, the following actions shall be taken by BOEM:

- (a) establish a broad national stakeholder program for the development of an OCS-wide wind leasing program in all waters of the United States;
- (b) prepare a plan to hold at least four lease sales of an area sufficient to install at least five hundred megawatts of offshore wind energy each year beginning in 2024, and support and improve the implementation of the oil and gas quarterly lease sale
- (c) at least one lease sale will be planned in each of these areas each year:
 - a. North Atlantic, from Maine to New Jersey;
 - b. South Atlantic, from Maryland to Florida;
 - c. Gulf of Mexico and Atlantic Territories, from Florida to Texas, including the territories of Puerto Rico and United States Virgin Islands;
 - d. Pacific, from Washington to California, including Alaska and Hawaii, and the territories of Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

Sec. 4. Implementation. The Assistant Secretary – Land and Minerals Management (ASLM) and the Director, Bureau of Ocean Energy Management (BOEM), shall report to the Counselor to the Secretary for Energy Policy within 180 days of the date of this Order on:

- (a) options identified to improve Federal offshore wind leasing;
- (b) a strategy to establish and identify the broad stakeholder group to prepare planning, including the potential for establishing an advisory group for such a process;
- (c) identify any provisions in existing policy and guidance documents

Point of Contact: Tim Charters, tcharters@noia.org; Randall Luthi, rluthi@noia.org

that would impede BOEM's preparation to carry out the leasing program.

Sec. 5. Effect of the Order. This Order is intended to improve the long term planning and management of the Department. This Order and any resulting reports or recommendations are not intended to, and do not, create any right or benefit, substantive or procedural, enforceable at law or equity by a party against the United States, its departments, agencies, instrumentalities or entities, its officers or employees or any other person. To the extent there is any inconsistency between the provisions of this Order and any Federal laws or regulations, the laws or regulations will control.

Sec. 6. Expiration Date. This Order is effective immediately. It will remain in effect until it is amended, superseded, or revoked.

Point of Contact: Tim Charters, tcharters@noia.org; Randall Luthi, rluthi@noia.org

Subcommittee Proposing Recommendation: Non-Fossil Working Group

Recommendation: In order to ensure the benefits of offshore energy and mineral development to all Americans it is necessary to expand the reach of the Outer Continental Shelf Lands Act (OCSLA) to the United States Territories; Guam, American Samoa, U.S. Virgin Islands, Commonwealth of the Northern Marianas and Puerto Rico.

Nature of change: Secretary will submit to Congress a proposed legislative amendment to OCSLA.

Proposed text:

APPLICATION OF OUTER CONTINENTAL SHELF LANDS ACT WITH RESPECT TO TERRITORIES OF THE UNITED STATES.

(1) in paragraph (a), by inserting after “control” the following: “or lying within the United States exclusive economic zone and the Continental Shelf adjacent to any territory of the United States”;

(2) in paragraph (p), by striking “and” after the semicolon at the end;

(3) in paragraph (q), by striking the period at the end and inserting “; and”; and

(4) by adding at the end the following:

“(r) The term ‘State’ includes each territory of the United States.”

Background: The effort to expand the OCSLA to the territories has passed one body or the other in Congress several times over the last decade, most recently in the SECURE Act (Scalise-LA), HR 4239. The Obama Administration issued a strong statement of support and the Trump Administration has continued that support. That statement reads:

“The Department supports the intent of Title V to expand the OCS Lands Act to include the Exclusive Economic Zone (EEZ) offshore the Territories of the United States. This would provide a statutory structure for procedures to manage the energy and mineral resources in areas of United States jurisdiction that are not currently covered by existing offshore energy and mineral resources law.

“Currently no Federal agency has the authority for overseeing energy, including renewable energy, and mineral development in the EEZ offshore of the U.S. territories. The Federal government is unable to evaluate potential resources in conjunction with the territorial governments for potential resources until OCSLA is extended to these areas. The same rules and limitations that exist in terms of the EEZ surrounding the continental U.S. would apply to the U.S. territories. Expanding the Secretary’s authority and responsibility under OCSLA provides a comprehensive process for evaluating, planning and developing, as appropriate,

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any potential conventional energy, renewable energy and mineral resources in consultation and coordination with the territorial governments. “

In addition, including the U.S. territories and possessions under the leasing authority of OCSLA will result in:

- Potential Economic Activity
 - Income and Employment: An effective and active minerals development plan for the territories would be expected to generate incremental revenue, income and employment in the economically-challenged territories.
 - Domestic Production of Strategic Minerals: There are a number of strategic minerals that the U.S. imports from abroad. Domestic minerals production would be of strategic value in reducing the U.S. dependence on foreign mineral imports.
 - Economic Diversification: Most of the territories are heavily dependent on only one or two key industries. Should offshore minerals mining become a significant industry, this could help to diversify the territorial economies.
 - Renewable Energy Potential: The renewable energy program could be applied equally to the territories. This would enable expanded employment and economic activity, as well as the growth of other enterprises that could benefit from reduced electrical costs derived from renewable energy.
 - Enable Sand and Gravel Program: Given that some territories are heavily dependent on tourism, the ability to maintain and replenish their beaches could be potentially valuable to some U.S. territories, particularly those in the Caribbean.
- Revenues
 - Increased Federal Revenues: If mineral leasing were to take place in the territories, the Federal government would obtain royalties, rents and bonus bids on minerals leased in the territories, all of which would be new income sources.
 - Increased Territorial Revenues: Under this initiative, the territories with submerged lands could obtain revenues from renewable energy projects leased within three miles of the boundary of their submerged lands and see employment benefits from development activities if the areas are ultimately leased and developed.
- Increased Scientific Research and Incentive for Improved Technology
 - Increased Knowledge of Resource Base: Exploration would provide the government new data which would increase its knowledge as to the available resources offshore the territories and also how to best develop these resources. There is a possibility, of course, that such exploration would determine that the resources are less than expected and not viable for economic exploitation.
 - Improved Environmental Knowledge: All of the processes and procedures used by BOEM (e.g., NEPA) to evaluate the environmental impacts of any proposed development needing BOEM approval would apply to activities

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offshore territories. New research would be undertaken to better understand the natural environments offshore the territories. The assessments would also ensure the protection of fragile habitats from unrestrained resource extraction activities.

- Improved Technology: Active interest in the new areas would expand knowledge of seabed mineral deposits where little or no exploration has previously occurred, which may lead to encouraging the exploration and development of deposits in other deep seabed areas. Also opening up the area offshore the territories to this kind of mineral exploration and development may help advance technologies for both exploration and development of minerals in the deep ocean floors, particularly for U.S. companies.

Finally, both the rebuilding of the electrical grid of Puerto Rico as part of the recovery from the hurricanes of 2017 and the significant investment of resources by the Department of Defense into Guam provide unique opportunities for energy investment in the OCS if the Department of Interior is given the opportunity to plan offshore energy development.

Analysis: According to the Congressional Budget Office enacting this provision could increase federal revenues by \$20 million over the 2018-2027 period.

Specifically, CBO says in analysis of HR 4239 that “Renewable Energy Leases on the OCS. H.R. 4239 would direct DOI to study the potential for production of electricity generated by wind off the coasts of Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and the Northern Marianas Islands. If those studies showed that developing offshore wind resources was feasible, the bill would direct DOI to conduct lease sales in those areas. CBO estimates that implementing those provisions would increase offsetting receipts by \$20 million over the 2018-2027 period, net of payments to states and territories. (<https://www.cbo.gov/system/files/115th-congress-2017-2018/costestimate/hr4239.pdf>)

Point of Contact: Tim Charters, tcharters@noia.org or Randall Luthi, ruthi@noia.org, with National Ocean Industries Association

Subcommittee Proposing Recommendation: Planning, Analysis, and Competitiveness

Recommendation: The Committee recommends that the Secretary direct the National Office of the Bureau of Land Management to issue an Instruction Memorandum, or other mechanism, to update and clarify solar energy right-of-way (ROW) acreage rent schedules, megawatt (MW) capacity fees, lease and grant renewal processes, bond requirements, and application priority for projects in the six southwestern states subject to BLM's Western Solar Plan (Arizona, California, Colorado, Nevada, New Mexico, and Utah), including guidance on the implementation of the rule on Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections, 81 Fed. Reg. 92,122 (Dec. 16, 2016) (the "Rule").

Nature of change: Instruction Memorandum

Background: America's multiple use public lands in six southwestern states offer some of the best solar resources in the nation and have been identified by the BLM as highly suitable and potentially suitable for such use. However, despite a solar boom on America's private lands, prevailing federal land solar policies discourage solar development on public lands. Clarifications to and guidance on current policy should be made to ensure that multiple-use federal lands are made competitive with private lands.

The BLM authorizes ROW grants and leases for solar energy projects under Title V of the Federal Land Policy and Management Act (FLPMA) and its implementing regulations at 43 CFR Part 2800. Outside Designated Leasing Areas (DLA), the BLM issues ROW grants to authorize solar energy development on BLM-administered lands. Inside DLAs, the BLM issues ROW leases to authorize solar energy development on BLM-administered lands.

Consistent with the regulations at 43 CFR 2806.50, the BLM has developed a schedule to calculate rental fees for both solar energy grants and solar energy ROW leases. Rents include a base rent for the acreage of public land included within a solar energy ROW authorization and an additional phased-in megawatt (MW) capacity fee based on the total authorized MW capacity for the approved solar energy project. The MW capacity fee varies depending on the size and technology of the solar energy development project. The BLM's rental rates for solar energy grants are calculated consistent with the provisions of 43 CFR 2806.52 and the rental rates for solar energy leases are calculated consistent with the provisions of 43 CFR 2806.54.

ROW grant and lease holders must make payments, including acreage rent and a MW capacity fee, in consideration for their authorized use of the public lands for solar generation facilities. The current payment schedules for solar energy ROW authorizations were updated with the issuance of IM 2017-096 on September 14, 2017, and are effective through 2021. Both the Rule and IM 2017-096 provide that BLM may adjust the conditions imposed by the Rule, including, but not limited to, the payment terms on an individual basis or on a regional basis after receiving concurrence from the

Point of Contact: Marisa Mitchell

Washington Office Assistant Director of Energy, Minerals, and Realty Management. Rental adjustments are to be based on changes in fair market value as determined by the application of sound business management principles.

Instruction Memorandum IM 2017-096 set forth guidance for implementation of the Rule that resulted in strong economic disincentives for solar project developers to seek to develop solar power plants on federal lands. If elements of IM 2017-096 are not superseded and clarification to the Rule not made, conditions will continue to prevail which result in a less than optimal use of public lands in the region identified for such development, inconsistent with objectives to use public lands to further American energy dominance.

Analysis:

1. Acreage Rent

The rent escalation terms specified in 43 CFR 2806.52 (grants) and 43 CFR 2806.54 (leases), whether standard (subdivision a) or scheduled (subdivision d) have proven to be untenable in the region covered by these recommendations for large-scale solar projects. The revenue for these projects is uniquely fixed by the terms of their Power Purchase Agreements, which must be negotiated with a utility (or other offtaker) after prevailing in a highly competitive bidding process, and then approved by a state Public Utilities Commission. The resulting price establishes a set revenue stream that can only be revised with the offtaker's consent and further regulatory approval, which cannot be obtained in a declining market. Solar energy generation facilities have no means for adjusting their costs or profits to account for changes in rental rates. In addition, applicants cannot calculate the net present value of the total rental cost under a variable rent structure, which is necessary for purposes of selling and financing the project.

Permitting the acreage rent to periodically adjust to unknowable national index values for irrigated farmland, or any other unknown and limitless number, is unworkable given the business model described above. To the extent that the Rule offers a fixed escalator, the rates offered – 20% every 5 years over the term of a grant or 40% every 10 years over the term of a lease specified in 43 CFR 2806.52(d)(2)(ii) and 43 CFR 2806.54(d)(2), respectively – are well above the market for non-irrigated rangeland private leases. To remain competitive with private land options in the region, a more modest, almost fixed escalation factor, specifically, the IPD-GDP rate as defined in 43 CFR 2806.22, should be applied.

To further remain competitive with prevailing market conditions, the obligation to pay rent should commence once the BLM issues a Record of Decision or Decision Record, as appropriate, approving the terms of development. Paying rent before the developer is authorized to occupy the premises and begin development, as potentially required by

Point of Contact: Marisa Mitchell

43 CFR § 2806.12, would make development on public lands uncompetitive in this region.

2. MW Capacity Fee

The MW capacity fee component of the annual grant and lease payments identified in 43 CFR 2806.52 and 43 CFR 2806.54, respectively, create a strong disincentive for solar project developers to seek to use public land for development, resulting in a less than optimal use of public lands in the region identified for such development and inconsistent with objectives to use public lands to further American energy dominance, consistent with executive and secretarial orders. Furthermore, given the cost of land for private developments, it is clear that the annual per-acre zone rent in accordance with 43 CFR 2806.52 and 43 CFR 2806.62 is sufficient to capture the fair-market value of the property while facilitating its highest and best use of the land for solar development. The MW capacity fee should not be added to the annual payment owed for solar grants and leases in the area covered by the Western Solar Plan.

3. ROW Grant and Lease Renewal

43 CFR § 2807.22 provides that if a ROW grant or lease includes renewal provisions, the BLM “will renew the grant or lease if you are in compliance with the renewal terms and conditions; the other terms, conditions, and stipulations of the grant or lease; and other applicable laws and regulations.” If renewal provisions are omitted, the BLM may renew the lease or grant. The ability to extend leases and grants beyond the standard 30 year maximum duration provided in the Rule would make public lands more competitive with private lands for solar energy generation projects. Accordingly, for leases and grants in the area of the Western Solar Plan, the BLM should allow, after compliance with the National Environmental Policy Act (NEPA), a 10 year extension of a 30-year ROW grant or lease according to the same terms as the original ROW grant or lease to the full extent permitted by law.

4. Bond Rates for Solar Grants and Leases

The minimum per-acre bonding rate of \$10,000 per acre for solar energy ROW grants specified in 43 CFR 2805.20(b) is well above market in the area covered by the Western Solar Plan, which disincentivizes solar development on federal land inconsistent with the goal of American energy dominance. The minimum bond amount should not be imposed where an engineer has prepared a reclamation cost estimate (RCE), inclusive of salvage value, to calculate the bond required for a project. In addition, to ensure the timely permitting of projects in areas programmatically identified for development, the BLM Field Office Manager or District Office Manager should respond to a proposed performance bond within 60 days of submittal of a reasonable RCE by a project proponent and approval of the RCE and corresponding bond shall not be unreasonably withheld.

Variance Application Processing

Point of Contact: Marisa Mitchell

The Rule provides that lands outside of the designated leasing areas *may* be made available through a competitive leasing process. 43 CFR 2804.23. Because the BLM has already identified the best locations within the Western Solar Plan area for development and designated these areas as Solar Energy Zones (SEZs), developers that have the skills to find a good site within the remaining variance lands should be first in line to process the application for that site. If company A's expenditure of resources to find the site simply allows companies B and C to outbid company A for the site, then the BLM would be rewarding deep pockets over skilled developers and would risk awarding development rights to inexperienced speculators. The BLM has discretion to hold a competitive bidder selection process, or not, when more than one ROW application is filed on the same variance process lands. Recognizing that the ROW grant application program has worked well for solar development on public lands and wanting to avoid discouraging development by creating site control uncertainty for developers, the BLM should not hold a competitive lease auction for the land subject to an original application in good standing.

Subcommittee Proposing Recommendation: Planning, Analysis and Competitiveness

Recommendation

The Royalty Policy Committee recommends that the Secretary issue a Secretarial Order that grandfathers projects which were under construction, development, or for which an application had been accepted by the Bureau of Land Management (BLM) at the time the BLM issued its “Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections (81 Fed. Reg. 92122 (December 19, 2016))”.

Nature of change

81 FR 92164 (Section 2806.12(d)) of the Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections (Rule) acknowledges that the Secretary may take action that could affect rents and fees through issuance of a Secretarial Order. This provision gives the Secretary authority to accomplish this recommendation.

The Secretarial Order may incorporate the following provisions to make this change:

- 1) Definition of Project.--The term "project" means a system described in section of title 43 CFR 2801.9(a)(4).
- 2) Unless agreed to by the owner of a project, the rule shall not apply to projects that applied for a right-of-way under section 501 of the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1761) on or before December 19, 2016.
- 3) The owner of a project that applied for a right-of-way under section 501 of the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1761) on or before December 19, 2016, shall be obligated to pay with respect to the right-of-way all rents and fees in effect before the effective date of the rule described in subsection (b).

These three changes would allow for projects under development at the time the Rule was issued to be grandfathered in under the prior regulatory structure in place. While a change like this would be subject to alteration by another Secretary, it provides regulatory consistency to developers that had projects under construction or in development at the time this new rule was issued. Developers to which this change would apply will be subject to the rules and conditions in place prior to issuance of this rule. These changes will not affect new projects.

Background

In 2016, the BLM issued this new rule. Prior to this rule, developers were subject to a capacity fee. However, the new rule instituted an additional acreage fee and changed how the capacity fee is calculated.

While it does have aspects that are positive for newly proposed wind and solar projects, it carries significant financial burdens for projects that were under development at the time of issuance.

Point of Contact: Colin McKee email: colin.mckee@wyo.gov

This was a significant and common issue brought up by a number of commenters, including the American Wind Energy Association, the Solar Energy Industries Association and many others.

For example, please see AWEA comments, page 21 and other

- **Link:** <https://www.regulations.gov/document?D=BLM-2014-0002-0029>
- **Text**
 - o BLM should clarify the grandfathering provisions of the Proposed Rule: AWEA encourages BLM to make clear that the Proposed Rule does not have a retroactive effect on existing ROWs. If applied to existing projects, certain provisions of the Proposed Rule would breach existing ROW agreements. To that end, we believe that if BLM moves to finalize this rule, it should provide that holders of existing ROWs would be grandfathered in under the current rules. We support the following limited grandfathering language in the draft rule: “Applications for . . . wind energy development filed on lands outside of designated leasing areas, which subsequently become designated leasing areas: (1) Will continue to be processed by the BLM and are not subject to the competitive leasing offer process of this subpart, if such applications are filed prior to the publication of the notice of availability of the draft or proposed land use plan amendment to designate the . . . wind leasing area. . . .” While we support this language, it should be expanded so that it clearly provides grandfathering to holders of all existing ROWs both inside and outside of DLAs, and not just applications therefor.

Analysis

Making this change, the U.S. Treasury can expect to see the same level of revenue from projects. It will not affect projects applying with Interior after the issuance date of the Rule. At most, without this change the impacts of the new rule may put at risk projects that were under development at the time of its issuance. At the least, this change will allow projects under development at the time of Rule issuance to play under the same regulatory system that was in effect when projects first started permitting with Interior. Projects considered under development were referenced above through 43 CFR 2801.9(a)(4).

The important factor with this recommendation is providing equity to projects that were under development at the time of Rule issuance. Making this change continues Interior’s commitment to advancing renewable projects on federal lands and can provide some certainty to upcoming projects that the rules of the game will not change during the course of permitting.

Subcommittee Proposing Recommendation:

Recommendation:

BLM should issue an Instruction Memorandum (IM) directing all field offices to issue Categorical Exclusions (CX) when any of the Energy Policy Act of 2005 (EPAAct 2005) Section 390 criteria are met, unless specifically rebutted.

Nature of change:

Issuance of policy guidance in the form of an IM. The suggested draft IM from new Mexico Governor Martinez and North Dakota Governor Burgum could be used as a starting point (attached.)

Background:

Lengthy Application for Permit to Drill (APD) timeframes often occur because BLM is conducting redundant NEPA analysis rather than granting CXs when companies meet the criteria under Section 390 of the EPAAct. BLM should issue guidance that CXs must be used when a company meets any of the statutory Section 390 criteria, as below.

SEC. 390. NEPA REVIEW.

(a) NEPA REVIEW.—Action by the Secretary of the Interior in managing the public lands, or the Secretary of Agriculture in managing National Forest System Lands, with respect to any of the activities described in subsection (b) shall be subject to a rebuttable presumption that the use of a categorical exclusion under the National Environmental Policy Act of 1969 (NEPA) would apply if the activity is conducted pursuant to the Mineral Leasing Act for the purpose of exploration or development of oil or gas.

(b) ACTIVITIES DESCRIBED.—The activities referred to in subsection (a) are the following:

- (1) Individual surface disturbances of less than 5 acres so long as the total surface disturbance on the lease is not greater than 150 acres and site-specific analysis in a document prepared pursuant to NEPA has been previously completed.
- (2) Drilling an oil or gas well at a location or well pad site at which drilling has occurred previously within 5 years prior to the date of spudding the well.
- (3) Drilling an oil or gas well within a developed field for which an approved land use plan or any environmental document prepared pursuant to NEPA

analyzed such drilling as a reasonably foreseeable activity, so long as such plan or document was approved within 5 years prior to the date of spudding the well.

- (4) Placement of a pipeline in an approved right-of-way corridor, so long as the corridor was approved within 5 years prior to the date of placement of the pipeline.
- (5) Maintenance of a minor activity, other than any construction or major renovation or a building or facility.

Analysis:

The Section 390 CXs are mandated, unless specifically rebutted, by EPAAct 2005 and should not be discretionary. Use of CXs would reduce APD processing time by avoiding redundant NEPA analysis. Currently, [BLM data](#) show APDs take 260 days on average. Often, a large portion of the time involves NEPA-related activities, and CXs could be used to reduce the NEPA burden and free staff to focus on projects not covered by one of the CXs.



January 4, 2018

The Honorable Ryan K. Zinke
Secretary of the Interior
U.S. Department of the Interior
1849 C Street, N.W.
Washington, D.C. 20240

Dear Mr. Secretary:

Two options to expedite permitting on federal acreage for mineral extraction currently exist in federal statutes but need a new Instruction Memorandum (IM) for uniform application among Bureau of Land Management (BLM) offices. Use of categorical exclusions and Determination of National Environmental Policy Act (NEPA) Adequacy would result in an immediate decrease in permitting cycle times.

President Bush signed into law the Energy Policy Act of 2005 (the "Act") to address long-term energy policy challenges, including significant delays inherent in the BLM oil and gas permitting scheme. Under Section 390 of the Act, when the BLM determines that proposed activities have no significant environmental impact — categorical exclusions — then the BLM needs no additional NEPA documentation.

The BLM issued Instruction Memorandum No. 2005-247 (IM 2005-247) in September 2005, which provided guidance to BLM field offices regarding the implementation of Section 390 categorical exclusions. Under IM 2005-247, the BLM approved almost 7,000 drilling and associated oil and gas development activities from Fiscal Year 2006 through Fiscal Year 2008.

However, litigation filed in 2008 by radical environmental organizations challenged IM 2005-247 and resulted in a settlement by the Obama Administration and a new BLM Instruction Memorandum (IM 2010-118). Under the agreement and IM 2010-118, the BLM committed to review for extraordinary circumstances when applying Section 390 categorical exclusions, an administrative process not contemplated by the Act.

Shortly thereafter in 2011, a federal district court determined that IM 2010-118 was invalid. Largely due to uncertainty and a lack of guidance, the BLM and its field offices have taken little initiative to reimplement the statutory Section 390 categorical exclusions since that time.

We request that you restore implementation of the Section 390 categorical exclusions by directing the BLM to issue a new Instruction Memorandum, instructing BLM field offices regarding the Section 390 categorical exclusions and the separate but related process of determining that adequate NEPA has already been conducted (Determination of NEPA Adequacy).

To that end, we have attached draft language for your consideration as you prepare a new Instruction Memorandum addressing this critical issue.

Sincerely,



Susana Martinez
Governor of New Mexico



Doug Burgum
Governor of North Dakota

**Department of the Interior
Bureau of Land Management**

43 CFR Part _____

**Bureau of Land Management
Discretion to Apply Categorical Exclusions
Under the National Environmental Policy Act**

Summary

The Bureau of Land Management (BLM) is proposing regulations which limit and clarify BLM's discretion to apply categorical exclusions under the National Environmental Policy Act (NEPA) and the Energy Policy Act of 2005. The Energy Policy Act of 2005 contains five statutory categorical exclusions (Section 390 Categorical Exclusions), which are categories of actions that Congress has determined do not normally result in individually or cumulatively significant environmental effects. These proposed regulations establish the process by which BLM shall apply the Section 390 Categorical Exclusions. This proposed rule does not apply to lands held by the United States in trust for Native American tribes or tribal members.

The use of statutory categorical exclusions can reduce paperwork and delay, so that agency resources are made available to focus on areas where categorical exclusions do not apply. Categorical exclusions are not exemptions or waivers of NEPA review; instead the use of a categorical exclusion may be used to help satisfy the NEPA review process, including efficient and streamlined approval of agency actions that will not result in individually or cumulatively significant impacts to the human environment. However, these efficiencies are lost when extensive agency analysis is required to determine whether to apply categorical exclusions. The changes proposed in this proposed rule would allow BLM to more efficiently manage its mineral resources for the benefit of the citizens of the United States. BLM proposes this rule to comply with Executive Order 13783, titled "Promoting Energy Independence and Economic Growth," which requires agencies to immediately review all agency actions, including regulations and guidance documents, that potentially burden the development or use of domestically produced energy resources, especially oil, natural gas, coal, and nuclear energy resources. This proposed rule is also consistent with and furthers the purpose of Secretarial Order No. 3354, titled "Supporting and Improving the Federal Onshore Oil and Gas Leasing Program and Federal Solid Mineral Leasing Program," which directs federal agencies to take immediate and specific action to alleviate or eliminate burdens on domestic energy development.

Dates

Send your comments on this proposed rule to the BLM on or before_____. The BLM is not obligated to consider any comments received after the above date in making its decision on the final rule.

Addresses

Mail: U.S. Department of the Interior, Director (630), Bureau of Land Management, Mail Stop 2134 LM, 1849 C St., NW., Washington, DC 20240, Attention: 1004-AE15. *Personal or messenger delivery:* 20 M Street SE., Room 2134LM, Washington, DC 20003. *Federal Rulemaking Portal:* <http://www.regulations.gov>. Follow the instructions at this Web site.

For Further Information Contact:

[BLM to Insert]

Supplementary Information

I. Public Comment Procedures

II. Background

III. Discussion of the Proposed Rule

I. Public Comment Procedures

If you wish to comment on the proposed rule, you may submit your comments by any one of several methods specified (see ADDRESSES above). If you wish to comment on the information collection requirements, you should send those comments directly to the OMB as outlined (see ADDRESSES); however, we ask that you also provide a copy of those comments to the BLM.

Please make your comments as specific as possible by confining them to issues for which comments are sought in this notice and explain the basis for your comments. The comments and recommendations that will be most useful and likely to influence agency decisions are:

1. Those supported by quantitative information or studies; and
2. Those that include citations to, and analyses of, the applicable laws and regulations.

The BLM is not obligated to consider or include in the Administrative Record for the rule comments received after the close of the comment period (see DATES) or comments delivered to an address other than those listed above (see ADDRESSES).

Comments, including names and street addresses of respondents, will be available for public review at the address listed under ADDRESSES during regular hours (7:45 a.m. to 4:15 p.m.), Monday through Friday, except holidays.

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask

us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

II. Background

The Department of the Interior (DOI) recognizes that development of energy resources on public lands increases the nation's domestic energy supply, provides alternatives to overseas energy resources, generates revenue, creates jobs, and enhances national security. To this end, DOI has been directed to and is eliminating harmful regulations and unwarranted policies that unnecessarily burden the development of our nation's energy resources. In 2017, the DOI issued seven Secretarial Orders aimed at improving domestic onshore and offshore energy production and increasing efficiencies within the regulatory approval process. BLM is the bureau within the DOI charged with administering over 245 million surface acres and 700 million acres of subsurface mineral development. BLM's policies for complying with NEPA are included within BLM Handbook 1790-1 and the DOI NEPA implementing regulations are located within 43 CFR Part 46. In conjunction, these regulations, manuals, and handbooks establish the policies and procedures BLM follows when conducting land use planning and NEPA compliance, including specific actions related to energy and mineral development. Pursuant to the Secretarial Memorandum of March 27, 2017, entitled "Improving the Bureau of Land Management's Planning and National Environmental Policy Act Processes," the BLM has been identifying potential actions it could take to streamline its planning and NEPA review procedures, which include expressly limiting the discretion of BLM field offices when applying categorical exclusions – particularly the congressionally-enacted Section 390 Categorical Exclusions.

NEPA is a tool enacted by Congress to analyze environmental, economic, and social values associated with significant actions taken by federal agencies. Under NEPA, federal agencies are mandated to evaluate the environmental impacts of their proposed actions before deciding to approve permits or take other forms of agency action. Many federal actions do not result in significant effects on the environment. When BLM and other federal agencies identify categories of activities that do not pose a potential for individually or cumulatively significant impacts, they may establish a categorical exclusion for those activities. Regulations adopted by the Council on Environmental Quality (CEQ) provide the basic elements for establishing and using categorical exclusions. Section 1508.4 of the CEQ Regulations define a "categorical exclusion" as a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a federal agency in implementation of these regulations (§ 1507.3) and for which, therefore, neither an environmental assessment (EA) nor an environmental impact statement (EIS) is required. The applicability of these regulatory categorical exclusions can be limited, under the existing CEQ regulations, by the existence of "extraordinary circumstances." Such extraordinary circumstances may exist when there are factors or circumstances that pose significant environmental effect, and which require further analysis in either an EA or an environmental impact statement EIS.

Congress has enacted legislation finding that certain federal actions will not significantly affect the human environment. These statutory categorical exclusions differ from regulatory categorical exclusions promulgated by agencies such as BLM in both formation and application. An example of such legislation is Section 390 of the Energy Policy Act of 2005. This Act established five

statutory categorical exclusions that apply to oil and gas exploration and development activities taking place on federal oil and gas leases, pursuant to the Mineral Leasing Act. When BLM receives a request for agency action that falls within the scope of a Section 390 Categorical Exclusion, no further NEPA compliance is required. Unlike regulatory categorical exclusions, statutory categorical exclusions do not require review for extraordinary circumstances under the Council for Environmental Quality (CEQ) regulations. This is because statutory categorical exclusions are established by Congress and, as a result, their application is governed by a specific statute apart from NEPA. CEQ has not specifically been delegated discretion to interpret the Energy Policy Act of 2005.

Despite long-standing recognition of the differences between statutory and regulatory categorical exclusions, in 2010, BLM implemented informal policies in Instruction Memorandum IM 2010-118, which required the agency to review the existence of extraordinary circumstances when applying statutory categorical exclusions enacted under the Energy Policy Act of 2005 (Section 390 CXs). This IM directs that “field offices are directed to conduct a review for extraordinary circumstances when considering use of any of the Section 390 CXs.” On August 12, 2011, the United States District Court for the District of Wyoming invalidated this IM because it had not undergone a notice and comment process and imposed significant new legislative requirements. *See Western Energy Alliance v. Salazar*, No. 10-CV-237F, 2011 WL 3738240 (D. Wyo. Aug. 12, 2011). The IM was officially rescinded by BLM on April 27, 2012 by Instruction Memorandum No. 2012-110, which concludes that no review for extraordinary circumstances is required when Section 390 Categorical Exclusions are applicable. As a result of the issuance of the 2010 and 2012 IMs, there has been confusion and lack of uniformity amongst BLM field offices regarding application of Section 390 Categorical Exclusions, reducing the efficiencies sought to be gained by the statutory categorical exclusion process.

Field offices have been applying Section 390 Categorical Exclusions inconsistently based on discretionary decisions. The discretionary application of the Section 390 Categorical Exclusions by BLM has led to increased regulatory burdens on the agency which have unreasonably increased permit approval times and resulted in deferred royalty payments to the federal government. Furthermore, the discretionary use of the Section 390 Categorical Exclusions may be based on an erroneous application of CEQ regulations, which specifically pertain to regulatory categorical exclusions. Current CEQ regulations provide that even when a proposed activity fits within the definition of a regulatory categorical exclusion and does not raise extraordinary circumstances, BLM may, at its discretion, decide “to prepare an environmental assessment * * * in order to assist agency planning and decision making.” 40 C.F.R. § 1508.4. This proposed rulemaking clarifies that the discretionary application of categorical exclusions does not apply when a proposed activity falls within the scope of a statutory categorical exclusion under the Energy Policy Act of 2005 because the statute does not vest BLM with discretion to disregard the application of the Section 390 Categorical Exclusions.

Prior to drafting this proposed rule, BLM worked with stakeholder groups including state and local elected officials and groups, the Western Governors’ Association, and the National Association of Counties. Once implemented, this proposed rule will reduce the time and/or cost of complying with NEPA when evaluating proposed actions and will provide greater consistency to the application of the Section 390 Categorical Exclusions. The proposed rule also provides a more-

standardized analysis in BLM's NEPA reviews at the land use plan and project level. The reduction in burden is measured and evaluated in terms of processing times and/or costs of authorizing energy development.

III. Discussion of the Proposed Rule

A. General Overview

Which categorical exclusions are governed by the proposed rule?

This proposed rule applies to five different categorical exclusions contained within the Energy Policy Act of 2005 (the "Act") for oil and gas development and operations. Congress enacted the Energy Policy Act of 2005 in part to expedite oil and gas development within the United States. The Act specifically authorizes BLM, for certain oil and gas activities, to approve projects without preparing environmental analysis, which would normally be required under NEPA. These categorical exclusions—commonly referred to as "Section 390 CXs"—define specific conditions under which Congress has determined that BLM does not need to prepare an EA or EIS. As originally implemented, projects approved with Section 390 CXs were not subject to any screening for extraordinary circumstances. Subsection (a) of the Act states:

NEPA Review.—Action by the Secretary of the Interior in managing the public lands or the Secretary of the Agriculture in managing National Forest System Lands, with respect to any of the activities described in subsection (b) shall be subject to a rebuttable presumption that the use of a categorical exclusion under the National Environmental Policy Act of 1969 (NEPA) would apply if the activity is conducted pursuant to the Mineral Leasing Act for the purpose of exploration or development of oil and gas.

Subsection (b) of the Act then outlines five categories of activities to be considered statutory categorical exclusions. These Section 390 CXs (referred to as Section 390 CX1, CX2, CX3, CX4, and CX5) include:

- (1) Individual surface disturbances of less than 5 acres so long as the total surface disturbance on the lease is not greater than 150 acres and site-specific analysis in a document prepared pursuant to NEPA has been previously completed.
- (2) Drilling an oil or gas well at a location or well pad site at which drilling has occurred previously within 5 years prior to the date of spudding the well.
- (3) Drilling an oil or gas well within a developed field for which an approved land use plan or any environmental document prepared pursuant to NEPA analyzed such drilling as a reasonably foreseeable activity, so long as such plan or document was approved within 5 years prior to the date of spudding the well.
- (4) Placement of a pipeline in an approved right-of-way corridor, so long as the corridor was approved within 5 years prior to the date of placement of the pipeline.

- (5) Maintenance of a minor activity, other than any construction of major renovation or a building or facility.

This proposed rule would limit BLM's discretion to complete an EA or EIS in lieu of applying these five categorical exclusions, and further clarifies how BLM will apply Section 390 CXs going forward.

Is screening for extraordinary circumstances required when Section 390 CXs are applied?

Screening for extraordinary circumstances is not required when Section 390 CXs are applicable. This position coincides with BLM precedent and the plain language included with in the Energy Policy Act of 2005. In Instructional Memorandum No. 2012-110, BLM instructed field offices that reviews for extraordinary circumstances do not apply when Section 390 CXs are applicable. Such guidance agrees with the statutory text of the Energy Policy Act of 2005, which is silent as to BLM's discretion to conduct reviews for extraordinary circumstances when applying categorical exclusions under the Act.

In addition, BLM's NEPA Handbook, H-1790-1 has long-stated that reviews for extraordinary circumstances should not be undertaken in conjunction with the application of Section 390 CXs. BLM, however, must still ensure that agency actions and approvals comply with the Endangered Species Act and National Historic Preservation Act.

Is the use of Section 390 CXs discretionary?

The plain text of the Energy Policy Act of 2005 does not vest BLM with discretion to decide whether additional environmental analysis should be applied. Instead, the statutory text states that the Section 390 CXs are presumed to apply unless rebutted. The purpose of the Act was to "ensure jobs for our future with secure, affordable, and reliable energy." 109 P.L. 58, 119 Stat. 594. To this end, the DOI has recently announced a strong interest in reducing regulatory burdens in order to increase domestic oil and gas production. As a consequence, BLM proposes in this rulemaking to limit its discretion when applying Section 390 CXs. The text of the proposed rule provides that when a Section 390 CX applies, the authorized officer shall apply the Section 390 CX and shall not prepare an EA or EIS. This proposed language is intended to streamline the application of Section 390 CXs for BLM field offices and to provide uniformity in their application.

What is the rebuttable presumption applied under the Energy Policy Act of 2005 when a Section 390 CX is considered?

The express language contained within the Energy Policy Act of 2005 states that a Section 390 CX applies unless the presumption of applicability has been rebutted. Nothing within the statute, however, specifically defines how the presumption that a Section 390 CX is rebutted. Pursuant to the authority delegated to BLM, the agency proposes to define the scope of this rebuttable presumption and how it will be applied by the agency. These new definitions and regulatory requirements were developed after engaging in discussions with stakeholders including industry members, local communities, state and local governments, and interested citizens.

Under the rule, the statutory presumption that a Section 390 CX applies can be rebutted only by showing that the authorized officer has found in writing that:

- (1) the proposed activity will not comply with the requirements contained within a Section 390 CX;
- (2) the well is not part of an activity pursuant to the Mineral Leasing Act; or
- (3) the well is not for the purpose of exploration or development of oil or gas.

When an authorized officer determines that one of the above factors applies, he is required to provide notice to the applicant that explains that the presumption of applicability has been rebutted and provides a reasoned explanation for that decision. This written decision issued by the authorized officer will be appealable under the DOI's regulations.

When does Section 390 CX1 apply?

The first categorical exclusion in Section 390 of the Energy Policy Act of 2005 applies when there is: "Individual surface disturbances of less than five (5) acres so long as the total surface disturbance on the lease is not greater than 150 acres and site-specific analysis in a document prepared pursuant to NEPA has been previously completed." 42 U.S.C. § 15942(b)(1).

BLM, and other agencies applying this exclusion, have historically applied the following factors when determining whether Section 390 CX1 is applicable:

- (1) a five-acre disturbance threshold,
- (2) 150-acre unreclaimed disturbance limit, and
- (3) prior site-specific analysis of oil or gas exploration/development in a NEPA document.

Reliance on this categorical exclusion requires the authorized officer to consider the following:

(1) Five-acre disturbance threshold – The authorized officer must determine that each individual action under consideration will disturb less than five acres on the site. If more than one activity is proposed for a lease (e.g., two individual wells or when reviewing a Master Development Plan (MDP) collectively adding several wells), each activity is counted separately, and each must disturb less than five acres.

(2) 150-acre unreclaimed disturbance limit – The authorized officer must determine that the current unreclaimed surface disturbance on the entire leasehold is not greater than 150 acres, including the action under consideration. This would include disturbance from previous rights-of-way issued in support of lease development. If one or more federal leases are committed to a BLM approved unit or communitization agreement, the 150-acre threshold applies separately to each lease. For larger leases, the requirement for adequate documentation would be satisfied with a copy of the most recent aerial photograph in the file with an explanation of recent disturbance that may

not be shown on the aerial photos. Maps, tally sheets, or other visuals may be substituted for aerial photographs. The 150-acre unreclaimed disturbance threshold includes only disturbance associated with oil and gas activities and associated rights-of-ways on the leasehold regardless of surface ownership. It does not include disturbance from other activities. Activities without surface disturbance or successfully reclaimed surface areas would not be included in the 150-acre constraint (e.g., an above ground pipeline).

(3) Site-specific analysis of oil or gas exploration/development in a prior NEPA document

– The authorized officer must determine that a site-specific NEPA document exists which previously analyzed oil or gas exploration and/or development. For the purposes of this categorical exclusion, the site-specific NEPA document can be: an exploration and/or development EA/EIS, an EA/EIS for a specific Master Development Plan (MDP), a multi-well EA/EIS, or an individual permit approval EA/EIS. The NEPA document must have analyzed the exploration and/or development of oil and gas (not just leasing) and the proposed activity must be within the general boundaries of the area analyzed in the EA or EIS. The NEPA document need not have addressed the specific permit or application being considered.

When does Section 390 CX2 apply?

The second categorical exclusion in Section 390 of the Energy Policy Act of 2005 applies when there is: “Drilling an oil and gas well at a location or well pad site at which drilling has occurred previously within five (5) years prior to the date of spudding the well.” 42 U.S.C. § 15942(b)(2).

BLM, and other agencies applying this exclusion, have applied the following factors when determining whether Section 390 CX2 is applicable:

- (1) drilling at a location or well pad previously drilled, and
- (2) five-year limitation from previous drilling.

Reliance on this categorical exclusion requires the authorized officer to consider the following:

(1) Drilling at a location or well pad previously drilled – The authorized officer must determine that the action under consideration will occur on an oil and gas location or well pad that had previous drilling, including a drilling pad or well pad which has been reclaimed through interim reclamation. Drilling includes drilling operations, reworking operations that involve a drilling rig, completion operations, or any plugging operations. A previous location or well pad will be recognized only where a previously constructed well pad was constructed. Previous drilling refers to *any* drilled well including injection, water source, or any other service well. Additional disturbance or expansion of the existing well pad is not restricted as long as it is tied to the original location or well pad.

(2) Five-year limitation from previous drilling – The authorized officer must determine that the previous drilling occurred within five years prior to the date of spudding the proposed well. The five-year constraint is based on when the most recent previous drilling occurred. This means that the most recent drilling activity resets the time period clock for determining the five-year limit.

When does Section 390 CX3 apply?

The third categorical exclusion in Section 390 of the Energy Policy Act of 2005 applies when there is: “Drilling an oil or gas well within a developed field for which an approved land use plan or any environmental document prepared pursuant to NEPA analyzed such drilling as a reasonably foreseeable activity, so long as such plan or document was approved within five (5) years prior to the date of spudding the well.” 42 U.S.C. § 15942(b)(3).

BLM, and other agencies applying this exclusion, have applied the following factors when determining whether Section 390 CX3 is applicable:

- (1) proposed drilling is within a developed oil or gas field,
- (2) analysis of drilling as a reasonably foreseeable activity in a NEPA document, and
- (3) five-year limitation from when the aforementioned NEPA document was finalized or supplemented.

Reliance on this categorical exclusion requires the authorized officer to consider the following:

(1) Proposed drilling is within a developed oil or gas field – The authorized officer must determine that the action under consideration is within a developed oil or gas field. A developed field consists of any field in which a confirmation well has been completed.

(2) Analysis of drilling as a reasonably foreseeable activity in a NEPA document – The authorized officer must determine that a NEPA document exists which addresses reasonably foreseeable activity at issue (*i.e.*, drilling). For the purposes of this categorical exclusion, the NEPA document can be of any type, regardless of which agency prepared the analysis and may include land management plans when such an analysis was performed. The statute identifies no particular requirement regarding the degree or specificity of detail required for use of Section 390 CX3. It is adequate if the proposed well is in the general geographic vicinity of the predicted development disclosed in the prior NEPA document.

(3) Five-year limitation from when the aforementioned NEPA document was finalized or supplemented – The authorized officer must determine that the NEPA document, referred to in criteria 2 above, was completed within five years prior to the date of spudding the proposed well. The five-year constraint is based on when the most recent NEPA document was finalized or supplemented.

When does Section 390 CX4 apply?

The fourth categorical exclusion in Section 390 of the Energy Policy Act of 2005 applies when there is: “Placement of a pipeline in an approved right-of-way corridor, so long as the corridor was approved within five (5) years prior to the date of placement of the pipeline.” 42 U.S.C. § 15942(b)(4).

BLM, and other agencies applying this exclusion, have applied the following factors when determining whether Section 390 CX4 is applicable:

- (1) an approved right-of-way corridor, and
- (2) five-year limitation from corridor approval.

Reliance on this categorical exclusion requires the authorized officer to consider the following:

(1) Approved right-of-way corridor – The authorized officer must determine that the action under consideration would occur within an approved right-of-way corridor. The term “right-of-way corridor” is a general term that includes any preexisting or approved corridor or right-of-way (whether on or off lease). This term is not limited to those corridors authorized under 43 C.F.R. Part 2800 but is a more generalized term that applies to any type of corridor or right-of-way approved under any authority or vehicle of the BLM. The authorized officer is not limited to any particular types of corridors or rights of way but should identify the date, location, and underlying authority for the approval or authorization in the documentation. Approved right-of-way corridors of any type may be used for new pipeline placement, including those approved for the burial of a pipeline or pipeline conduit in an existing road bed or along a power line right-of-way. Minor variations that allow additional disturbance or width needed to properly or safely install a new pipeline are permissible under this exclusion. The extent of additional disturbance or width needed to properly or safely install the new pipeline is at the discretion of the authorized officer who shall assure that any variation will minimize effects on surface resources and prevent unnecessary or unreasonable surface resource disturbance, including effects to cultural and historical resources and fisheries, wildlife, and plant habitat. There is no requirement for the approved right-of-way to be currently in use or occupied. The approved right-of-way corridor may be either on or off lease. However, if off lease, this categorical exclusion is only available where approval and placement of the pipeline is authorized pursuant to the Mineral Leasing Act and does not include instances where a pipeline is approved pursuant to other general authorities.

(2) Five-year limitation from ROW corridor approval – The authorized officer must determine that use of the right-of-way or corridor, referred to in criteria 1 above, was approved within 5 years prior to the date of the proposed pipeline placement. Determination of the five-year constraint is based on when the most recent decision (NEPA or permit authorization, as applicable) which approved to allow use of the corridor. The time period extends to the date placement (installation) of any portion of the new pipeline is concluded, provided that placement activities began within the five-year constraint.

When does Section 390 CX5 apply?

The fifth categorical exclusion in Section 390 of the Energy Policy Act of 2005 applies when there is: “Maintenance of a minor activity, other than any construction or major renovation of a building or facility.” 42 U.S.C. § 15942(b)(5).

BLM, and other agencies applying this exclusion, have applied the following factors when determining whether Section 390 CX5 is applicable:

- (1) Maintenance of a minor activity.

Reliance on this categorical exclusion requires the authorized officer to consider the following:

- (1) Maintenance of a minor activity – The authorized officer must determine that the activity under consideration constitutes maintenance of a minor activity. Actions would include maintenance of a well, wellbore, road, well pad, or production facility having surface disturbance. Actions would not include construction or major renovation of a building or facility. Road maintenance is considered a minor maintenance activity within the scope of Section 390 CX5. Road reconstruction or construction is not considered a minor activity for use of this categorical exclusion.

DRAFT

SUMMARY AND PURPOSE: This rule provides regulations governing the application of categorical exclusions issued under the Energy Policy Act of 2005. The purpose of this rule is to allow the BLM to more efficiently and consistently apply categorical exclusions enacted by Congress in the Energy Policy Act of 2005.

1. **Issuing Agency:** The Bureau of Land Management (BLM).
2. **Scope:** This rule applies to those activities described at 42 U.S.C. 15942(b)
3. **Statutory Authority:** The Mineral Leasing Act, as amended and supplemented (30 U.S.C. 181 et seq.), the Act of May 21, 1930 (30 U.S.C. 301-306), the Mineral Leasing Act for Acquired Lands, as amended (30 U.S.C. 351-359), the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the Federal Oil and Gas Royalty Management Act of 1982, as amended by the Federal Oil and Gas Royalty Simplification Act of 1996 (30 U.S.C. 1701 et seq.), and the Energy Policy Act of 2005 (42 U.S.C. § 15942).
4. **Duration:**
5. **Effective Date:**
6. **Objective:** To authorize more efficiently those categorical exclusions which meet discrete criteria complying with the Energy Policy Act of 2005 and to allow the efficient, necessary development of oil and gas on federal lands.
7. **Definitions:**
 - a. APD: Application for permit to drill or re-enter.
 - b. Authorized Officer: any person authorized to perform the duties prescribed by BLM.
 - c. Developed Field: Any field in which a confirmation well has been completed.
 - d. Drilling Operations: The actual drilling or re-entry of a well.
 - e. Extraordinary Circumstances: those circumstances for which the Department has determined that further environmental analysis is required for an action, and therefore an EA or EIS must be prepared.
 - f. Section 390 CX: A categorical exclusion issued by Congress in 42 U.S.C. § 15942.
8. **Presumption that Section 390 CXs Apply.**
 - a. As provided by 42 U.S.C. § 15942(a), actions with respect to the following Section 390 CXs are presumed to be categorically excluded from the requirement to prepare an environmental assessment or an environmental impact statement:
 - i. Individual surface disturbances of less than 5 acres so long as the total surface disturbance on the lease is not greater than 150 acres and site-

specific analysis in a document prepared pursuant to NEPA has been previously completed.

- ii. Drilling an oil or gas well at a location or well pad site at which drilling has occurred previously within 5 years prior to the date of spudding the well.
- iii. Drilling an oil or gas well within a developed field for which an approved land use plan or any environmental document prepared pursuant to NEPA analyzed such drilling as a reasonably foreseeable activity, so long as such plan or document was approved within 5 years prior to the date of spudding the well.
- iv. Placement of a pipeline in an approved right-of-way corridor, so long as the corridor was approved within 5 years prior to the date of placement of the pipeline.
- v. Maintenance of a minor activity, other than any construction or major renovation or a building or facility.

9. Rebuttable Presumption.

- a. The presumption that the activities under Section 8 are categorically excluded from the requirement to prepare an environmental assessment or an environmental impact statement can only be rebutted by a written finding of the authorized officer that:
 - i. the proposed activity will not comply with the requirements contained within a Section 390 CX.
 - ii. showing that the well is not part of an activity pursuant to the Mineral Leasing Act; or
 - iii. showing that the well is not for the purpose of exploration or development of oil or gas.

10. Notice of Rebuttable Presumption.

- a. If the presumption that a Section 390 CX applies is rebutted by BLM, the applicant shall be provided written notice of BLM's decision that the presumption of applicability has been rebutted, and that the Section 390 CX does not apply. Such notice shall be sent by BLM to the applicant via certified mail return receipt requested. Applicant shall be afforded the opportunity to appeal this decision, pursuant to 43 C.F.R. Part 4.

11. Application of Section 390 CXs.

- a. **Section 390 CX1.** Section 390 CX1 shall apply when the following is established:
 - i. The authorized officer has determined that each individual action under consideration will disturb less than five acres on the proposed site. If more than one activity is proposed for a lease, each activity is counted separately, and each activity must disturb less than five acres.

- ii. The authorized officer has determined that the current unreclaimed surface disturbance on the entire leasehold will not be greater than 150 acres, including the action under consideration. This determination includes consideration of disturbances from previous rights-of-way issued in support of lease development. If one or more federal leases are committed to a BLM approved unit or communitization agreement, the 150-acre threshold applies separately to each lease. For larger leases, the requirement for adequate documentation may be satisfied with a copy of the most recent aerial photograph in the file with an explanation of recent disturbance that may not be shown on the aerial photos. Maps, tally sheets, or other visuals may be substituted for aerial photographs. The 150-acre unreclaimed disturbance threshold includes only disturbance associated with oil and gas activities and associated rights-of-ways on the leasehold regardless of surface ownership. It does not include disturbance from other activities. Activities without surface disturbance or successfully reclaimed surface areas would not be included in the 150-acre constraint (e.g., an above ground pipeline).
 - iii. The authorized officer has determined that a site-specific NEPA document exists, which previously analyzed oil or gas exploration and/or development. For the purposes of this categorical exclusion, the site-specific NEPA document may be: an exploration and/or development EA/EIS, an EA/EIS for a specific Master Development Plan (MDP), a multi-well EA/EIS, or an individual permit approval EA/EIS, or similar approval. The NEPA document must have analyzed the exploration and/or development of oil and gas (not just leasing) and the proposed activity must be within the general boundaries of the area analyzed in the EA or EIS. The NEPA document need not have addressed the specific permit or application being considered.
- b. **Application of Section 390 CX2.** Section 390 CX1 shall apply when the following is established:
- i. The authorized officer has determined that the action under consideration will occur on an oil and gas location or well pad that had previous drilling, including a drilling pad or well pad which has been reclaimed through interim reclamation. Drilling includes drilling operations, reworking operations that involve a drilling rig, completion operations, or any plugging operations. A previous location or well pad will be recognized only where a previously constructed well pad was constructed. Previous drilling may have occurred on *any* drilled well including injection, water source, or any other service well. Additional disturbance or expansion of the existing well pad is not restricted as long as it is tied to the original location or well pad.
 - ii. The authorized officer has determined that the previous drilling occurred within five years prior to the date of spudding the proposed well. The five-year constraint is based on when the most recent previous drilling occurred.

This means that the most recent drilling activity resets the time period clock for determining the five-year limit.

- c. **Application of Section 390 CX3.** Section 390 CX3 shall apply when the following is established:
 - i. The authorized officer has determined that the action under consideration is within a developed oil or gas field. A developed field consists of any field in which a confirmation well has been completed.
 - ii. The authorized officer has determined that a NEPA document exists which addresses reasonably foreseeable activity at issue (*i.e.*, drilling). For the purposes of this categorical exclusion, the NEPA document can be of any type, regardless of which agency prepared the analysis and may include land management plans when such an analysis was performed. It is adequate if the proposed well is in the general geographic vicinity of the predicted development disclosed in the prior NEPA document.
 - iii. The authorized officer has determined that the NEPA document, referred to in criteria (ii) above, was completed within five years prior to the date of spudding the proposed well. The five-year constraint is based on when the most recent NEPA document was finalized or supplemented.

- d. **Application of Section 390 CX4.** Section 390 CX4 shall apply when the following is established:
 - i. The authorized officer has determined that the action under consideration would occur within an approved right-of-way corridor. The term “right-of-way corridor” is a general term that includes any preexisting or approved corridor or right-of-way (whether on or off lease). This term is not limited to those corridors authorized under 43 C.F.R. Part 2800 but is a more generalized term that applies to any type of corridor or right-of-way approved under any authority or vehicle of the BLM. Approved right-of-way corridors of any type may be used for new pipeline placement, including those approved for the burial of a pipeline or pipeline conduit in an existing road bed or along a power line right-of-way. Minor variations that allow additional disturbance or width needed to properly or safely install a new pipeline are permissible under this exclusion. The extent of additional disturbance or width needed to properly or safely install the new pipeline is at the discretion of the authorized officer who shall assure that any variation will minimize effects on surface resources and prevent unnecessary or unreasonable surface resource disturbance, including effects to cultural and historical resources and fisheries, wildlife, and plant habitat. There is no requirement for the approved right-of-way to be currently in use or occupied.
 - ii. The approved right-of-way corridor may be either on or off lease. However, if off lease, this categorical exclusion is only available where approval and placement of the pipeline is authorized pursuant to the Mineral Leasing Act

and does not include instances where a pipeline is approved pursuant to other general authorities.

- iii. The authorized officer has determined that use of the right-of-way or corridor, referred to in criteria (i and ii) above, was approved within 5 years prior to the date of the proposed pipeline placement. Determination of the five-year constraint is based on when the most recent decision (NEPA or permit authorization, as applicable) which approved to allow use of the corridor. The time period extends to the date placement (installation) of any portion of the new pipeline is concluded, provided that placement activities began within the five-year constraint.

- e. **Application of Section 390 CX5.** Section 390 CX5 shall apply when the following is established:

- i. The authorized officer has determined that the activity under consideration constitutes maintenance of a minor activity. Actions would include maintenance of a well, wellbore, road, well pad, or production facility having surface disturbance. Actions would not include construction or major renovation of a building or facility. Road maintenance is considered a minor maintenance activity within the scope of Section 390 CX5. Road reconstruction or construction is not considered a minor activity for use of this categorical exclusion.

12. Council on Environmental Quality Regulations Shall Not Apply.

- a. The presumed categorical exclusions in Section 8 are not subject to the Council on Environmental Quality (CEQ) Regulations, including, without limitation, any additional review for extraordinary circumstance. The authorized officer shall not apply an extraordinary circumstances analysis, such as that contained in the 516 Department Manual.

13. The Application of Section 390 CXs is Not Discretionary.

- a. If an activity fits within one of the five categories listed under subsection (a), the authorized officer shall apply the applicable statutory categorical exclusion and shall not prepare an environmental assessment or an environmental impact statement.

14. Special Provisions.

- a. The categorical exclusions listed in Section 8 (a)(ii) and (iii) are not conditioned on the existence of prior activity-level or project-specific NEPA documents and pertain to those activities necessary to drill and produce oil or gas as described in an approved Application for Permit to Drill (APD) and subsequent modifications to the approved APD, so long as the subsequently modifying activity occurs entirely within the location, site, or field specified in the original APD.

15. Forms.

- a. When determining whether a Section 390 CX applies, the authorized officer shall complete Form 31 -.

DRAFT

Categorical Exclusion Determination for Section 390 CXs

Application Serial Number:	_____
Applicant Address	_____ _____
Agent Address:	_____ _____
Application for (facility/well name)	_____
API No.	_____
Location	_____

Section 390 CX1			
Five-Acre Individual Disturbance	Will each individual action under consideration disturb less than 5 acres?	Yes	No
150-Acre Disturbance Limit	Is the un-reclaimed surface disturbance on the entire leasehold less than 150 acres?	Yes	No
Site-Specific Oil and Gas Analysis in Prior NEPA	Does a site-specific NEPA document exist which previously analyzed oil and gas development?	Yes	No

If the answer to all of the above questions is yes, a Section 390 CX applies.

Section 390 CX2			
Drilling at a Location or Well Pad Previously Drilled	Will the activities occur on an oil and gas location or well pad that had previous drilling?	Yes	No
5-Year Limitation From Previous Drilling	Will the date of spudding the proposed well occur within 5 years of the previous drilling?	Yes	No

If the answer to all of the above questions is yes, a Section 390 CX applies.

Section 390 CX3			
Proposed Drilling in a Developed Field	Will the activity take place in a field in which any confirmation wells have been completed?	Yes	No
Analysis of Drilling as Reasonably Foreseeable in a NEPA documents	Has a NEPA document been prepared for lands within the general geographic vicinity which analyze the impacts of oil and gas drilling activities?	Yes	No
5-Year Limitation From the Date of the NEPA Document	Was the NEPA document completed within 5 years prior to the date the proposed well is spudded?	Yes	No

If the answer to all of the above questions is yes, a Section 390 CX applies.

Section 390 CX4			
Approved ROW Corridor	Will the activity take place within an approved right-of-way corridor?	Yes	No
5-Year Limitation From the Date of the NEPA Document	Was use of the right-of-way corridor approved within 5 years prior to the date of the proposed pipeline placement?	Yes	No

If the answer to all of the above questions is yes, a Section 390 CX applies.

Section 390 CX5			
Maintenance of a Minor Activity	Does the activity at issue constitute maintenance of a minor activity?	Yes	No

If the answer to all of the above questions is yes, a Section 390 CX applies.

Section 390 CX _____ applies and satisfies the National Environmental Policy Act.

Prepared By: _____

Date: _____

Approved By: _____

Date: _____

Authorized Officer

Subcommittee Proposing Recommendation: PAC Subcommittee, Onshore Working Group

Recommendation:

BLM should use the opportunity as it updates IM 2009-78 *Processing Oil and Gas Applications for Permit to Drill for Directional Drilling into Federal Mineral Estate from Multiple-Well Pads on Non-Federal Surface and Mineral Estate Locations* (otherwise known as the fee-fee-fed IM) to avoid unnecessary NEPA analysis of impacts to nonfederal surface when multi-well pads develop both federal and nonfederal minerals from off-lease, nonfederal surface locations. Similar, this guidance should avoid unnecessary analysis of horizontal wells that develop a minority of federal minerals.

Nature of change: Issuance of policy guidance in the form of an IM.

Background:

The law is clear that NEPA analysis need not consider impacts from nonfederal actions that would occur independently of a federal authorization. Therefore, when a multi-well pad is sited on off-lease, nonfederal surface to access nonfederal minerals, NEPA analysis need not consider the surface impacts of the well pad, even if a federal well will be drilled from the pad. BLM should provide concrete guidance for distinguishing between situations in which multi-well pads are and are not determined by access to the federal mineral estate. In particular, there should be a presumption that a multi-well pad developing both federal and nonfederal minerals has been sited to access the nonfederal minerals, unless specific facts demonstrate otherwise.

Under this same rationale, NEPA analysis need not consider all impacts of drilling a well that develops a minority of federal minerals. BLM should establish clear guidance for analyzing impacts of horizontal wells that develop a minority mineral interest.

Current guidance supports this interpretation, but the guidance is not being followed in the field offices. Therefore, clearer, more specific guidance is necessary.

Analysis:

NEPA can delay approvals of Applications for Permits to Drill (APDs), slowing development of wells that are primarily nonfederal and delaying revenue to private mineral owners. BLM should not conduct unnecessary analysis of impacts from nonfederal actions that would occur regardless of whether BLM approves an APD.

Subcommittee Proposing Recommendation: PAC Subcommittee, Onshore Working Group

Recommendation:

In an effort to reduce NEPA processing timelines and increase regulatory certainty on public lands, project-specific NEPA documents should be scoped to the actual impact of projects and limited to best-available information, tiering to existing environmental analyses already analyzed in prior NEPA documents. Project proponents should not be required to fund new research to produce data that go beyond the scope of the project.

Nature of change:

Guidance to NEPA planning staff

Background:

Project NEPA documents can take several years, and are often the longest source of delay to oil and natural gas projects. Project NEPA can take as long as eight to ten years for larger projects, and even small project NEPA documents can take three to five years. These NEPA delays hold up development, thereby delaying the return of royalties to the federal government. Long permitting and NEPA timelines also discourage many companies from even considering developing on federal lands, which further limits the potential to grow federal royalties. The Royalty Policy Committee should be concerned with reducing NEPA and other approval timelines in order to encourage more development and hence, increase royalty revenue.

NEPA documents should also be scoped to best available information. Processing of NEPA documents should not be put on hold while waiting for new research to be completed. In addition, often companies are asked to produce new data or redo studies multiple times, which adds years to the NEPA process. Examples where companies have been required to conduct research beyond the scope of their proposed projects include:

1. EPA Region 8 routinely requires companies to conduct additional air quality analysis to expand regional modeling data under the BLM-EPA NEPA MOU.
2. Colorado BLM requires companies to submit APD specific emission inventory data under the guise of permit requirements for purposes of building out its regional air model.
3. Through the NEPA and Section 7 consultation processes, USFWS imposes significant survey and research requirements or mitigation funding for research that extends far beyond the parameters of projects.

Analysis:

In order to implement Secretarial Order 3355 and reduce NEPA timelines to one year and page counts to 150, proper scoping of NEPA documents is necessary to keep the analysis focused on actual impacts of the projects and not speculative impacts beyond the scope of the proposed project. NEPA documents can be completed in a reasonable timeframe and page length by tiering to existing environmental analyses, thereby eliminating repetitive discussions of the same resource issues already analyzed in prior NEPA documents.

NEPA gives agencies the authority to tier to related NEPA documents, which allows incorporation of discussion and review of prior environmental analyses, and does not generally require an agency preparing an Environmental Assessment for a project to reevaluate the analyses included in relevant underlying Environmental Impact Statements.

Subcommittee Proposing Recommendation: PAC Subcommittee, Onshore Working Group

Recommendation:

The Department of the Interior should revise Onshore Orders 43 CFR 3173, 3174, and 3175 by giving due consideration to applicable API standards and GPA standards.

Nature of change:

Full rulemaking process.

Background:

BLM should rewrite the onshore orders to reduce their overly burdensome nature and to adopt API and GPA standards. The Onshore Working Group recommends the rulemaking also fix the retroactive aspects of the rule that threaten existing unitization and commingling agreements, which can make older fields uneconomic.

- **Recommended Overall Policy and Approach:** The simplest and most equitable means of modifying the regulations would be to adopt the American Petroleum Institute (API) and GPA Midstream (GPA) standards in their entirety. The API and GPA standards are based on proven measurement technologies and constitute the consensus of industry's foremost experts in oil and gas measurement. These standards are prescribed and can be validated through audit. Participation by government agency representatives in the API standards program allows for input by these representatives on the standards referenced by BLM.
- **Continue to honor all variances, commingling agreements, and off-site measurement agreements approved prior to the effective dates of the new rules.** The new rules should only be applied to applications submitted after the effective date of the new rules.
- **Existing Commingling and Allocation Approval:** The practice of commingling offers a number of operational benefits. Adding unnecessary operational barriers and/or costs to commingling would result in otherwise recoverable oil and gas reserves being left in the ground, a matter of physical and economic waste for both operators and the federal government as the steward of public lands and collector of royalty and other revenues therefrom on behalf of the nation. BLM should incorporate into the rule a definition of "economically marginal" that would establish when commingling of production is always allowed from a property meeting that definition.

Analysis:

There are several portions of the rules which are over burdensome with no benefit to the American people or the regulated community. In some cases, the rules are

scientifically unsound and can cause detrimental effects to the measurement and resultant values. Re-opening the rules for adjustments would be beneficial to all stakeholders.

Subcommittee Proposing Recommendation: PAC

Recommendation: This follows on the previous recommendation for **Royalty relief for late life or challenging assets** by adding specificity as committed in the last full RPC meeting. Offshore committee recommends appropriate DOI/agency personnel consider, in their review of potential avenues for improved achievability of existing statutory royalty relief options, such factors as enhanced oil recovery (EOR); high pressure/high temperature wells (HPHT); and reservoir depths. (*NOTE: 20,000 feet TVDSS is a common marker for exceptionally challenging reservoir depth.*)

Nature of change: This change is within the discretion of the DOI under existing authorities. It is likely that no more than an NTL would be sufficient agency action to effectuate the policy should the Secretary elect to advance the recommendation.

Background: It is the committee's understanding that royalty relief is technically available to certain challenging and/or late life projects, but official dialogue at the last full RPC meeting confirmed that there has been little to no successful application for such relief in many years.

The linked DOI data seems to substantiate the absence of such successful policy application in modern OCS operations:

<https://www.data.boem.gov/Other/DataTables/RoyaltyReliefApplications.aspx>

Analysis: Where there are risks that certain projects either would not materialize, would materialize sub-optimally (i.e. likely to produce substantially lower EURs), or would face earlier than optimal end of asset life/abandonment *but for* certain royalty relief, there is a public interest in seeking the “win/win” wherein greater production volumes and associated revenues and associated benefits continue to flow to the taxpayer, government, and employment markets. Creating improved certainty and accessibility for those situations would remedy the identified risks.

Royalty Policy Committee – Tribal Energy Subcommittee
June 6, 2018

Proposed Clarification of “Inherently Federal Functions” in
Tribal Energy Resource Agreements Under 25 C.F.R. Part 224
And Proposed Recommendation to the Secretary of the Department of the Interior

Background

Title V of the Energy Policy Act of 2005 amended existing statutes concerning development of tribal energy resources to establish a process by which a tribe can obtain a Tribal Energy Resource Agreement (TERA) granting authority to the tribe to review, approve and manage leases, business agreements and rights-of-way for energy development on tribal lands without the approval of the Secretary of the Interior. In 2008, DOI issued regulations, codified at 25 CFR Part 224, establishing the process for tribes to apply for and manage TERAs.

The TERA process has to date been unsuccessful. No tribes have formally applied to DOI for a TERA; various legal uncertainties and procedural barriers in the TERA application and management have been cited by tribes as reasons for not doing so. One specific reason that has been identified by tribes is the lack of certainty as to what permitting and regulatory functions can be delegated to a tribe under a TERA. 25 CFR § 224.52 allows the assumption by a tribe of activities normally carried out by DOI “except for inherently federal functions.” To date, however, DOI has not provided any guidance on what is considered an inherently federal function that must be retained by the Department when approving a TERA.

Proposal

The Tribal Energy Subcommittee proposes that the Secretary clarify what constitutes an inherently federal function, with the goal of having DOI issue guidance to tribes seeking approval of a TERA. As an initial matter, it should be noted that otherwise required reviews under the National Environmental Policy Act (NEPA) and Section 106 of the National Historic Policy Act are not applicable to tribal approval of leases, business agreements or rights-of-way under an approved TERA, because there is no federal action in either case. Instead, under 25 U.S.C. §3504(e)(2)(C), an approved TERA must include environmental and cultural resource review and protection procedures. Since those functions have been delegated to tribes, they are not, by definition, inherently federal functions.

Similarly, to the extent that a particular tribe has been granted “treatment as a state” under federal environmental laws, or otherwise delegated specific regulatory authority

under other applicable law, regulatory and permitting actions taken under those delegations should not be considered inherently federal.

For other federal functions, the Subcommittee recommends that one method of analyzing what other functions are “inherently federal” is to ask the question of which regulatory functions would remain in federal control if the lands in question were private or state lands, instead of tribal trust lands. There is no reason that tribes, upon the required showing of capacity, should not be able to assume responsibilities that are currently handled by state. Conversely, there are some federal regulatory functions that are universally applicable, and may therefore be considered inherently federal.

Recommendation

Below is a list of functions that are regularly performed by states in managing the development of energy resources on private and state lands. The Tribal Energy Subcommittee recommends that the Secretary issue guidance clarifying that the following items are not inherently federal functions and therefore, appropriate for tribes to manage in a TERA:

- Surface and mineral leasing
- Oilfield regulation (APD approvals, site layout, sundry notices for petroleum operations)
- Approval of rights-of-way for access to energy development sites
- Inspection and enforcement of all permitted activities
- General land use management, such as determining what lands are available for leasing and under what conditions
- Plugging and abandonment of oil and natural gas wells and reclamation of abandoned energy development sites to return them to their original condition
- Management of wildlife and vegetation, including threatened and endangered species listed under the Endangered Species Act.

This is not a comprehensive list of all activities; it is a manageable number of activities for the Secretary to analyze to provide timely guidance. Finally, the Tribal Energy Subcommittee requests the Secretary to provide any additional guidance regarding inherent federal functions that the Secretary deems appropriate



Royalty Policy Committee

Wednesday, June 6th, 2018

U.S. DEPARTMENT OF THE INTERIOR





Registration

8:30a.m. – 9:00a.m.





Welcome, and Overview

9:00a.m. – 9:15a.m.





Fair Return and Value Subcommittee Presentation

Co-Director's Introduction: Matthew Adams, Cloud Peak Energy
Oil and Gas Payor Handbook: Gabrielle Gerholt, Concho Resources
Index Pricing: Pat Noah, ConocoPhillips Company
Marketable Conditions: Stella Alvarado, Anadarko Petroleum
Coal Benchmarks: Matthew Adams, Cloud Peak Energy
Audit: Greg Morby, Chevron

9:15a.m. – 10:00a.m.





Public Comment

10:00a.m. – 10:30a.m.





Break

10:30a.m. – 10:45a.m.





Planning, Analysis, & Competitiveness Subcommittee Presentation

Co-Director's Introduction: Colin McKee, State of Wyoming
Non-Fossil and Renewables: Marisa Mitchell, Intersect Power
Offshore Oil & Gas: Patrick Noah, ConocoPhillips Company

10:45a.m. – 12:00p.m.



Committee Voting: Planning, Analysis, & Competitiveness Subcommittee

Recommendations	Accept	Reject	Return
<p>The Secretary shall plan a wind leasing program to bring at least twenty additional gigawatts from offshore wind to the United States over the decade beginning in 2024. This goal shall be achieved by leasing at least two gigawatts annually through at least four lease sales on the United States Outer Continental Shelf (OCS) of at least five hundred megawatts each.</p>			
<p>In order to ensure the benefits of offshore energy and mineral development to all Americans it is necessary to expand the reach of the Outer Continental Shelf Lands Act (OCSLA) to the United States Territories; Guam, American Samoa, U.S. Virgin Islands, Commonwealth of the Northern Marianas and Puerto Rico.</p>			
<p>The Committee recommends that the Secretary direct the National Office of the Bureau of Land Management to issue an Instruction Memorandum to update and clarify solar energy right-of-way (ROW) acreage rent schedules, megawatt (MW) capacity fees, lease and grant renewal processes, bond requirements, and application priority for projects in the six southwestern states subject to BLM's Western Solar Plan (Arizona, California, Colorado, Nevada, New Mexico, and Utah), including guidance on the implementation of the rule on Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections, 81 Fed. Reg. 92,122 (Dec. 16, 2016) (the "Rule").</p>			
<p>The Royalty Policy Committee recommends that the Secretary issue a Secretarial Order that grandfathers projects which were under construction or development at the time the Bureau of Land Management issued its "Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections (81 Fed. Reg. 92122 (December 19, 2016)."</p>			





Lunch

12:00p.m. – 1:15p.m.





Planning, Analysis, & Competitiveness Subcommittee Presentation, Cont.

Onshore Oil & Gas: Kathleen Sgamma, Western Energy Alliance

Alaska: John Crowther, State of Alaska

Coal: Matthew Adams, Cloud Peak Energy

Studies: Emily Kennedy Hague, American Petroleum Institute

1:15p.m. – 2:45p.m.



Committee Voting: Planning, Analysis, & Competitiveness Subcommittee

Recommendations	Accept	Reject	Return
BLM should issue an Instruction Memorandum (IM) directing all field offices to issue Categorical Exclusions (CX) when any of the Energy Policy Act of 2005 (EPA 2005) Section 390 criteria are met.			
BLM should use the opportunity as it updates IM 2009-78 Processing Oil and Gas Applications for Permit to Drill for Directional Drilling into Federal Mineral Estate from Multiple-Well Pads on Non-Federal Surface and Mineral Estate Locations (otherwise known as the fee-fee-fed IM) to avoid unnecessary NEPA analysis of impacts to nonfederal surface when multi-well pads develop both federal and nonfederal minerals from off-lease, nonfederal surface locations. Similar, this guidance should avoid unnecessary analysis of horizontal wells that develop a minority of federal minerals.			
In an effort to reduce NEPA processing timelines and increase regulatory certainty on public lands, project-specific NEPA documents should be scoped to the actual impact of projects and limited to best-available information, tiering to existing environmental analyses already analyzed in prior NEPA documents. Project proponents should not be required to fund new research to produce data that go beyond the scope of the project.			
The Department of the Interior should rewrite Onshore Orders 43 CFR 3173 , 3174, and 3175 by adopting API standards and GPA standards in their entirety.			
This follows on the previous recommendation for Royalty relief for late life or challenging assets by adding specificity as committed in the last full RPC meeting. Offshore committee recommends appropriate DOI/agency personnel consider, in their review of potential avenues for improved achievability of existing statutory royalty relief options, such factors as enhanced oil recovery (EOR); high pressure/high temperature wells (HPHT); and reservoir depths. (NOTE: 20,000 feet TVDSS is a common marker for exceptionally challenging reservoir depth.)			





Break

2:45p.m. – 3:00p.m.





Tribal Affairs Subcommittee Presentation

Co-Director's Introduction: President Russell Begaye, Navajo Nation

TERA: Bidtah Becker, Navajo Nation Office of Natural Resources

Model Congressional Statute: Prof. Monte Mills, University of Montana School of Law

Taxation: Jackson Brossy, Navajo Nation Washington Office

3:00p.m. – 4:30p.m.



Committee Voting: Tribal Energy

Recommendations

Below is a list of functions that are regularly performed by states in managing the development of energy resources on private and state lands. The Tribal Energy Subcommittee recommends that the Secretary issue guidance clarifying that the following items are not inherently federal functions and therefore, appropriate for tribes to manage in a TERA:

- Surface and mineral leasing
- Oilfield regulation (APD approvals, site layout, sundry notices for petroleum operations)
- Approval of rights-of-way for access to energy development sites
- Inspection and enforcement of all permitted activities
- General land use management, such as determining what lands are available for leasing and under what conditions
- Plugging and abandonment of oil and natural gas wells and reclamation of abandoned energy development sites to return them to their original condition
- Management of wildlife and vegetation, including threatened and endangered species listed under the Endangered Species Act.

This is not a comprehensive list of all activities; it is a manageable number of activities for the Secretary to analyze to provide timely guidance. Finally, the Tribal Energy Subcommittee requests the Secretary to provide any additional guidance regarding inherent federal functions that the Secretary deems appropriate

Accept

Reject

Return





Wrap-up, Timeline, Conclusions, and Next Steps

Adjourn

4:30p.m. – 5:00p.m.



Oil and Gas Payor Handbook Update

June 6, 2018

ONRR has made great progress

5 draft chapters

Regulatory citations

Illustrations

Tables

User Group Review and Comment

ONRR Finalization

Participants

Gabrielle Gerholt

Matthew Adams

Rowena Cheromiah

Brian Bex

Pat Noah

Adam Red

Stella Alvarado

Claire Ware

ONRR Staff

Fair Return and Value Marketable Condition Update

June 6, 2018

Standardized Table for Calculating Allowances/Disallowances

The work group met twice a month

Reviewed Examples of Standardized Tables

Index Pricing

Participants

Stella Alvarado

Matthew Adams

Pat Noah

Adam Red

Roderick Eggert

Greg Morby

ONRR Staff

Coal Workgroup Update

June 6, 2018

Overview of discussions to date and upcoming analysis.

Participants

Matthew Adams

Rod Eggert

Kwame Awuah-Offei

Daniel Rusz

ONRR Staff

Outside Experts

Fair Return and Value Audit Work Group Update

June 6, 2018

At the last work group meeting on April 17th

- ONRR provided a status update of initiatives presented at the February RPC
- We discussed new concerns and potential opportunities

Participants

Greg Morby
Stella Alvarado
Matthew Adams
Adam Red
Rowena Cheromiah

John Barder
Pat Noah
Kwame Awuah-Offei
Brian Bex



Royalty Policy Committee

Planning, Analysis and Competiveness Subcommittee
(Economics)



**Planning, Analysis &
Competitiveness
Subcommittee
Recommendations**



Non-Fossil Fuel Working Group Recommendations

Presenter: Marisa Mitchell, Intersect Power

Colin McKee, Governors Office, Wyoming

Non-Fossil Fuel Working Group Recommendation #1

Recommendation: The Secretary shall plan a wind leasing program to bring at least twenty additional gigawatts from offshore wind to the United States over the decade beginning in 2024. This goal shall be achieved by leasing at least two gigawatts annually through at least four lease sales on the United States Outer Continental Shelf (OCS) of at least five hundred megawatts each.

Nature of change: Secretarial Order

Background

America's energy future demands an aggressive "All of the Above" energy strategy in the OCS. This includes the responsible development of offshore wind power to support the energy needs of our coastal communities. This development will spur investments in local economies – creating job growth and avoiding the need to export hard-earned energy dollars outside the region.

The first handful of leases offered by BOEM has put in place leases for the first generation offshore wind, which is generally enough to meet the market demand (supported by state policies) through roughly 2030. However, that market demand is expected to grow, requiring the next generation of leasing and a commitment to a broader plan and the next generation of investment.

Experience from Europe has shown that an industrial commitment of two gigawatts of development is necessary to establish a significant and competitive supply chain for the offshore wind industry.

Analysis

This level of federal commitment, planning and investment of resources by the Federal Government, will spur follow on investment from States, industries, and researchers nationwide. Too often major energy projects, particularly in new areas, suffer from a “chicken and the egg” syndrome. For offshore wind this means no leasing, without power contracts, but no power contracts without leasing. By ensuring that the Federal Government is making an active effort to plan, prepare and initiate leasing of areas of the OCS, the Department of the Interior creates an important benefit of signaling that the Federal resources are open and available for investment and development.

Considering that a single lease can take as long as 5 years to prepare and plan prior to an actual lease sale, initiating a plan now to begin in 2024 puts us right on schedule for kick starting an American energy future with offshore wind all over the US OCS.

Non-Fossil Fuel Working Group

Recommendation #2

Recommendation: In order to ensure the benefits of offshore energy and mineral development to all Americans it is necessary to expand the reach of the Outer Continental Shelf Lands Act (OCSLA) to the United States Territories, Guam, American Samoa, U.S. Virgin Islands, Commonwealth of the Northern Marianas and Puerto Rico.

Nature of change: Secretary will submit to Congress a legislative amendment to OCSLA

Background

The effort to expand the OCSLA to the territories has passed one body or the other in Congress several times over the last decade, most recently in the SECURE Act (Scalise-LA), HR 4239. In addition, the Obama Administration issued a strong statement of support and the Trump Administration has continued that support. Including the U.S. territories and possessions under the leasing authority of OCSLA will result in:

- Potential Economic Activity
- Revenues
- Increased Scientific Research
- Improved Technology

Both the rebuilding of the electrical grid of Puerto Rico as part of the recovery from the hurricanes of 2017 and the significant investment of resources by the Department of Defense into Guam provide unique opportunities for energy investment in the OCS if the Department of Interior is given the opportunity to plan offshore energy development.

Analysis

According to the [Congressional Budget Office](#) enacting this provision could increase federal revenues by \$20 million over the 2018-2027 period.

Specifically, CBO says in analysis of HR 4239 that “Renewable Energy Leases on the OCS. H.R. 4239 would direct DOI to study the potential for production of electricity generated by wind off the coasts of Puerto Rico, the U.S. Virgin Islands, Guam, American Samoa, and the Northern Marianas Islands. If those studies showed that developing offshore wind resources was feasible, the bill would direct DOI to conduct lease sales in those areas. CBO estimates that implementing those provisions would increase offsetting receipts by \$20 million over the 2018-2027 period, net of payments to states and territories.

Non-Fossil Fuel Working Group

Recommendation #3

Recommendation: The Committee recommends that the Secretary direct the National Office of the Bureau of Land Management to issue an Instruction Memorandum to update and clarify solar energy right-of-way (ROW) acreage rent schedules, megawatt (MW) capacity fees, lease and grant renewal processes, bond requirements, and application priority for projects in the six southwestern states subject to BLM's Western Solar Plan (Arizona, California, Colorado, Nevada, New Mexico, and Utah), including guidance on the implementation of the rule on Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections, 81 Fed. Reg. 92,122 (Dec. 16, 2016) (the "Rule").

Nature of change: Instruction Memorandum

Background

America's multiple use public lands in six southwestern states offer some of the best solar resources in the nation and have been identified by the BLM as highly suitable and potentially suitable for such use. However, despite a solar boom on America's private lands, prevailing federal land solar policies discourage solar development on public lands.

Clarifications to and guidance on current policy should be made to ensure that multiple-use federal lands are made competitive with private lands.

Analysis

- 1. Acreage Rent** – current policy creates rent uncertainty for fixed revenue stream assets and escalates at well above market rate, contributing to public land being uncompetitive with private land
- 2. MW Capacity Fee** – current policy includes a royalty-like payment that is well above market, contributing to public land being uneconomic with private land
- 3. ROW Grant and Lease Renewal** – current policy limits solar grants and leases to 30 years, inclusive of construction period, while useful life of equipment is 35+ years, causing assets on public land to be undervalued relative to private land counterparts

Analysis

- 4. Bond Rates for Solar Grants and Leases** – current policy sets minimum solar bond rates 10x above market, inconsistent with reclamation cost estimates, causing credit terms for public land sited facilities to be uneconomic compared to private land
- 5. Variance Application Processing** – current policy puts a would-be project's site control at risk by giving BLM staff the discretion to open "Variance Process Lands" to competitive bidding, even if a proponent has expended significant funds to diligence and secure the site, causing public land to be too risky for proponents to expend development capital

Consequence: American Taxpayers are not Benefiting from Solar Development as the Rule Intended

Analysis

	Coal	Oil + Gas	Solar PV ²	Wind ³
Per acre lease rate ¹	\$3	\$1.50 - \$2	\$16.77 - \$914.10	\$1.68 - \$91.31
Capacity fee	n/a	n/a	\$2,863 / MW	\$5,010 / MW
Royalty rate	12.5%	12.5%	n/a	n/a
Minimum bond rate	\$10,000 / lease	\$10,000 / lease	\$10,000 / acre (\$15,000,000 / lease)	\$20,000 / turbine (\$1,000,000 / lease)
Federal acres available	370,000,000	564,000,000	19,600,000	19,600,000
Production (2016)	728,000,000 tons	32,636,000,000 mcf	37,000,000 MWh	227,000,000 MWh
Treasury revenue (2017)	\$558,000,000	\$6,149,000,000	n/a	\$55,000,000

1 No annual escalation for coal, oil, gas; solar, wind escalate at IPD-GDP + 4%

2 Lease rates as high as \$56k/acre in areas largely unsuitable for solar

3 Lease rates as high as \$5.6k/acre in areas largely unsuitable for wind

Equivalent standard across industries: Fair Market Value to taxpayers

Source: https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf; USEITI

Analysis

Recommendations, if adopted, would:

- Allow American Taxpayers to benefit from the ~50 GW of installed capacity anticipated by 2021
- Estimate solar treasury revenue of ~\$350M/year by 2021
- Create tens of thousands of domestic jobs

Non-fossil Fuel Working Group Recommendation #4

Recommendation: The RPC recommends that the Secretary issue a Secretarial Order grandfathering projects that were under construction or development at the time the BLM issued its “Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections (81 Fed. Reg. 92122 (December 19, 2016))”.

Nature of change: Secretarial Order

Background

In 2016, the BLM issued this rule. Prior to this rule, operators were only subject to a capacity fee. However, the new rule instituted an additional acreage fee and changed how the capacity fee is calculated.

While it does have aspects that are positive for newly proposed wind and solar projects, it carries significant financial burdens for projects that were under development at the time of issuance. This was a significant and common issue brought up by a number of commenters, including the American Wind Energy Association, the Solar Energy Industries Association and many others.

Analysis

Making this change, the U.S. Treasury can expect to see the same level of revenue from projects. It will not affect projects applying with Interior after the issuance date of the rule. At most, without this change the impacts of the new rule may put at risk projects that were under development at the time of its issuance. At the least, this change will allow projects under development at the time of rule issuance to play under the same regulatory system that was in effect when projects first started permitting with Interior.

Making this change continues Interior's commitment to advancing renewable projects on federal lands and can provide some certainty to upcoming projects that the rules of the game will not change during the course of permitting.

A large offshore oil rig is positioned in the middle ground, floating on the dark blue ocean. The rig features a prominent yellow and red structure with a tall, white and black tower. In the background, a range of mountains with significant snow cover stretches across the horizon under a cloudy, overcast sky. The overall scene is industrial and set in a rugged, high-latitude environment.

Offshore Working Group Recommendations

Presenter: Patrick Noah, ConocoPhillips

Previous Recommendation

In February 2018, the U.S. Department of the Interior's Royalty Policy Committee voted to recommend the following language:

Revise, clarify and simplify process for granting varying royalty rate for declining or particularly costly fields.

Offshore Working Group Recommendation #1

Recommendation: This follows on the previous recommendation for Royalty relief for late life or challenging assets by adding specificity as committed in the last full RPC meeting. Offshore committee recommends appropriate DOI/agency personnel consider, in their review of potential avenues for improved achievability of existing statutory royalty relief options, such factors as enhanced oil recovery (EOR); high pressure/high temperature wells (HPHT); and reservoir depths. (NOTE: 20,000 feet TVDSS is a common marker for exceptionally challenging reservoir depth.)

Nature of change: Notice to Lessees

Background

It is the committee's understanding that royalty relief is technically available to certain challenging and/or late life projects, but official dialogue at the last full RPC meeting confirmed that there has been little to no successful application for such relief in many years.

The [linked DOI data](#) seems to substantiate the absence of such successful policy application in modern OCS operations.

Background



-IHS CERA BOEM

“However, the challenge is that the key to unlock the next phase of significant volumes in the GoM lies with ultra-high-pressure exploration and development. What is still especially relevant to move projects forward in deepwater GoM are potential policy incentives specific to these ultra-high pressure developments. Without some stimulus, these volumes will struggle to compete with more attractive reservoirs in Brazil and Mexico.”

*“The wide ranges of **government takes** between **53% for profitable projects to 86% for marginal projects in Deepwater GOM** suggests a **highly regressive fiscal system that penalizes marginal fields.**” P.5*

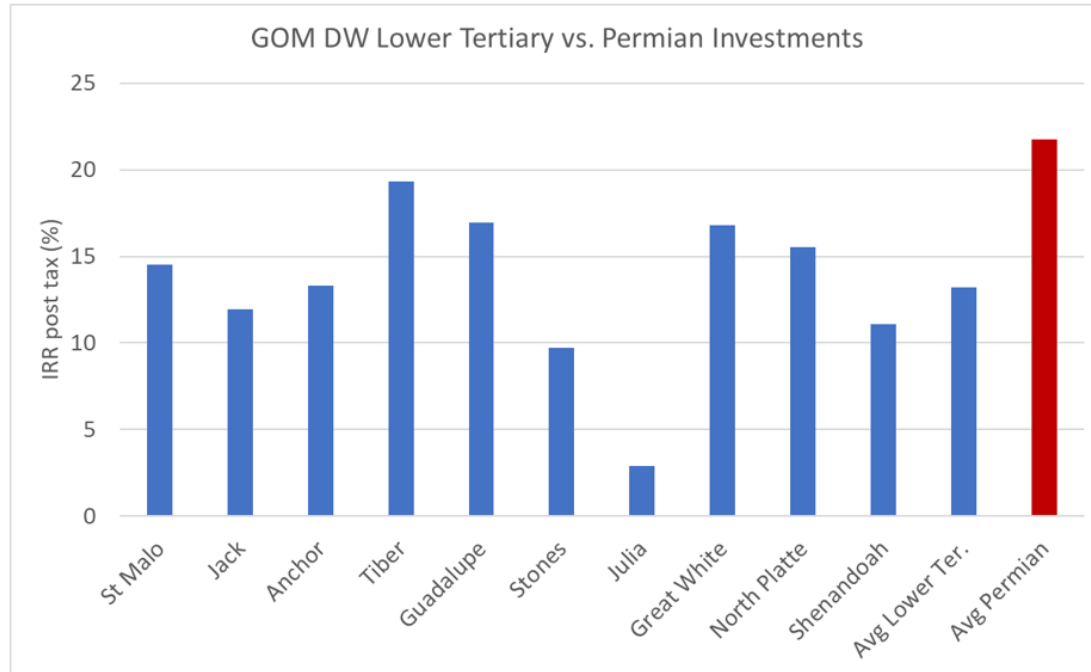
*“**The GOM is an attractive investment environment; however it is also among the most expensive** next to Alaska and other arctic environments. As exploration and production move beyond 5,000 feet, which seems to be the area with the greatest growth potential in the GOM according to EIA and DOI, achieving desirable rates of return is going to be quite challenging. P. 60*

*“...the **GOM nominal royalty rate is already higher than all offshore oil and gas jurisdictions** outside the United States.” P. 133*

Background

Current IRR of DW Lower Tertiary vs. Permian

Data Source: Wood Mackenzie's "Upstream Asset Valuation" tool Nov 2017



Current IRR of DW Lower tertiary vs Permian

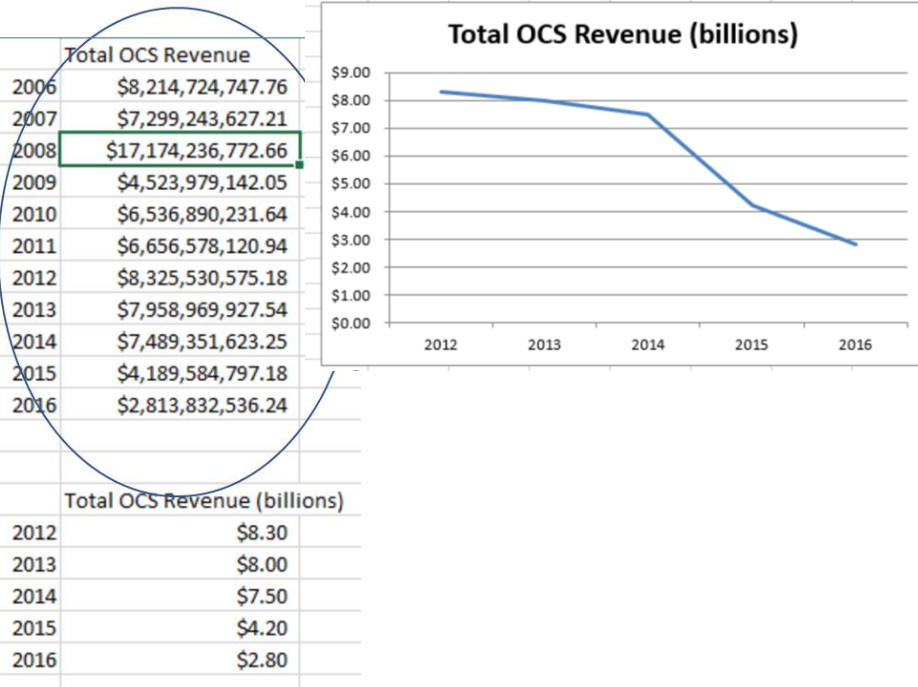
Source: Wood Mackenzie's "Upstream Asset Valuation" tool, November 2017

**IRR= Internal Rate of Return*

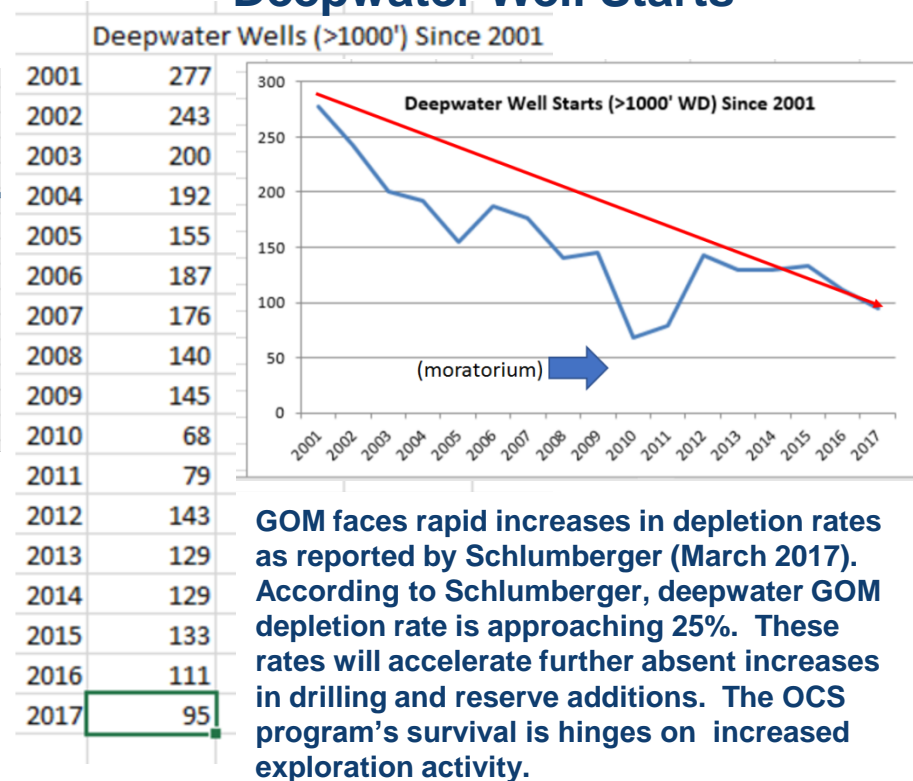
Background

10 Yr Sustained Decline in Revenue

Source: ONRR Data (CY 2017 not yet available)



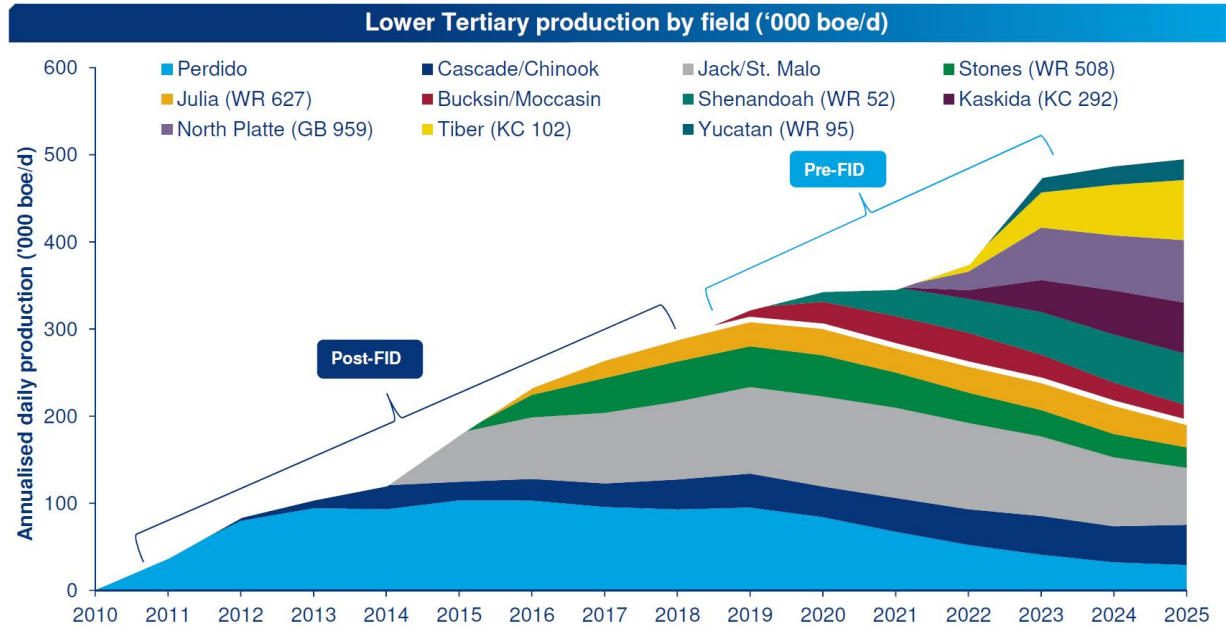
15 Yr Sustained Decline in Deepwater Well Starts



Background

Approximately 300,000 boe/d at risk by 2025 due to lower oil prices

Final Investment Decision for the next round of Lower Tertiary projects depends on a number of key factors including: 1. successful appraisal results (North Platte & Shenandoah); 2. development of HP/HT equipment and; 3. confidence in a stronger oil price. If pre-FID projects are sanctioned, we expect production to roughly triple over the next 10 years.



Source: Wood Mackenzie Upstream Data Tool (UDT) July 2015

Background

Relief is rarely sought and even more rarely approved (10 total applications; 7 approvals minus 2 withdrawn by government.)

Most recent approval was 17 years ago.

The multiple indicators of declining GOM competitiveness strongly suggest that the lack of applications in recent decades are not for lack of need, but for lack of achievability.

BUREAU OF OCEAN ENERGY MANAGEMENT

GO FULL VIEW

BOEM.GOV Online Queries Scanned Documents PDF Reports ASCII Downloads Other Resources

Data Center>>Other>>
Listing of Deepwater Royalty Relief Applications
data last updated: 05-20-2018 03:00 AM(CST)

The following is a listing of deepwater royalty relief applications received for pre-Act Fields. Please contact the GOMR with questions regarding the royalty relief status of individual leases within these Fields.

Data Grid

Customization: Export Current Grid:

Drag a column header here to group by that column

Field Name	△	Type	Action	Action Date	Suspension Volume	Withdrawn	Withdrawn Date
DC133		IDWNP	Approved	7/16/1998	87.5		
EW958		IDWNP	Approved	6/5/1997	52.5	MMS Withdrawn	12/1/1999
GB161		IDWSE	Denied	11/4/1999			
GB409		IDWNP	Approved	11/9/2001	52.5		
GB783		IDWNP	Denied	3/30/2005	0		
GC236		IDWNP	Approved	12/4/2000	87.5		
GC472		IDWNP	Approved	6/1/2001	87.5		
MC084		IDWNP	Approved	4/30/1998	87.5	MMS Withdrawn	5/23/2000
MC718		IDWNP				Operator Withdrawn	3/25/1999
MC718		IDWNP	Approved	7/23/1999	87.5		

< >

[Download the Royalty Relief Applications Raw Data](#)
[View the Field Definitions for Royalty Relief Applications](#)

Analysis

Where there are risks that certain projects either would not materialize, would materialize sub-optimally (i.e. likely to produce substantially lower EURs), or would face earlier than optimal end of asset life/abandonment but for certain royalty relief, there is a public interest in seeking the “win/win” wherein greater production volumes and associated revenues and associated benefits continue to flow to the taxpayer, government, and employment markets. Creating improved certainty and accessibility for those situations would remedy the identified risks.

An onshore oil drilling rig stands in the center of a field. The rig is a tall, lattice-structured tower with a blue and white base. In the background, there are several blue and white storage tanks and other industrial structures. The sky is filled with soft, grey clouds, and the foreground is a field of dry, brown grass with a small stream or ditch running through it.

Onshore Working Group Recommendations

Presenter: Kathleen Sgamma, Western Energy Alliance

Onshore Working Group Recommendation #1

Recommendation: BLM should issue an Instruction Memorandum (IM) directing all field offices to issue Categorical Exclusions (CX) when any of the Energy Policy Act of 2005 (EPAAct 2005) Section 390 criteria are met.

Nature of change: Instruction Memorandum

Background

Lengthy Application for Permit to Drill (APD) timeframes often occur because BLM is conducting redundant NEPA analysis rather than granting CXs when companies meet the criteria under Section 390 of the EAct.

BLM data show APDs take 260 days on average.

BLM should issue guidance that CXs must be used when a company meets any of the statutory Section 390 criteria.

The Section 390 CXs are mandated by EAct 2005 and should not be discretionary.

Use of CXs would reduce APD processing time, avoiding redundant NEPA analysis and allow analysis on non-CX activities.

Onshore Working Group Recommendation #2

Recommendation: In an effort to reduce NEPA processing timelines and increase regulatory certainty on public lands, project-specific NEPA documents should be scoped to the actual impact of projects and limited to best-available information, tiering to existing environmental analyses already analyzed in prior NEPA documents. Project proponents should not be required to fund new research to produce data that go beyond the scope of the project.

Nature of change: Instruction Memorandum or Guidance to NEPA staff

Background

NEPA analysis can take up to ten years for larger projects, and even small project NEPA documents can take three to five years.

The Royalty Policy Committee has evaluated reducing NEPA and other approval timelines to encourage more development and hence, increase royalty revenue.

To implement Secretarial Order 3355 (one year time frame and 150 pages NEPA documents should focus on actual, not speculative, beyond the scope of the proposed project.

Tiering to existing environmental analyses should be used wherever possible.

NEPA documents should also be scoped to best available information. Processing of NEPA documents should not be put on hold while waiting for new research to be completed.

Onshore Working Group

Recommendation #3

Recommendation: BLM should use the opportunity as it updates IM 2009-78 Processing Oil and Gas Applications for Permit to Drill for Directional Drilling into Federal Mineral Estate from Multiple-Well Pads on Non-Federal Surface and Mineral Estate Locations (otherwise known as the fee-fee-fed IM) to avoid unnecessary NEPA analysis of impacts to nonfederal surface when multi-well pads develop both federal and nonfederal minerals from off-lease, nonfederal surface locations. Similar, this guidance should avoid unnecessary analysis of horizontal wells that develop a minority of federal minerals.

Nature of change: Guidance to NEPA planning staff

Background

NEPA analysis need not consider impacts from nonfederal actions that would occur independently of a federal authorization such as when a multi-well pad is sited on off-lease, nonfederal surface to access nonfederal minerals.

BLM should provide clear concrete guidance for distinguishing between situations in which multi-well pads are and are not determined by access to the federal mineral estate. There should be a presumption that a multi-well pad developing both federal and nonfederal minerals is sited to access the nonfederal minerals, unless specific facts demonstrate otherwise.

NEPA analysis need not consider all impacts of drilling a well that develops a minority of federal minerals. BLM should establish clear guidance for analyzing impacts of horizontal wells that develop a minority mineral interest.

BLM should not conduct unnecessary analysis of impacts from nonfederal actions that would occur regardless of whether BLM approves an APD.

Onshore Working Group Recommendation #4

Recommendation: The Department of the Interior should rewrite Onshore Orders 43 CFR 3173 , 3174, and 3175 by adopting API standards and GPA standards in their entirety.

Nature of change: Full rulemaking process

Background

The rulemaking should fix the retroactive aspects of the existing rule that threaten existing unitization and commingling agreements.

- The simplest and most equitable means of modifying the regulations would be to adopt the American Petroleum Institute (API) and GPA Midstream (GPA) standards in their entirety.
- Continue to honor all variances, commingling agreements, and off-site measurement agreements approved prior to the effective dates of the new rules.
- Existing Commingling and Allocation Approval: BLM should consider a provision in the rule to define “economically marginal” that would establish when commingling of production is allowed from a property.



Alaska Working Group

Presenter: John Crowther, State of Alaska

Update

The Alaska Workgroup is not bringing forward any formal recommendations at this time, but has a number of topics under discussion related to our prior recommendation and potential upcoming recommendations:

- DOI has begun the NEPA scoping process for leasing in the 1002 Area, and we expect robust involvement from the State government and local stakeholders.
- The National Petroleum Reserve-Alaska continues to be an important new exploration opportunity for federal production, and DOI needs to ensure appropriate acreage is available and permitting is coordinated and efficient.
- The OCS 5 year planning process continues in Alaska, including planning for a 2019 lease sale in the Beaufort sea area. These are significant long-term national opportunities.
- Federal royalty valuation for OCS transportation costs and other factors should take into consideration the Alaska-context to promote production.



Coal Working Group

Presenter: Matthew Adams, Cloud Peak Energy

Update

The Coal Workgroup is not bringing forward any formal recommendations at this time, but has a number of topics under discussion:

- The Coal Workgroup has reviewed the Lease By Application process and discussed potential changes. We have reviewed a number of concepts, but do not have a recommendation at this time.
- The Coal Workgroup has discussed and attended presentations covering the current permitting and review processes necessary for new coal projects. We will continue to focus on this area.

Studies Working Group

Presenter: Emily Kennedy Hague
American Petroleum Institute



Update

The PAC Studies Workgroup, working with BOEM and BLM subject matter experts, has kicked off an effort to analyze modeling conducted within the Department. The team plans to review existing model assumptions and how the bureaus review and update those assumptions periodically to stay in line with current economic conditions. The group will also explore how the models are used within the Department to inform policy decisions and also look to see if there are gaps or additional factors that should be included within the models.



Thank You

Planning, Analysis and Competiveness Subcommittee

Recommendation: TERA

Tribal Energy Subcommittee

Royalty Policy Committee

TERAs: Tribal Energy Resource Agreements

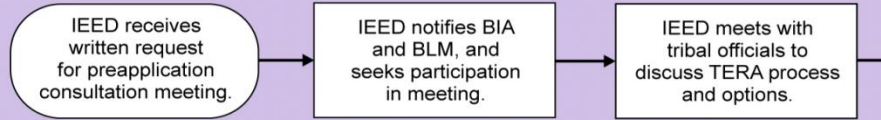
- ▶ Authorized through the Indian Tribal Energy Development and Self-Determination Act, Title V of the 2005 Energy Policy Act
- ▶ Authorizes Secretary of the Interior and a tribe to enter into a TERA
- ▶ Authorizes tribe to develop and approve its own leases, business agreements, or rights-of-way for a broad range of activities related to development of energy resources **without requiring secretarial approval** for each lease, agreement, or right-of-way

No Tribe Has Yet to Enter into a TERA: some of the hurdles

- ▶ Undefined limitation on the scope of TERA: a tribe cannot assume “inherently federal functions”
- ▶ Tribal Environmental Review Process, similar to the federal National Environmental Policy Act process
- ▶ Unknown funding for tribes to engage in NEPA like compliance
- ▶ Demonstration of tribal capacity
- ▶ Opportunity for Review and Comment of TERA

As of 2015, at least six (6) tribes had requested preapplication meetings to discuss establishing a TERA

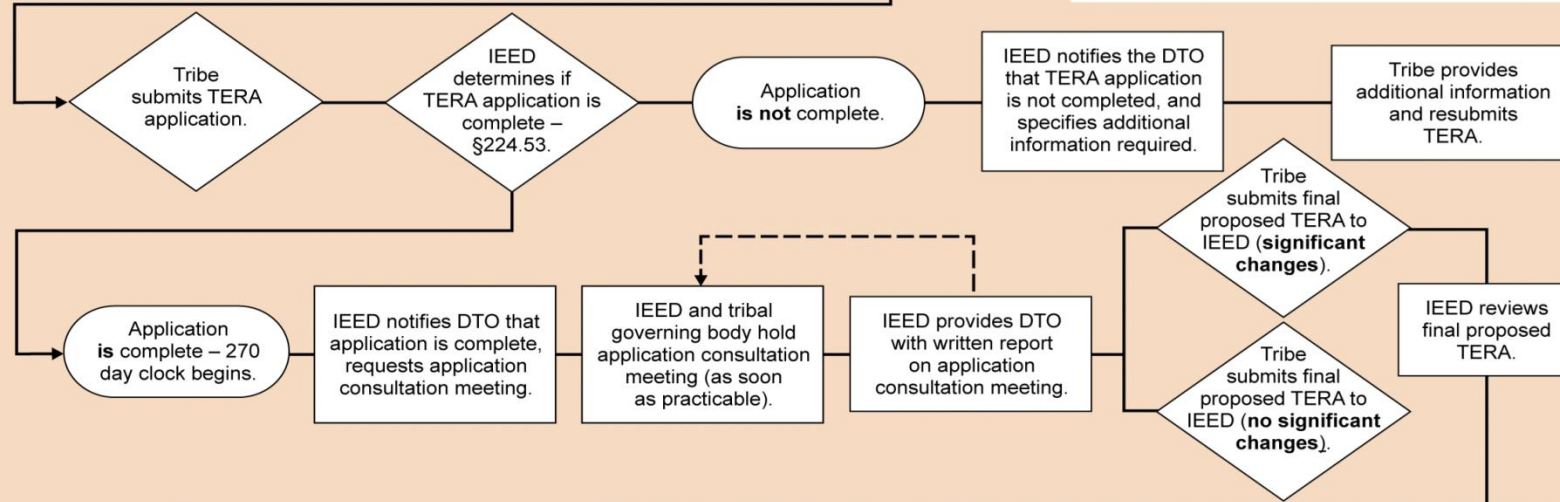
TERA preapplication consultation



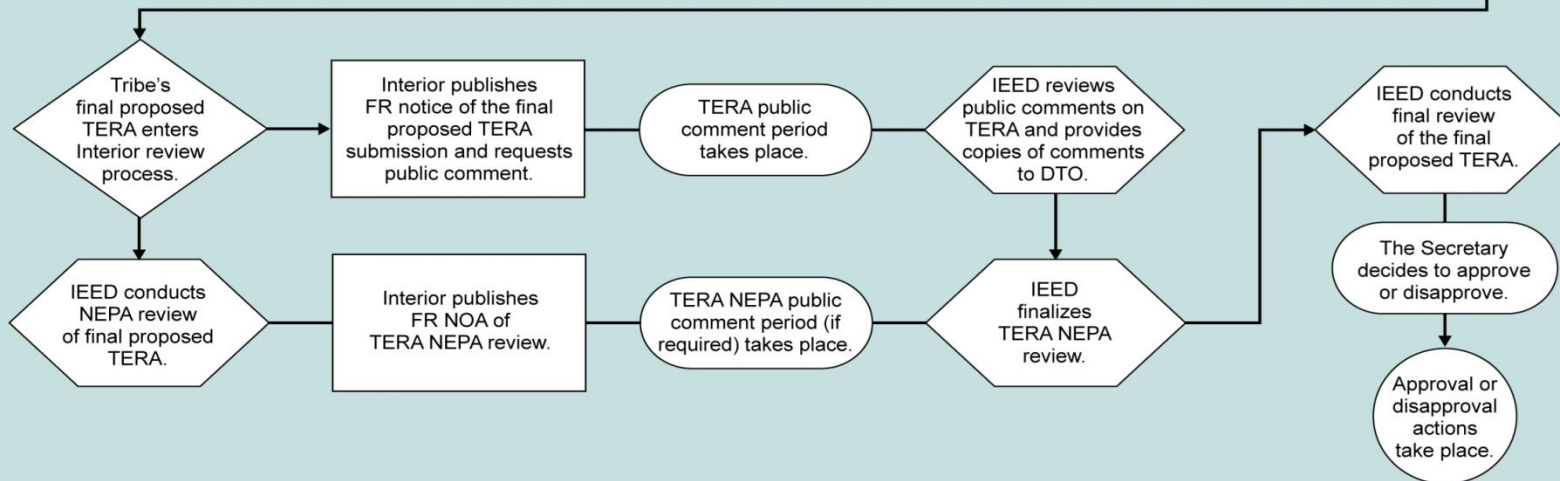
Abbreviation legend:

BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
DTO	designated tribal official
FR	<i>Federal Register</i>
IEED	Office of Indian Energy and Economic Development
Interior	Department of the Interior
NEPA	National Environmental Policy Act
NOA	Notice of Availability
TERA	Tribal Energy Resource Agreement

TERA application submission and review



Interior (IEED) TERA review



Recommendation: 2015 GAO Report Indian Energy Development

- ▶ For the Department of the Interior to provide additional energy development-specific guidance on provisions of TERA regulations that tribes have identified as unclear.
- ▶ Specifically:
 - ▶ TERA regulations authorize tribes to assume responsibility for energy development activities that are not “inherently federal functions.”
 - ▶ DOI has not provided guidance on what are non inherently federal functions
 - ▶ Lack of guidance prevents tribes from knowing what it can and cannot perform and where to build capacity

Recommendation

- ▶ Entire Recommendation is represented in the two page document
- ▶ Recommendation redrafted after the Houston RPC meeting
 - ▶ DOI staff very helpful in suggesting a recommendation that will be actionable
 - ▶ Incorporates lessons learned from preapplication discussions from __ tribes in 2006 - 2008

Recommendation is Provided because:

- ▶ Development of energy resources on tribal lands is critical to develop energy independence of the United States.
- ▶ Clarifying TERA is wholly within the authority of DOI to do.
- ▶ TERA is an existing tool that in theory can be refined relatively quickly so that it can fully utilized and tested as a tool for enhancing tribal flexibility in energy development and advance the United States' overall energy development portfolio.

TERA Work Group

- ▶ John Andrews
- ▶ Bidtah Becker
- ▶ Kathleen Sgamma
- ▶ Chris Stolte
- ▶ Joshua Campbell



JAN 2019	FEB 2019	MAR 2019	APR 2019	MAY 2019	JUNE 2019	JULY 2019	AUG 2019	SEPT 2019	OCT 2019	NOV 2019	DEC 2019
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Subcommittees continue work.

January 31, 2019
Committee Meeting
Phoenix, AZ

Subcommittees continue work.

May 2, 2019
Committee Meeting
Pittsburgh, PA

Subcommittees continue work.

August 7, 2019
Committee Meeting
Salt Lake City, UT

2019

TENTATIVE TIMELINE FOR FUTURE COMMITTEE MEETINGS

Title: 3 ways to save your future

An energy consultant for the DOE, Athena Christodoulou understands solar, including the technology, policy, and business. A retired Navy Commander, she earned a B.S. in civil engineering, M.S. in environmental engineering, and most recently at UNM, a Professional Science Master in nanoscience and business management. She is also the president of the NM Solar Energy Association and co-founder of Udorami.com. She is currently developing solar projects in the Solar in Your Community Challenge, managing the Solar Fiesta for October 20, and absolutely determined to be personally fossil fuel free by 2023.

Sorry that this is in the form of a speech. But main points are clear and in boxes.

Look at history

Remember, Syria was once part of the fertile crescent. Look what ^{cheap} gas + oil did for them!

Fracking
Read Chapter 17, Revelation. Consider that Fossil Fuels

is the beast, Royalty committee = Kings without kingdoms along with CEOs

Close your eyes - gravity, don't explore past the horizon thinking the Earth is flat, or to burn fossil fuels in the name of comfort, convenience, and money without paying the consequences?

Open your eyes. Welcome to the United States of America. A once great country that is now led by people believing we can continue our flamboyant fossil fuel ways at YOUR expense.

My son, Mark, came home for Easter

like UNM, with a diverse opinions. different view of science! "Flat Earthers." NOT so logical reasoning. Mostly ignoring evidence-based science.

latching onto such malarky. my generation
It all begins by closing your eyes and ignoring the evidence.

Sort of like playing peek a boo with a baby.

But unfortunately, the problem isn't going to go away by ignoring it, relegating it to...later, or can't afford to make the necessary changes.
We can't afford NOT to make changes.

Here's my top three recommendations for you

first, **Beware of Flat Earthers.** Forget Climate Change deniers, I'm calling them Flat Earthers from now on. Same idea, different scientific principles.

Caution: I am a reformed Flat Earther: AS recent as 2015, because we were misled, brainwashed and deceived by industry and some leaders. Embrace the reformed Flat earthers because now we KNOW

Scientists have determined, and recent disasters have confirmed, continuing to extract fossil fuels for combustion is disastrous for human life

It was, is not, yet is = algae changed to fossil fuels

comes up from the bottomless pits = wells, mines, fracking (mikedown mile across?)

on earth. NO fossil fuel burning is worth the price you'll pay. Even Natural gas. ^{These are} methane explosion of GHGs. Burns cleaner, but fracking, flaring, transporting, processing, venting, and leaks make it as bad as coal. Flat Earthers will try to **distract** you, **belittle** your efforts and **make you feel sorry** for simply making choices which hurt their wallet.

So Beware of Flat Earthers (but embrace the reformed) Top down approach
Second, Stay or get involved with the right advocacy groups on focused projects (legislative actions) ~~Top down approach 350NM, Sierra Club, Environment NM~~

Top three - From an engineer and scientist who agrees with the rest of the scientific community

- 1) 100% Clean Renewable energy for making electricity at home or by utilities by 2040 aim high!
- 2) Stop subsidizing fossil fuel extraction with ^{low royalty fees} oil depletion allowances etc.
- 3) Electrify our transportation sector quickly - several routes using carrot and stick. take away depreciation for heavy vehicles.

~~350NM.org, Sierra Club, Environment NM~~

~~Not~~ Top Down by focused involvement

Third - (where NMSEA excels!) Ditch the fossil fuels! No quemas tu futuro. Don't burn your future. Go fossil fuel free yourself - Can't demand they stop drilling, fracking, and mining unless we stop our demand for those same fossil fuels.

sit down and think of all the ways you personally burn fossil fuels or create Greenhouse Gases. a list. a whole scary spreadsheet. and I've started a plan to whittle **dependence** on fossil fuels.

Does that mean no more comfortable home, hot showers, travel, convenience, etc. Am I going to go on the "Living off the Land" show?

Heck no! Thanks to the sun and technology. 90 minutes ~~to~~ of sunshine provides enough energy to power humanity for a year!

Stop your insidious attitude

And goes to perdition = Burns in its own destruction (combustion)

Now, I have a whole list of options and none of them include living in a cave and reverting to a hunting and gathering lifestyle.

But they do include a mindful stewardship of our planetary resources. I mention planetary. We have been to the moon and have sent a Tesla into space. Trouble is, we haven't actually lived there.

So what can an Earthling like you do? If you try to do it all at once, you're going to get frustrated, and end up doing nothing at all. We

must be the generation of reformed Flat Earthers Assess, Plan, and Act over a fifteen

year period.

finish this ~~committee~~ administration

For you, though, before you leave college. Make it your goal, because you're going to have to lead my generation to do what's right. If you haven't figured it out yourself, get cracking.

Then, to coax the reformed, mention that it's so old school to cling to items like the internal combustion engine and gas cookstoves.

Make us sit up as you zoom by in your ALL electric vehicle, (trucks coming soon!)

ASK us, Do you still have a rotary-dial telephone?

In Summation

Beware of Flat Earthers (though embrace and encourage the reformed), get involved with the right group working on focused projects. And finally

Ditch the Fossil Fuels! - No quemas Tu Futuro

Dept. of Interior should be making oil & gas pay their fair share, not perpetuate the destruction of our future

Counties with Fossil Fuels Royalty Committee, CEOs of FF
Involves 7 kingdoms and 10 Kings w/out kingdoms =

A B C D E F
1 2 3 4 5 6

Fracking Fossil Fuels = 6666



MANDAN, HIDATSA & ARIKARA NATION

Three Affiliated Tribes * Fort Berthold Indian Reservation
Tribal Business Council

Mark N. Fox
Office of the Chairman

Tribal Priorities for the Department of the Interior Royalty Policy Committee June 6, 2018

Introduction

The Mandan Hidatsa and Arikara Nation (MHA Nation) strongly recommends that the Royalty Policy Committee and its Tribal Energy Subcommittee refocus and prioritize efforts to bring immediate and needed relief for Indian energy development. In addition to addressing state dual taxation, the Subcommittee should focus on providing Indian tribes with the same relief from overly burdensome National Environmental Policy Act (NEPA) review as is being recommended for federal public lands.

The Tribal Energy Subcommittee is currently working to:

- 1) Propose improvements to Tribal Energy Resource Agreements (TERAs),
- 2) Draft a Model Statute for Indian energy development,
- 3) Propose changes to the 1938 Indian Mineral Leasing Act; and
- 4) Address status dual taxation of Indian energy development.

With the exception of state dual taxation, these are all longterm efforts. Two require Congressional approval and TERAs require tribes to take over an already unmanageable process without federal budget funding or the tax revenues needed to do the work. Indian energy development needs immediate relief.

State Dual Taxation

We recommend that the Subcommittee continue its work to address state dual taxation of Indian energy development. Addressing state dual taxation is the single biggest drain on tribal economies and Indian energy development. As you may know, over the last 10 years the State of North Dakota took more that \$2 billion in taxes from the MHA Nation's Fort Berthold Indian Reservation including \$1.2 billion from lands and minerals held in trust for the MHA Nation. During this time, and over the next 10 years, our tribal nation has and will experience a \$6 billion budgeting shortfall. Meanwhile, the state continues to build a \$4 billion legacy fund, with a significant portion coming from Fort Berthold tax revenue.

State dual taxation can be addressed through regulations. Interior already has volumes of data on the negative impacts of state dual taxation on Indian energy development and all other areas of tribal economic activity. Interior should revise the regulations implementing the Act of March 3, 1909 (25 U.S.C. 396), the Indian Mineral Leasing Act of 1938 (25 U.S.C. 396a), the

Indian Mineral Development Act of 1982 (25 U.S.C. 2102), and the Energy Policy Act of 1992 (25 U.S.C. 3503) to eliminate dual state taxation.

NEPA Streamlining

The Subcommittee should study and make recommendations that would streamline NEPA review for Indian energy projects similar to the recommendations of the Planning, Analysis, and Competitiveness Subcommittee. NEPA was never intended to apply to Indian lands, but has become one of the greatest barriers to Indian energy and economic development. Instead of forcing tribes to take over managing NEPA review through TERAs, we need to streamline NEPA review under the mineral leasing laws that are in use by Indian tribes.

Even without the authority that the Bureau of Land Management (BLM) was granted under the Energy Policy Act of 2005, the Bureau of Indian Affairs (BIA) could streamline NEPA review for Indian energy projects through a variety of methods:

- 1) *Programmatic NEPA Review.* BIA should develop guidance and implement a policy of preparing programmatic NEPA documents for areas with a high level of permitting or development. While a programmatic NEPA document could cover an entire reservation, these need not be reservation-wide. A programmatic NEPA document could cover a limited geographic area with similar characteristics, or a certain kind of development.

BIA is also notoriously slow in completing programmatic NEPA documents. Interior should provide the budgets, staffing and expertise for BIA to complete these documents. Other Interior agencies should lend staff and expertise as needed.

- 2) *Determination of NEPA Adequacy.* In areas with high levels of energy development and existing NEPA reviews for similar types of energy development, BIA should work with Indian tribes to make “Determinations of NEPA Adequacy” or DNAs in appropriate cases. DNAs are already used by BLM and BIA should adopt BLM’s guidance for using DNAs.
- 3) *Categorical Exclusions.* BIA should develop categorical exclusions for certain types of energy development. Rather than continuing to review similar kinds of energy projects in similar geographic areas, BIA should develop best practices and standards for types of energy development and then categorically exclude projects that adopt those practices and standards. An over arching theme for these categorical exclusions would be acting on a government-to-government basis with Indian tribes and acting in the best interests of the Indian trust mineral owner.

BLM IM 2009-78 Revisions

The Tribal Energy Subcommittee should also assess revisions to BLM Instruction Manual (IM) 2009-78 as the Planning, Analysis, and Competitiveness Subcommittee is doing. Most important, IM 2009-78 should not apply within Indian reservations because of existing

jurisdictional complexity. As a result of the federal government's allotment policies, Indian reservations are often a checkerboard of tribal, federal, state and private lands. Despite this checkerboarding, tribal laws and regulations apply to activities on those lands.

BLM IM 2009-78 does not account for this jurisdictional complexity and is designed for federal public lands, not Indian reservations. On Indian reservations, tribal, federal and state governments may all have jurisdiction over a particular energy project. By limiting NEPA review under IM 2009-78, BLM can create a situation where the lead federal agency approves a project that may require additional review by another government. Or, BLM may limit the production of information needed by other governments.

BLM has a trust responsibility and a government-to-government relationship with Indian tribes. This includes cooperating with Indian tribes on energy permitting within Indian reservations and working to overcome the impacts of the federal governments failed allotment policy. To help address these issues, BLM IM 2009-78 should be revised to not apply to projects within Indian reservations.

June 6, 2018 Department of Interior Hearing for Royalty rules

When I invited some people of faith to this Royalty hearing, they immediately asked who is the royalty? This got me to thinking about the disparity between special interest royalty that seems to be focused on accumulating wealth at the cost of the common good, school children, future generations and the effects of greed in relationship to climate justice.

This hearing is about justice, fairness and the common good. Some of the earliest written guidance for how to live in society with a sense of the Common Good is found in the Epistle of Paul: "Do not live entirely isolated, having retreated into yourselves, as if you were already fully justified, but gather instead to seek together the common good."

This hearing should be about seeking what is fair and protects the common good. Just and fair royalties, lease pricing, and rules that capture methane gas pollution from oil and gas production should be the foundation of good and responsible stewardship. New Mexicans and our school children require fairness and good stewardship.

To St. Thomas Aquinas the common good was the goal of law and government. James Madison saw common public good as justice tied to the end result of government and society. The common good is the end of government and for the good of all its citizen and no government should become the "perverted servant of special interests."

Confucian thought states that there should be a mutual flourishing between an individual and the group. Islamic tradition speaks of Sharia law which holds the concept of common good or public interest of the collective.

St. Augustine of Hippo in the City of God stated that the normative political thought should be upon well being of the whole society and the common good. Contemporary Catholic teaching believes that "[T]he common good [is] the good of all people and of the whole person... The human person cannot find fulfillment..., apart from the fact that he/she exists "with" others and "for" others" (#165; italics original). "The goal of life in society is... attainable common good" (#168). Pope Francis from his encyclical on Care of Our Common Home would add our Sister Mother Earth with all her creatures and creation as members of the common good. Our discernment in how we responsibly and fairly utilize the resources which none of us have created or own and are really sacred gifts. How far we have strayed from these guiding truths.

Today we wear white as an SOS. SOS's are major alerts to grave danger, or to save someone from death. Today we warn SOS because we face death on several levels. In religious terms we might say this SOS is about Saving Our Souls. SOS for Sister Mother Earth who cries as we loose our souls to a mentality of extraction to the point of extinction and climate change. SOS the children cry as they seek a properly funded education from resources that are being stolen from their future. SOS we cry to save our souls because the sickness of greed is wiping out what it means to be brothers and sisters. The Old Testament Book of Amos states, "You have my judgment, because you sell the righteous for silver and the needy for a pair of sandals. You trample on the heads of the poor as on the dust of the earth; you push the needy out of your way." Please answer this SOS with ethical and moral decisions.

Peggy Deneweth, SC
Sisters of Charity
Anthony, NM

Carol Wirtz, SC
Sisters of Charity
Anthony, NM

Rev. Karen Bash
Retired United Church of Christ Minister
Albuquerque, NM

Rev. Allen Bash
Retired United Church of Christ Minister
Albuquerque, NM

Rev. Alexander Lenzo+
Priest, St. Francis Episcopal Church
Rio Rancho, NM

Public Comments to the Interior Royalty Policy Committee
June 6, 2018
Dan Bucks

My name is Dan Bucks, former Montana Director of Revenue and former Executive Director of the Multistate Tax Commission.

I would request this committee reconsider through a meaningful public process the recommendations approved on February 28. Those recommendations, the product of closed subcommittees, were publicly released only a few days prior to the meeting, preventing thorough analysis and submittal of written comments by the public before action was taken. Further, time for public input at the meeting was inadequate for any detailed input to the committee.

Given the inadequacy of public input, there are serious issues this committee did not consider regarding the February recommendations. I am attaching an analysis prepared since that meeting for four of those recommendations to illustrate issues not considered. Without an adequate public process, the February actions are simply illegitimate and should be reconsidered.

As to new items, the PAC Subcommittee proposal to repeal onshore oil and gas measurement orders and replace them with industry-adopted procedures would establish unacceptable industry control of government decision-making. Delegating Interior's authority to private industry groups whose decision-making is neither accountable nor open to the public is bad policy and legally questionable. Government agency presence in the industry standards program does not cure the delegation of authority problem—and still leaves the public who owns the oil and gas in the dark and out in the cold.

This committee should remember that excessive industry influence has played a major role in the recurring scandals of fraud and abuse regarding federal minerals—even as recent as a decade ago. Proposals to expand industry influence over mineral policy will justifiably be greeted with public mistrust and resistance.

The justification for the proposal makes sweeping assertions that the existing orders are “burdensome” and “threaten unitization and commingling agreements.” There is no empirical evidence presented to support these assertions. There is not even a description of or link to the industry standards to be adopted under this proposal. Without a clear public record and reasonable basis being established for this proposal, it should not be approved.

With regard to the proposal to expand rate relief in challenging offshore situations, there is a larger policy issue for both offshore and onshore production that should be evaluated before more relief is authorized as to the wisdom of subsidizing otherwise non-economic production and violating free-market principles of equitable competition among energy sources.

Analysis of Royalty Policy Committee Recommendations Meeting in Houston, Texas, February 28, 2018

Dan R. Bucks
June 2018

Executive Summary

Meeting in Houston, Texas, the Royalty Policy Committee made a suite of technical recommendations that effectively move toward converting vast public lands into fossil fuel production zones at bargain basement prices—short-changing the American people and local communities where production occurs. They have sent recommendations to Secretary Zinke as described in this document that propose to:

- Surrender Interior’s authority to value minerals to natural gas and coal companies,
- Inflate royalty loopholes and exemptions,
- Undermine the Interior’s Office of Natural Resources Revenue (ONRR) as the public’s last line of defense for securing a fair return for the American people from the minerals they own,
- Increase fossil fuel industry control of the future use of public land—pushing aside other beneficial and sustainable uses of public land of broad public benefit that are otherwise intended to be served under law, and
- Lay the groundwork for linking U.S. minerals policy to whatever concessions, secret or otherwise, that fossil fuel companies persuade rulers in other countries to give them.

All of this—with more to come—would be pursued under the banners of “energy dominance” and “making Interior a better business partner with the energy industry” instead of what is required of Interior by federal law: to be an effective steward of public lands used for multiple public benefits and a prudent trustee of the mineral wealth that belongs to the American people.

These recommendations are also based on a false promise of generating more production and more jobs—outcomes that history and sound economic analysis has proven time and again will not arise from the subsidies being proposed. Instead, the proposals will pad corporate profits, fund corporate stock buybacks, and boost executive bonuses.

Federal law requires that each volume of oil, gas, and coal extracted produce a fair return to the American people. The law also requires Interior to sustainably manage federal lands for multiple uses: Clean air and water, a healthy landscape with abundant wildlife, preservation of historical and cultural resources, renewable energy, agriculture and forestry, oil, gas and mineral extraction, and other activities—all to be evaluated in balance with each other for use of the federal land. The recommendations would, instead, grant companies power to pay less than fair value for minerals and enable fossil fuel production to dominate the public domain. The public would pay twice: once in underpaid leases and royalties and again in benefits lost from being denied other beneficial and sustainable uses of the land.

The recommendations should be firmly rejected in their current form.

Dan Bucks served as Montana Director of Revenue from 2005-2013 and as Executive Director of the Multistate Tax Commission from 1988-2004.

Index of RPC Recommendations and Analysis

General Comments

Page 3

The American people and resource-dependent states and communities have been chronically short-changed by federal mineral practices that fail ensure a fair return on the minerals owned by the public.

There is no evidence to support the idea that cutting mineral lease or royalty payments will increase production. To the contrary, higher tax and royalty rates are often correlated with higher production.

Subsidizing fossil fuel leases on public lands unfairly crowds out other beneficial uses of public lands that, by law, have the right to be given balanced consideration in land management decisions. The public pays twice: once in underpaid leases and royalties and again in benefits lost from being denied other beneficial uses of the land.

RPC Proposal Re: Index Pricing for Natural Gas Royalties

Page 5

The RPC proposal improperly surrenders Interior's authority to value minerals to the natural gas industry and potentially short-changes the American people and local communities where the natural gas production occurs.

RPC Proposal to Exempt Natural Gas from Royalties

Page 7

Residue gas has economic value in performing a marketable function, and Americans are entitled to a royalty on this value. The exemption proposal is unjustified.

RPC Proposals on Coal Valuation

Page 8

The RPC coal valuation recommendations unacceptably transfer control of valuations from Interior to coal companies, disable ONRR audits as a means of protecting the interests of the American people, expand opportunities for coal companies to underreport mineral values, and likely violate both administrative and leasing laws. They should be firmly rejected.

RPC Proposals on Competitiveness Studies for Oil and Gas Policies

Page 13

RPC proposals for "competitiveness studies" comparing U.S. mineral revenue policies with other nations is contrary to the fair return policy of federal law and risks linking U.S. mineral policies to those granted by rulers in other nations where serious questions exist about corruption and bribery affecting mineral extraction practices. Heady down this path endangers the integrity of U.S. policy and the degradation of public resources.

General Comments

The following comments, presented to the February 28, 2018, Royalty Policy Committee meeting, provide a framework decision-makers should apply in setting policies for leasing federal minerals and determining appropriate royalties:

In managing public resources, we should recall our moral obligation to pass on to our children and grandchildren a clean and healthful environment with federal lands conserved for their continuing enjoyment. That obligation is linked to Interior's legal duty to ensure the American people receive fair value for the minerals they own. Fair value is the sum of the market value of energy plus the cost to society of environmental, health and other damages energy producers fail to mitigate. When producers fail to pay full market value plus the cost of damages to society, Interior breaches its duty under federal law and its obligation to future generations.

However, analysis of the specific recommendations below evaluates items in relation to whether they ensure that royalties match the first level threshold of market value. Consideration is not given here to the second threshold of royalties also covering the costs imposed on society by energy production that producers fail to mitigate. Attaining market value is a necessary but not sufficient condition for royalties to return fair value to the American people.

The history of Interior's administration of the federal minerals has been marred by mismanagement and recurring scandals. Prevailing evidence is that Interior has, the history of public minerals leasing, failed to achieve consistently fair market value for fossil fuels extracted from federal land. Interior's practices need to move in the direction of finally attaining the full and fair return for the American people that the federal leasing law requires. Unfortunately, the items recommended by the RPC would move in the wrong direction by reducing lease and royalty payments further below market value. Thus, the analysis here focuses only on preventing those steps backward from the market value threshold.

The committee discussion at several points referred to using reductions in royalty payments to encourage higher levels of fossil fuel production from federal lands. There are several problems with this policy direction. The first is that the federal law requires that royalties and bonus bids reflect fair value and not a lesser amount provided to spur production. Amounts less than fair value are subsidies, and that standard in federal law does not authorize general subsidies.

The second problem is that even if it were not contrary to law, there is no indication that reducing royalty or lease payments would increase production. A study by the U.S. Council of Economic Advisors¹ and a report by the General Accountability Office² (which relies in part on the Council report) do not support for the notion that cutting royalties will result in more production.

¹ U.S. Council of Economic Advisers, "The Economics of Coal Leasing on Federal Lands: Ensuring a Fair Return to Taxpayers." June 2016, found at:

https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160622_cea_coal_leasing.pdf.

² General Accountability Office, "Oil, Gas and Coal Royalties," GAO-17-540, June 2017, found at:

<https://www.gao.gov/assets/690/685335.pdf>.

Montana's experience in the late 1980s of cutting its coal severance tax rate from 30 to 15 percent—much larger than any royalty reductions under discussion—did not materially increase coal production in that state. Coal production remained essentially flat for 15 years after the rate cut. Further, repeated Montana Department of Revenue research studies comparing regional state oil and gas severance taxes found no evidence that lower severance tax rates spurred oil and gas production. To the contrary, states with the highest taxes often had the highest production. Similarly, states with the highest royalty rates have the highest production. Texas, the largest oil-producing state, charges 25% for royalties on state-owned oil and gas production—twice the federal rate. Two other major producing states—New Mexico and North Dakota—charge royalties at the rate of 18.75%. The realities of geology, production technology, and market prices determine production levels, not taxes and royalties. Cutting royalties and lease payments to spur production is a foolish, wasteful and ineffective policy.

The third problem of subsidizing fossil fuels through below value royalty and bonus payments is that they also conflict with the required multiple use management of federal lands. Interior cannot put its thumb on the scale to artificially favor one use of land—fossil fuel energy—over other public uses. Fossil fuel subsidies unfairly crowd out conservation, wildlife, recreational, historical, cultural, and alternative commercial uses of public lands. The public pays twice: once in underpaid leases and royalties and again in benefits lost from being denied other beneficial uses of the land.

Further, after leases for oil, gas or coal are granted, they can lie dormant for a long time—even longer than their initial stated terms because of frequent extensions and suspensions. The potential for fossil fuel production on public lands in the distant future tends to cause federal land managers to reduce their consideration of other uses of the land surface over the mineral estate. So subsidies for fossil fuel development, especially low-priced leases prices that also lock in low royalty terms, can deny the public the benefits of other uses of the public land over several decades—even if the mineral leases are never developed.

Recommendation for Use of Index Pricing for Natural Gas

Issue:

In conceptual terms, the use of index prices for valuing minerals extracted from federal lands is a potentially promising approach that deserves consideration if designed and implemented properly through a transparent and accountable public process. However, Royalty Policy Committee (RPC) recommendation for price indexing federal natural gas is deeply flawed and unacceptable. Index pricing is only as good as the index used. The RPC recommendation would require the industry to approve whatever price index or average price is used for each geographic area, giving it veto power over decisions that should be instead be made by Interior through a public process. Under the proposal, industry can steer the selection of prices for various geographic areas to those that understate the market value of natural gas. The proposal improperly surrenders Interior's authority to value minerals to the industry and potentially short-changes the American people and local communities where the natural gas production occurs.

Discussion:

The RPC recommendation fails to provide certainty to the public that it is receiving royalties reflecting market value for the natural gas it owns. Instead, it enables for the natural gas industry to pay royalties on values that fail to yield a fair return. Indeed, one argument industry makes for their "industry veto" is that the 2017 valuation rules produced values they considered too high, a judgment the public can rightfully suspect is affected by corporate self-interest. Further, the proposal would average prices, which may only serve to dilute prices reflecting market value with those that do not and that were cherry-picked for that reason. The proposal is also fatally flawed because choices among prices would apparently be made in secret by the industry and Interior, thus shutting out the public that owns the natural gas from the process.

A proper index pricing system should involve Interior selecting the indices based on public input through a rule-making process. Citizens should have as much opportunity to comment on the selection of indices as the industry does. Further, if no sufficient index currently exists for an area, Interior should reserve the option of developing its own index through a price-reporting system it would create. Any Interior-established index should be also public in nature and subject to continuing public input on its validity and accuracy.

A proper system would be transparent and create certainty for the American people and producers alike that the right amount of royalty is consistently and reliably paid on the market value of natural gas. The RPC recommendation fails to achieve these standards and unacceptably grants governmental authority to private companies. The recommendation should be rejected.

Recommendation on “Marketable Condition” Exempting Residue Gas from Royalties

Issue:

The Royalty Policy Committee proposes to grant the natural gas industry the unjustified gift of an exemption from public royalties for residue gas (methane), which companies use to place raw natural gas into marketable condition. Natural gas producers are required to bear all costs of placing its products in marketable condition, and those costs should not be shifted to the public as proposed by the Committee in this case. As a result of a company’s own business choices, the gas used in processing plants is technologically necessary so that the company can market two streams of product: dry natural gas (methane) and natural gas liquids (non-methane hydrocarbons). Residue gas has economic value in performing this work, and Americans are entitled to a royalty on this value.

Discussion:

It is helpful to understand from the outset some natural gas definitions and the basic steps in bringing natural gas to a marketable condition.

Raw or wet natural gas extracted from wells is a varying combination of methane, natural gas liquids, water, and other contaminants. Wet gas is not in marketable condition. Processing of the natural gas removes water and contaminants, separates out natural gas liquids into a marketable form and yields residue gas which, when pressurized, is pipeline quality, dry natural gas in marketable condition. Processing gets rid of the junk and yields two marketable streams of products: dry methane gas and natural gas liquids.

One should be confused by the term “residue gas.” It is not some type of waste gas. It is the valuable remainder or “residual” methane gas left after removal of contaminants and separation of the valuable natural gas liquids. As noted, residue gas, when pressurized to flow over pipelines, is the dry natural gas marketed to consumers to burn in boilers, furnaces, stoves, electrical generators and industrial applications of a wide variety.

Natural gas liquids (NGLs) are non-methane hydrocarbons of different types and uses. They include ethane, propane, isobutene, pentane and other products. They are used as feedstock for petrochemical products (plastics, anti-freeze, detergents, synthetic rubber), burned for space heating and cooking, and blended in vehicle fuels. As noted by the Energy Information Administration, higher crude oil prices have increased NGL prices, thus increasing their value.

Among other steps, the industry’s current technology of choice is a cryogenic process that separates out NGLs in marketable condition and also yields dry methane as a residual. While it is the cost-effective technology of choice, it has the downside of reducing the pressure of the dry methane below what is required for marketable condition. So the methane, which did not fully attain marketable condition earlier in the process, needs to be re-pressurized at this point to achieve all the marketability criteria simultaneously for the first time. Some of this same methane, or residue gas, is used to accomplish the pressurization needed for this last step to marketability.

Industry argues this is “double compression,” and since the raw or wet natural gas was once at pipeline pressure when it entered the plant, they shouldn’t have to bear the cost of pressurizing it again. The industry is wrong for two reasons:

1. First, when the wet gas enters the plant at pressure it is not otherwise in marketable condition and does not achieve that condition for the first time until the dry natural gas is pressurized after the separation of the NGLs. The industry is not and should not be allowed cost deductions until the dry natural gas meets all the marketability requirements simultaneously. Further, it is the marketplace, and not ONRR, that requires natural gas to achieve all the marketability criteria, including pipeline pressures, at the same time. The fact that the pressure fluctuates in the processing stages prior to marketability is irrelevant. The industry is cherry-picking points of pressure fluctuation to make a false and deceptive case for the royalty exemption.
2. Second, the downward pressure fluctuation is caused by the industry's choice of technology for separating out valuable NGLs in their marketable condition. The industry might choose other methods besides cryogenics to separate out the NGLs, but those other methods are apparently not as cost-efficient. It is the industry's business choice that causes the gas to lose pressure and requires it to be brought back to pipeline pressures before it fully attains marketability as dry natural gas.

To summarize: the point at which the industry first fully meets standards of marketable condition for its two product lines—NGLs and pipeline quality, dry natural gas—comes after the NGLs are separated out and the dry natural gas is brought back to pipeline pressures. The methane used for this final pressurization should not be exempt from royalties because this use occurs before producers fully and completely attain marketability of the dry natural gas for the first time.

ONRR's disallowance of a royalty exemption for residue gas is not the consequence of some imagined misinterpretation on its part. Industry is attempting to blame ONRR for what is merely the result of economic and technology realities created by industry's own business decisions. ONRR's stance on this issue is not even an interpretation, but is the necessary consequence of these realities. The industry's arguments are simply inconsistent with the facts and logic relevant to this issue.

Residue gas produced from federal lands and used in processing gas to place it in full, marketable condition performs a necessary function and is of economic value. The American people are entitled by law to a royalty on that value. The RPC recommendation should be firmly rejected.

Recommendations on Coal Valuation: Valuation Rule, Payor Notice, and Handbook Change

Issue:

Together, the several Royalty Policy Committee coal valuation proposals would allow producers to select sales for coal valuation purposes that are below market value and falsely labeled as “comparable arm’s length” sales. Further, the changes largely disable ONRR audits—the last line of defense of the American people—that might correct any undervalued sales chosen by coal producers. Finally, the proposals would implement the key element of the policy of “coal producers picking their own values” through executive fiat—before the completion of the rule-making process ostensibly designed to consider the policy. The proposals improperly surrender Interior’s authority to determine the value of coal to producers and disables audits of the producer’s chosen values—all without a proper, public process for decision-making. By putting coal producers in charge of royalty valuations, the changes invite companies to abuse the royalty process and deny the public a fair return on the coal they own.

Discussion:

What the RPC Proposed: Even though presented as three recommendations, the Royalty Policy Committee actually proposed five coal valuation changes, all of which interact with each other.

1. Amend a key royalty valuation rule, 30 C.F.R. 1206.257 (c)(2)(i) to allow producers to use at the time of filing royalty returns what they claim to be their own arm’s length sales prices—effectively granting the power to producers to select their own prices for coal from the outset of the royalty process;
2. Further amend 30 C.F.R. 1206.257 (c)(2)(i) to implicitly, but somewhat ambiguously, narrow the choice of values for coal to only those chosen by coal producers for their own coal by deleting the reference to “within the range of” gross proceeds to “equivalent to;”
3. Remove from the same rule, 30 C.F.R. 1206.257 (c)(2)(i), the arm’s length comparability factors that ONRR could use to adjust the producer’s chosen sale on audit (using relevant, independent arm’s length sales by other producers)—thus depriving ONRR auditors of any standards they could use to correct the producer’s selection of sales for valuation purposes or any other non-arm’s length sales;
4. Provide an administrative interpretation in a “Secretarial Order, Dear Payor Letters and/or a Policy Memorandum” notifying producers that their own selected “arm’s length sales” are “preferential,” thus, relegating the use of sales by other producers to the status of being “non-preferential”—and taking this step by executive fiat before the completion of the rulemaking process on amendments to 1206.257 (c)(2)(i), and
5. Incorporate the changes above, also by executive fiat, in the Interior Solid Minerals Reporting Handbook to further deter ONRR auditors from making audit assessments using the “non-preferential” sales made by other producers to overturn the “preferential” producer’s choice of their own sales.

The Fair Return and Value Subcommittee claimed to be presenting three proposals to the RPC, but there were hidden—without discussion in its written report—two other changes: item two above narrowing the range of relevant coal values to be considered and item three concerning the removal of the comparability factors that ONRR can use to correct non-arm’s length values in the course of audits. To understand how these additional changes were implicitly included, but not declared, in the RPC recommendations, one needs only review the actual text of its recommendation “amending the regulation at 30 C.F.R. 1206.257 (c)(2)(i) to read:”

“The gross proceeds accruing to the lessee pursuant to a sale under its non-arm's-length contract (or other disposition of produced coal by other than an arm's-length contract), provided that those gross proceeds are equivalent to the gross proceeds derived from, or paid under, comparable arm's length contracts for sales, purchases, or other dispositions of like-quality coal produced in the area.”

The introductory statement that it was “recommending the regulation at (citation) to read” and the closed quotes for the proposed regulation indicate that the above text is the entirety of the final language the RPC proposed for 30 C.F.R. 1206.257 (c)(2)(i). To arrive at this proposed language, the RPC recommendation would make the following deletions (stricken text) and additions (underlined text) to the existing 30 C.F.R. 1206.257 (c)(2)(i):

“The gross proceeds accruing to the lessee pursuant to a sale under its non-arm's-length contract (or other disposition of produced coal by other than an arm's-length contract), provided that those gross proceeds are ~~within the range of~~ equivalent to the gross proceeds derived from, or paid under, comparable arm's length contracts ~~between buyers and sellers neither of whom is affiliated with the lessee~~ for sales, purchases, or other dispositions of like-quality coal produced in the area. ~~In evaluating the comparability of arm's length contracts for the purposes of these regulations, the following factors shall be considered: Price, time of execution, duration, market or markets served, terms, quality of coal, quantity, and such other factors as may be appropriate to reflect the value of the coal.”~~

Background on Arm's Length Issues and Comparability Standards: To understand the coal issues underlying the RPC recommendations, it is helpful to review the concept of “comparable arm's length” sales, which will be considered in two parts: (1) arm's length sales and (2) comparable sales.

“Arm's length sales” are transactions between buyers and sellers who are independent of each other and are on an equal footing. Each party is serving its own interest such that they are not colluding with each other. Neither party is able to exercise influence or power over the transaction. Both parties have reasonable access to information relevant to the sale.

In contrast “non-arm's length sales” typically include those between related parties, such as within families or between parent companies and their affiliates. Sales where the parties engage in side agreements that distort the price of the property sold are also not at arm's length. Instances where a seller manipulates a price, for example, by deliberately selling a minor amount of property at a discount to an otherwise independent purchaser to establish a low price precedent for undervaluing a larger amount of property to minimize tax or royalty payments is also a “non-arm's length” sale.

The idea of “comparable arm's length prices” arises in the administration of tax and royalty laws whenever it is necessary to determine values for property for which either no sales data exist or only non-arm's length sales data are available. The comparable arm's length prices used to adjust “non-arm's length” values cannot be just any arm's length price. To meet standards of comparability, the arm's length prices must be for the sale of products of comparable type and quality into comparable markets under a host of other comparable facts and circumstances that affect value, such as timing, volume, terms and conditions and other factors. For example, a small volume of coal sold into domestic markets may not qualify as a “comparable” sale to be used to value a larger volume of coal sold into export

markets where prices are higher, even after deducting for the cost of transporting the coal from the mine to the export terminal. Or, under circumstances where prices fluctuate, a sale made when the market was down may not be a comparable sale for coal sold under a non-arm's length contract when prices were higher. Comparability of arm's length sales is critical in selecting sales to adjust non-arm's length commodity prices to market value to achieve a fair return on royalties to the public.

Problems Created by the RPC Recommendations

Long-standing Interior valuation rules prohibit coal producers from selecting their own sales to non-affiliated purchasers to use as "arm's length sales" when they are reporting adjusted coal values for their non-arm's length sales. Even though such sales are ostensibly "arm's length sales" because they are made to independent parties, the facts and circumstances remain subject to too much influence or control by the coal producer to qualify as such or to meet standards of comparability. The coal producer can too often influence the timing and volume of sales or contract terms and conditions in ways that would normally disqualify the producer's own sales to be used as comparable arm's length sales. Because of the ability of producers to influence their own sales to various parties, Interior—for decades under Administrations of both parties—has wisely disallowed their use in determining values for coal royalty purposes.

Is it possible for a producer to manipulate its own supposed "arm's length sales?" Yes, as the following examples illustrate:

- A producer can make small, occasional sales to independent, domestic purchasers at a discounted price and use that price to value large volume sales made to its captive affiliates for sale into export markets at higher prices, even after accounting for transportation costs to the export terminal.³
- A producer might, as a variation on the first example, make several, independent sales at regular intervals so as to capture market fluctuations in the domestic market, and select the lowest price among these sales—and again substitute those values for higher export market values it secures through sales to captive affiliates.
- A producer might use complex contract provisions and other methods to divert part of its receipts from coal sales into a stream of payments excluded from the sales price of the coal, and then use that depressed price of coal as its chosen "arm's length sale."⁴

Allowing producers to choose their own sales to purchasers as the basis for coal royalty valuation is a radical departure from well-established practices and would likely produce extensive undervaluation of coal—shortchanging the American people of the fair value promised them by the law.

³ Because the allocation of overhead costs is not a determinant process and other factors, it is possible for a company to use various accounting methods to justify a discounted price on an occasional sale as an "arm's length sale," but it would not qualify as a "comparable" sale to the coal being valued. The recommendation would allow the producer to use this sale to value their coal sold to captive affiliates, but that is not proper because these occasional sales are not comparable.

⁴ See Isaiah T. Peterson, "Devaluing Coal: Reasons for Restructuring How Federal Coal is Valued," *Georgetown Journal of Law and Policy*, Winter, 2015, 13 Geo. J.L. & Pub. Pol'y 165, for an advanced discussion of how current rules allow producers to use multiple means to artificially manipulate its sales prices to outside purchasers and report values for royalty purposes that do not attain fair value for the public.

The RPC recommendations would turn the coal valuation process on its head making producers, instead of Interior, the *de facto* valuation authorities to the detriment of the public interest. The process of ceding Interior's powers to coal companies only begins with allowing producers to use self-selected sales in royalty returns—inviting valuation abuses. The RPC also proposes to designate those sales as the “preferential sales” for valuation purposes (after implying with the “equivalent to” amendment that they might be the only sales used in the valuation process). Arbitrarily declaring coal producer self-selected sales as “preferential” at the return filing effectively short-circuits what should be a determination made only after an audit of the facts and circumstances surrounding such sales. In addition, by removing standards of comparability for royalty rules, it undercuts the ability of auditors to reject or modify the producer self-selected sales on audit. The RPC recommendations would preemptively declare the producers choice of coal values as “the best” and effectively immunize them from correction by ONRR auditors.

The proposals would hinder ONRR audits in irresponsible ways. Labeling a producer's chosen sales as “preferential” before any factual examination of those sales is absurd. Whether or not a sale is a proper arm's length sale is a determination that can only be made after analysis of the facts and circumstances surrounding the sale. Yet, the proposed executive actions regarding producer notifications and Interior handbook change would declare in advance—without the benefit of any factual analysis—producer-selected sales to be automatically “preferential” above all others. If ONRR auditors were to attempt to adjust the producer's chosen values, they would first run headlong into the obstacle of those values having been determined “preferential” before being subject to examination.

The second obstacle ONRR auditors would confront is the removal from the rules the comparability factors it uses for pricing adjustments on audit: “price, time of execution, duration, market or markets served, terms, quality of coal, quantity, and such other factors as may be appropriate to reflect the value of the coal.” With this language removed from the rules, ONRR is provided no basis in the regulations for adjusting a producer's chosen values. Without legally established criteria for adjustments, it invites coal companies to attack ONRR assessments on appeal as “arbitrary and capricious” and lacking a reasonable legal foundation. No discussion occurred at the February 28 meeting of the Royalty Policy Committee of the implications of deleting the criteria on which auditors could base an adjustment of the producer's prices. A change of this nature certainly deserves some justification, but none was given. Overall, the RPC proposals effectively disable ONRR audits—the only means the American people have in defending their interests in the valuation process.

A further problem with the RPC recommendations, particularly the two final recommendations for executive action, is that they may violate the Administrative Procedures Act and potentially other laws. Designating producer-selected sales as “preferential” is a major policy change that would seem to require amending coal valuation regulations and the public process that accompanies such amendments. Thus, adopting this policy change by executive fiat without a public process is highly questionable. Further, designating producer-selected sales as “preferential” explicitly before completion, as the RPC recommends, of the amendment process for allowing producer-selected sales to be used at all under 30 C.F.R. 1206.257 (c)(2)(i) would appear to pre-judge the outcome of that public process. Indeed, taking those executive actions before the completion of that public process on that amendment makes it a charade. Finally, it is unclear that Interior, under the federal mineral leasing and land management laws, can abandon its authority to value minerals and ensure the receipt of fair market values as the RPC proposes it should.

The RPC coal valuation recommendations unacceptably transfer control of valuations from Interior to coal companies, disable ONRR audits as a means of protecting the interests of the American people, authorize expanded opportunities for coal companies to underreport mineral values, and likely violate both administrative and leasing laws. They should be firmly rejected.

Recommendations for “Competitiveness Studies” for Oil and Gas Royalty and Leasing Policies

Issue:

The Royalty Policy Committee recommended comparative studies of oil and gas revenue policies to evaluate factors for “the U.S. to remain competitive with emerging areas.” In the short term, the RPC recommended specific studies comparing U.S. offshore oil and gas policies with those of Guyana and Mexico. Longer term, the committee proposed broad comparisons of U.S. offshore and onshore policies with other nations, including “emerging areas.” Competitiveness with other nations is not the policy in federal law for setting the fiscal terms of oil and gas leases. Fair return is the federal policy. These studies are a radical step toward institutionalizing competitiveness and undermining a fair return for the American people. It would link U.S. policy to whatever concessions the oil and gas industry secures from rulers of other nations. Corrupt practices and bribery influence mineral development in nations around the world. Establishing “competitiveness” with other nations as a basis for U.S. policy would expose that policy to changes based on whatever questionable practices have occurred elsewhere. Further, the competitiveness idea is an instrument for implementing the Administration’s “energy dominance” policy that would convert vast expanses of public lands now managed for multiple uses into fossil fuel production zones and reserves.

Discussion:

One of the first acts of the Trump Administration was to support the congressional override of the U.S. implementation of the Extractive Industry Transparency Initiative (EITI) as implemented through an SEC rule required by the Dodd-Frank Act. Secretary Zinke later withdrew the U.S. from the EITI. One purpose of the EITI was to combat corruption in energy and other mineral development around the world. This retreat from EITI means that oil, gas and other extractive industry corporations operating in the U.S. and globally will not be required to report publicly payments they make to governments and officials wherever they operate. This retreat means the American people will not be informed about corrupt influences that affect policy around the world.

As noted, the “competitiveness” standard the RPC is advancing under these study recommendations would result in bringing to bear international corrupt practices on the setting U.S. policy. Whatever Practices adopted in other nations as a result of whatever questionable means of “persuasion” would become leverage for determining whether the U.S. is competitive. “Competitiveness with emerging areas” is an unwise and risky path for U.S. policy that is contrary to our nation’s democratic values of governmental transparency, integrity and accountability.

Competitiveness is the procedural companion to energy dominance. Energy dominance is contrary to the requirement of federal law that lands be managed for multiple uses. Clean air and water, a healthy landscape, abundant wildlife, the preservation of historical and cultural resources, renewable energy, agriculture and forestry, oil, gas and mineral extraction, and other activities are all to be evaluated in balance with each other for uses of the federal land. Energy dominance implemented through competitiveness would violate balance among competing uses and would establish energy production as the predominant use over all others. Public land management decisions would become a rigged lottery where fossil fuel energy companies would win the prize for using public lands wherever they purchased tickets.

To preserve the integrity of public land management, multiple uses of public lands, and a clean and healthy environment, competitiveness studies that would lead the U.S. along a path that risks corruption and degradation of public resources should be rejected.

The Royalty Policy Committee is meeting here in Albuquerque this week and it's Chairman is Vincent DeVito, a lawyer from Massachusetts, appointed by Donald Trump to be 'Counselor to the Secretary for Energy Policy.'

It says so on the card he gave me.

Mr. DeVito gave me the card in April when I met with him in his office at the Department of the Interior in Washington, DC. With me were Rio Arriba County Manager Tomas Campos and Utah Navajo Tribal official Sam Dee to extend our offer of assistance to his office and to present the facts about the impacts of living with oil and gas, and what effects federal policy really has when it hits the ground.

Manager Campos has 8,000 wells in his county and is part of one of the most productive oil and gas Basins in the US.

Sam Dee, my brother, has over 700 wells in his tiny community in Montezuma Creek, Utah.

My wife and I have 122 wells on and adjacent to our ranch - I can see 10 wells from the ranch house.

But Mr. DeVito did not accept our offer of assistance, and today we have instead more of this administrations's talk of ignoring the impacts of federal oil and gas policies as they hit the ground - the ground that we live on.

That April meeting did not go as I had hoped with the Royalty Policy Committee Chairman. At one point, he said, "...now don't take this personally, but..." and I interrupted him to say, Mr. DeVito, whatever you're going to say, how can we not take it personally?

Manager Campos is unable to get a simple audit or accounting of the oil and gas produced in his county. He doesn't even know what royalties and taxes should be paid. He's trying to insure that the county's basic services like law enforcement, schools, hospitals, the health of his citizens, are met. Services already pushed to the brink before any talk of actually cutting royalties or rolling back efforts to stop methane waste and the royalties lost with that waste. He asked for your help.

Sam Dee, who once lived in a healthy community is now living in a monoculture of oil and gas; How much oil and gas is produced, what royalties are paid, what comes back to offset the destruction of his culture and environment, he doesn't know. He asked you for answers. He didn't ask that royalties be reduced or that his oil and gas leases be sold for a pittance.

None of us proposed a drilling ban. Each of us has long, practical experience working with industry. Each of us brought facts about the impacts of oil and gas on our lives and how important fair royalty returns, reasonable lease pricing, the stopping of waste and the capture of lost royalties are to each of us, our friends and neighbors, our counties and communities.

We are sincerely disappointed that Mr. DeVito and his Committee have ignored us.

But, today, we make our offer again. Let our collective voices into this RPC Committee meeting today. Hear what we have to say.



June 2017

OIL, GAS, AND COAL ROYALTIES

Raising Federal Rates
Could Decrease
Production on Federal
Lands but Increase
Federal Revenue

GAO Highlights

Highlights of GAO-17-540, a report to congressional committees

Why GAO Did This Study

In fiscal year 2016, the federal government collected about \$2.5 billion in revenue associated with onshore oil, gas, and coal production on federal lands, including about \$2 billion from royalties. Federal royalty rates sometimes differ from the rates states charge for production on state lands. For example, state oil and gas rates tend to be higher than federal royalty rates and state coal rates are generally the same as federal rates in the six states representing more than 90 percent of federal oil, gas, and coal production in fiscal year 2015.

The explanatory statement accompanying the Consolidated Appropriations Act for fiscal year 2016 includes a provision for GAO to review issues related to royalty rates. This report describes what is known about how raising federal royalty rates would affect (1) oil, gas, and coal production on federal lands and (2) the federal revenue associated with such production. GAO reviewed an extensive list of studies and selected for more in-depth review four that modeled the effects of raising federal royalty rates—one study conducted by the Congressional Budget Office, one by the Council of Economic Advisers in the Executive Office of the President, one prepared for the Bureau of Land Management, and one by researchers. GAO also interviewed officials from federal and state agencies, industry groups, non-governmental organizations, academia, and other knowledgeable stakeholders.

GAO is not making recommendations in this report. Interior reviewed a draft of this report and provided technical comments that GAO incorporated as appropriate.

View GAO-17-540. For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov.

June 2017

OIL, GAS, AND COAL ROYALTIES

Raising Federal Rates Could Decrease Production on Federal Lands but Increase Federal Revenue

What GAO Found

Raising federal royalty rates—a percentage of the value of production paid to the federal government—for onshore oil, gas, and coal resources could decrease oil, gas, and coal production on federal lands but increase overall federal revenue, according to studies GAO reviewed and stakeholders interviewed. However, the extent of these effects is uncertain and depends, according to stakeholders, on several other factors, such as market conditions and prices.

Production. One study GAO reviewed found that oil and gas production could decrease by less than 2 percent per year if royalty rates increased from their current 12.5 percent to 22.5 percent, based on fiscal year 2016 production data. Another study stated the effect on production could be “negligible” over 10 years if royalty rates increased to 18.75 percent, particularly if the increased federal royalty rate remained equal to or below the royalty rates for production on state or private lands. Regarding coal, one study suggested that raising the federal royalty rate for coal to 17 percent would decrease production on federal lands by up to 3 percent after changes were fully implemented after 2025, while a second study said that increasing the effective rate—the rate actually paid by companies after processing and transportation allowances have been factored in, along with any royalty rate reductions—might decrease production on federal lands by less than 1 percent per year. Some stakeholders said that several other factors could influence the extent to which oil, gas, and coal production might decline. For example, some stakeholders said current market conditions, the cost advantages of different resources, and the regulatory burden associated with production on federal lands could influence the extent to which production might decline.

Revenue. The oil and gas studies that GAO reviewed estimated that raising the federal royalty rate could increase net federal revenue between \$5 million and \$38 million per year. One of the studies stated that net federal revenue would increase under three scenarios that modeled raising the royalty rate from the current 12.5 percent to 16.67 percent, 18.75 percent, or 22.5 percent, while the other study noted that the effect on federal revenue would initially be small but would increase over time. Both coal studies suggested that a higher royalty rate could lead to an increase in federal revenues. One of the studies suggested that raising the royalty rate to 17 percent or 29 percent might increase federal revenue by up to \$365 million per year after 2025. The other study suggested that increasing the effective rate could bring in an additional \$141 million per year in royalty revenue. Stakeholders GAO interviewed cited other factors that could influence the extent to which raising federal royalty rates could increase revenues—in particular, how bonus bids, another revenue source, could be affected. Some of the stakeholders stated that companies would be more likely to offer lower bids to obtain a lease for the rights to extract resources if they had to pay higher royalties.



Comparison of State Oil and Gas Royalties in New Mexico and Other Producing States. Prepared for New Mexico House Energy, Environment and Natural Resources Committee.

January 18, 2018

Dear Chair and Members of the Committee,

The purpose of this brief is to compare oil and gas royalty policy in New Mexico to other states that have production on state trust lands.

Table 1 summarizes royalty rates paid by oil and gas companies for producing on federal and state lands in 12 oil and gas producing states and federal onshore and offshore leases. Table 2 provides additional information about deductions and incentives that can lower royalty rates on federal and state leases.

Oil and gas companies also pay a variety of production taxes to state and local governments based on the value and/or volume of oil and gas extracted in each state. Figures 1 and 2 compare effective rates for oil and gas production taxes paid to state and local governments in a variety of states, including New Mexico.

Figure 1 measures total state and local tax revenue and federal and state royalty revenue as a share of the total gross value of oil and gas production in each state. Figure 2 estimates the effective tax rate in each state by comparing the gross value of oil production to the total value of state and local production tax collections from a hypothetical unconventional oil well if it were completed in each state.

Summary Points

- Royalty rates paid to states are generally higher than royalties paid to the federal government for onshore oil and gas production.
- The rates paid to states vary considerably, from a low of 12.5 percent to a high of 25 percent on average. In general, royalty rates are higher in more productive plays.
- New Mexico's royalty rates are lower than rates paid in several states, including Texas, but are on par with average rates in many states.
- New Mexico's effective rate for combined state and local government production taxes are slightly lower than the effective rate paid in Texas and the average rate across producing states covered in two studies.

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Federal and State Oil and Gas Royalty Rates

Table 1: Comparison of Oil and Gas Royalty Rates for Federal and State Leases¹

State	Tax Base	How Rate is Set	Average Rate	Deductions and Incentives	Bonus Payment
Arkansas		Negotiated	25%		
Texas	Gross Revenue	Fixed	25%	Production incentives	Yes
Louisiana	Gross Revenue	Negotiated	21.9%		Yes
Mississippi		Negotiated	20%		
Oklahoma		Fixed	18.8%		Yes
North Dakota			16.7 or 18.75%		Yes
Federal Offshore	Gross Revenue	Negotiated	18.8%	Deep gas	Yes
New Mexico		Variable Rates	12.5 - 20%	Stripper well and deep well incentives	Yes
Colorado	Gross Revenue	Fixed Rate	16.7%		Yes
Montana	Gross Revenue	Fixed	16.7%		Yes
Utah			12.5 - 16.67%		Yes
Wyoming		Fixed	16.7%	Economic considerations	Yes
Alaska	Net Revenue	Fixed	12.5%		Yes
Federal Onshore	Gross Revenue	Negotiated	12.5%	Economic considerations	Yes

Table 2: Notes on Deductions and Incentives in Federal and State Royalty Policy

State	Deductions and Incentives
Texas	20% if production, in paying quantities, is established, brought onstream, and sales thereof are commenced within the initial eighteen months of the primary term of the lease; 22.5% if production, in paying quantities, is established, brought onstream, and sales thereof are commenced between the 19th and 24th month of the primary term of the lease. If the initial well drilled is a dry hole: 20% if a second well is commenced and production, in paying quantities, can be established, brought onstream, and sales thereof are commenced by the end of the 21st month, as provided for in the lease; 22.5% if a second well is commenced and production, in paying quantities, can be established, brought onstream, and sales thereof are commenced by the end of the 27th month, as provided for in the lease.
Louisiana	The statutory prescribed minimum royalty is 12.5%. However, royalties offered in recent lease sales have varied between 12.5% and 61.1%.
Federal Offshore	Where applicable, deep gas and ultradeep gas royalty relief has been applied. Based on a threshold price.
New Mexico	Reduction to 5% for three years if: the production is: (a) from less than 5,000' (b) has produced less than - average of three (3) barrels of oil per day (<3 BOPD) during the preceding twelve (12) months & (c) has averaged <5 BOPD for any month during the preceding twelve months; - or - If the production is: (a) from formations 5,000' deep or deeper, (b) has produced less than an average <6 BOPD during the preceding twelve (12) months & (c) has averaged <10 BOPD for any month during the preceding twelve months;
Wyoming	Royalty rate reductions can be made if leases are not sold or for cost recovery and economic reasons.
Alaska	Royalty is levied on gross wellhead revenue, referred to as the "field price." If the oil, gas or associated substance is sold off of the leased premises, the field price is calculated as the price realized less the actual and reasonable transportation costs.
Federal Onshore	Royalty rate reductions may be granted by application to promote development, or whenever in his judgment the leases cannot be successfully operated under the terms provide therein. The royalty rate reduction must encourage the greatest ultimate recovery of the resource and must be in the interest of conservation of natural resources (e.g. full recovery).

Comparison of State Production Taxes

Figure 1: Sources of Government Revenues as a Share of Oil and Gas Production Value in FY 2013²

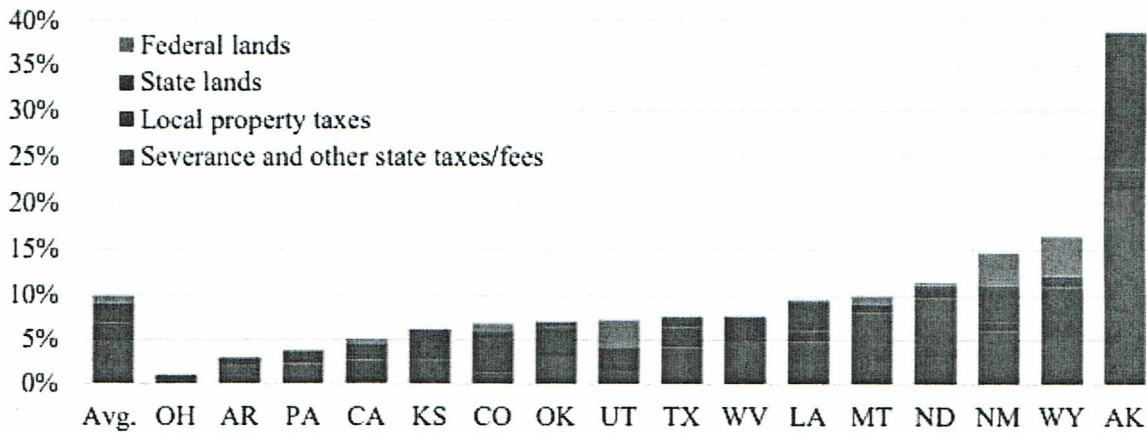
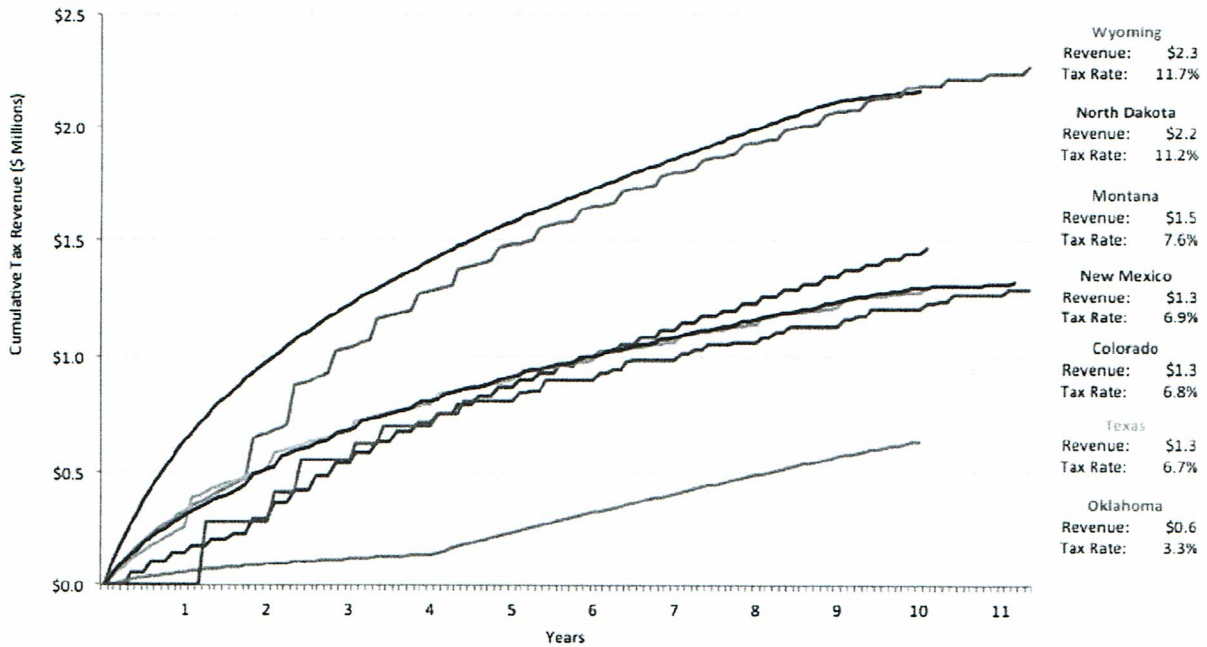


Figure 2: Comparison of Production Tax Revenue Collected from a Typical Unconventional Oil Well³



Endnotes

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- ³ Haggerty, Mark. 2014. *How New Mexico Returns "Unconventional" Oil Revenue to Local Governments*. *Headwaters Economics*. Bozeman, MT. <https://headwaterseconomics.org/energy/best-practices/state-energy-policies-nm/>.



June 6, 2018

My name is Pam Eaton. I am senior advisor for Energy and Climate at The Wilderness Society. I urge you to consider the broad values of our shared public lands and expand your committee to include the voices and interests of people and places who are not represented at this table today.

To start, I urge the Committee to reject the three recommendations from the Onshore Oil and Gas Working Group to limit BLM's environmental review and public participation in oil and gas permitting under the National Environmental Policy Act. Individually and together these recommendations—all aimed at constraining how and when environmental reviews of oil and gas permitting are conducted--could hide thousands of energy development decisions from public scrutiny and oversight. These recommendations follow a deeply troubling trend of this administration to significantly curb opportunities for people to be involved in energy decisions that affect them. You should reject them.

These recommendations also fall outside the charter of the Royalty Policy Committee which is "to ensure the public receives the full value of the natural resources produced from Federal lands" and to provide advice "on the collection of revenues derived from, the development of energy and mineral resources on Federal and Indian lands."

The Department of the Interior has justified the exclusion of environmental and other public interest representatives from membership on this committee claiming the committee does not deal with environmental policy. Yet this is the second time this Committee has considered recommendations specifically aimed at limiting environmental review and constraining implementation of the National Environmental Policy Act. You should expand the membership of this committee to include a broader and more diverse set of public interest representatives.

The Wilderness Society and our partners submitted a letter to the Committee providing initial responses to the recommendations from the Onshore and Offshore Oil and Gas Working Groups. We hope you all received copies of that

letter in advance of this meeting and that you will reject these proposals to further shield energy development from proper environmental and fiscal management.

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June 1, 2018

Delivered via email to rpc@ios.doi.gov

Royalty Policy Committee
U.S. Department of the Interior

Re: Response to Recommendations from the Planning, Analysis and Competitiveness Subcommittee Regarding Onshore Oil and Gas Program.

Dear Royalty Policy Committee Members,

The following responses to recommendations made by the Planning, Analysis and Competitiveness Subcommittee (PAC) of the Royalty Policy Committee regarding the Department of the Interior's onshore oil and gas program, as administered by the Bureau of Land Management (BLM) are submitted by The Wilderness Society, NRDC, Western Organization of Resource Councils, and Western Colorado Alliance.

At the outset, we note that our organizations' capacity to provide robust and meaningful comments on these recommendations is limited by the Royalty Policy Committee's (RPC) failure to provide for a fairly balanced and transparent decision-making process, particularly (1) its failure to make RPC subcommittee and working group meetings and documents available to the public; (2) its failure to provide adequate notice of Committee meetings and materials, and; (3) its exclusion of certain categories of public interest representatives from Committee membership and deliberation. We urge the Committee to comply with all statutes, regulations, and agency guidance governing RPC processes.

Notwithstanding the Committee's inadequate provisions for transparency and public comment, we have endeavored to respond to the aforementioned recommendations. We are concerned that these recommendations would remove important safeguards that require evaluation of environmental consequences, permit public oversight and ensure recovery of a fair return from oil and gas companies leasing our public lands and minerals. Our responses to these recommendations are discussed in detail below.

1. *PAC Recommendation on Categorical Exclusions*: The PAC recommended that BLM should issue an Instruction Memorandum (IM), directing all field offices to issue Categorical Exclusions (CX) when any of the Energy Policy Act of 2005 (EPAAct) Section 390 criteria are met to approve drilling of oil and gas wells. We note that the Western Energy Alliance has also recommended a rulemaking, in addition to guidance, to direct BLM field offices that uses of these CXs is mandatory, so that changes to both rules and policy are under consideration.¹ These proposed changes would direct BLM field offices that use of these CXs is mandatory – not up to the discretion of the agency or consideration of potential impacts from approving drilling.

¹ RPC, Planning, Analysis, and Competitiveness Subcommittee Recommendations, *available at* https://www.doi.gov/sites/doi.gov/files/uploads/pac_recommendations_-_with_page_numbers.pdf.

Response: This recommendation, as well as the proposals from the Western Energy Alliance, contradict the plain language of EAct which states that use of the CXs is subject to a “rebuttable presumption” that they apply. This common-sense backstop is vital to ensure that drilling is not approved without considering environmental consequences and providing for public review and input. CXs are generally reserved for extreme circumstances where it is unequivocal that environmental analysis is unnecessary.

Notably, under current guidance, BLM is not required to involve the public or issue any public decision documents concerning section 390 CXs.² Consequently, the current application of these CXs is at the discretion of the BLM without clarification on when they should not be used (i.e., where the presumption on their use can and should be rebutted) and not transparent. It would be more useful for the RPC to reiterate the importance of BLM field staff using their discretion and on-the-ground knowledge to determine when use of a CX is not appropriate, and when environmental analysis and public review are necessary prior to approving drilling

The oil and gas industry is trying to make the use of section 390 CXs mandatory, which could shield tens of thousands of future oil and gas wells from public scrutiny and oversight, as well as from detailed environmental review.

Specifically, industry is proposing to:

- **Make the use of section 390 CXs mandatory:** Under industry’s proposal, the presumption that a section 390 CX applies could only be rebutted when a well: (1) does not meet one of section 390’s criteria; (2) is not authorized by the Mineral Leasing Act; or (3) is not for the purpose of oil and gas exploration or development. This effectively reads the “rebuttable presumption” standard out of the statute, and impermissibly eliminates BLM’s discretion to not apply section 390 CXs when unique or “extraordinary” circumstances exist.
- **Eliminate “extraordinary circumstances” reviews:** The proposal would prohibit BLM from reviewing proposed section 390 CXs for “extraordinary circumstances,” as required by the NEPA regulations.³ These reviews ensure that when significant or unforeseen environmental impacts are identified, oil and gas wells are thoroughly vetted through the NEPA process.
- **Further prevent public scrutiny and oversight of oil and gas development on public lands:** This proposal is just the latest attempt by the oil and gas industry to cut the public out of the decision-making process. In January 2018, at the behest of industry, BLM adopted a new leasing policy that makes NEPA compliance – and public participation – optional for leasing on public lands.⁴ If the section 390 CX proposal is adopted, then the public could be excluded almost entirely from the decision-making process for leasing and drilling on public lands.

² BLM, NEPA Handbook H-1790-1, pp. 17-18 (Jan. 2008).

³ See 40 C.F.R. § 1508.4 (“Any procedures under this section [categorical exclusion] shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.”).

⁴ Darryl Fears, *Trump administration tears down regulations to speed drilling on public land*, Wash. Post, Feb. 1, 2018.

The Royalty Policy Committee should not support these recommendations. Industry is already benefitting from these categorical exclusions and mandating their application is not only unnecessary but also poses an unacceptable risk to the management of our shared public lands and resources.

Since BLM is already issuing numerous CXs to the oil and gas industry (so many, in fact that the Government Accountability Office found the agency was abusing this tool⁵), there is no need to mandate their use and every reason to ensure needed evaluations are made prior to authorizing drilling. Additionally, as of July 2017, industry was not utilizing nearly 8,000 drilling permits approved by the BLM. Thus, the RPC should focus on providing incentives for industry to use the permits (and leases) it already has, as well as ensuring that BLM retains the discretion to conduct needed environmental reviews and involve the public prior to approving more drilling.

2. *PAC Recommendation on Limiting Evaluation of Environmental Consequences from Oil and Gas Development*: The PAC has recommended that project-specific NEPA documents should be scoped to the actual impact of the project, and limited to best-available information, tiering to existing environmental analyses already analyzed in prior NEPA documents. Project proponents should not be required to fund new research to produce data that goes beyond the scope of the project.

Response: This recommendation is unnecessary, in addition to being arguably beyond the scope of the RPC’s mandate. NEPA analysis is, by definition, limited to the scope of the impacts a proposed action will have and can rely on previous analysis to the extent it is still accurate and covers potential environmental consequences. Seeking to preemptively limit analysis, however, is inconsistent with the requirements of NEPA to evaluate the direct, indirect and cumulative impacts of a proposed action and to rely on current, scientifically accurate information. *See*, 40 C.F.R. § 1508.8; 40 C.F.R. § 1500.1(b). In order to comply with NEPA, agencies must have sufficiently examined the evidence available and cannot conclude impacts will be minimal otherwise. *See, State of New Mexico v. Bureau of Land Management*, 565 F.3d 683, 714–715 (10th Cir. 2009) (BLM cannot conclude that drilling will have minimal impacts to groundwater without examining evidence to the contrary.), *citing, National Audubon Society v. Department of the Navy*, 422 F.3d 174, 187 (4th Cir. 2005) (Where evidence in the record indicated possible impacts on waterfowl, and no evidence pointed to the opposite conclusion, court could not find that the agency had sufficiently examined the evidence before reaching its determination.).

Directing agencies to ignore these requirements is irresponsible, and could expose projects to increased legal challenges. This recommendation is unnecessary and should not be adopted.

3. *PAC Recommendation on Revising Onshore Orders 3, 4 and 5*: The PAC has recommended that BLM should make changes to onshore orders 3, 4, and 5 to reduce their “overly burdensome nature.” The Onshore Working Group states that it “recognizes that there are

⁵ “BLM’s use of section 390 categorical exclusions has frequently been out of compliance with both the law and BLM’s guidance.” GAO, Greater Clarity Needed to Address Concerns with Categorical Exclusions for Oil and Gas Development under Section 390 of the Act 23 (Sept. 2009).

many needed updates in the onshore orders, but recommends a targeted rulemaking to fix the retroactive aspects of the rule that threaten existing unitization and commingling agreements, which can make older fields uneconomic.”

Response: Onshore Orders 3, 4 and 5 do not impose significant burdens, as the BLM documented in its thorough rulemaking process when updating these orders. Rather, these orders are designed to ensure accurate reporting and, consequently, accurate calculation and payment of royalties. These proposed changes are inconsistent with the RPC’s mandate to maximize return on oil and gas development on public lands. These recommendations should not be adopted, and the updated orders should be maintained.

4. *PAC Recommendation on Limiting NEPA Required on Wells Drilled into Federal Minerals:* The PAC has recommended that BLM should use the opportunity as it updates IM 2009-78 to reduce the situations where the full NEPA process is required on non-federal wells that are being drilled horizontally into a minority of federal minerals.

Response: Applicable guidance (such as Instruction Memorandum 2009-078) already limits the contexts in which NEPA applies, but also recognizes that the presence of federal minerals may require the application of NEPA as well as the Endangered Species Act and National Historic Preservation Act. Further narrowing this direction risks needed environmental analysis. Additionally, given the increased success and advances in horizontal drilling, this approach would encourage operators to avoid federal environmental reviews by locating federal wells on non-federal surface and/or mineral lands. Important federal interests in protecting air quality, threatened species, and cultural resources would not be protected. This recommendation should not be adopted to reduce compliance with these key federal laws.

5. *PAC Recommendation on Upgrading Systems to Monitor Agreements:* The PAC has recommended that BLM should make upgrades to its systems (AFMSS II and LR2000) to enable better monitoring of aging unitization and commingling agreements and quicker processing.

Response: BLM should certainly be more actively monitoring the age of agreements, as well as leases, not just to support “quicker processing” but also to ensure that expiring leases and agreements are terminated, and that lease suspensions are not maintained beyond their intended scope. BLM should not focus only on granting more authorizations and extending leases. The agency must also ensure that units and leases are not permitted to remain in suspension or in effect where companies are not producing paying quantities of oil and gas. We would draw the RPC’s attention to a report produced by The Wilderness Society showing that there are approximately 3.25 million acres of leases in suspension, many for decades, which is costing the public rent and royalties, as well as unnecessarily tying up public lands.⁶

If the RPC adopts this recommendation, it should only do so in conjunction with recommending that BLM also update its systems to monitor expiring leases, unitization/communitization agreements and suspensions, to ensure they are not improperly extended.

⁶ The Wilderness Society. (2015). *Land Hoarders: How Stockpiling Leases is Costing Taxpayers*. Available at: <https://wilderness.org/sites/default/files/TWS%20Hoarders%20Report-web.pdf>

6. *PAC Recommendation on Granting Relief from Obligations to Pay Royalties on Production:*
The PAC has recommended that BLM consider a broader set of factors when analyzing royalty relief applications.

Response: If certain projects are not economic either at the outset or later in their existence, then there should be no presumption in favor of approval or providing royalty relief. Under federal law, there is no presumption in favor of development, and there are competing public interests in providing for other economic development opportunities on public lands, as well as protecting environmental and cultural values. Under FLPMA to manage the public lands based on principles of multiple use and sustained yield. The multiple-use mandate directs DOI to achieve “a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations.” 43 U.S.C. § 1702(c). Sustained yield further requires BLM to seek “the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the public lands consistent with multiple use.” 43 U.S.C. § 1702(h). This mandate is clear that uses such as outdoor recreation, fish and wildlife, grazing, and wilderness are to be equally considered as multiple uses, along with energy development. 43 U.S.C. § 1702(l); *see also, New Mexico ex rel. Richardson v. BLM*, 565 F.3d 683, 710 (10th Cir. 2009) (“It is past doubt that the principle of multiple use does not require BLM to prioritize development over other uses.”); *Ore. Natural Desert Ass’n v. BLM*, 625 F.3d 1092, 1122 (9th Cir. 2010). Consequently, BLM may not manage public lands primarily for energy development. Projects that are not economic should be wound down, consistent with reclamation obligations and duties to restore public lands for other uses.

As noted above, the RPC is charged with ensuring a suitable return on development, as is the Department of the Interior under the Mineral Leasing Act. This recommendation should not be adopted based on its absolute inconsistency with the obligations of the Department of the Interior and this committee.

We appreciate your consideration of these comments and hope to see the Royalty Policy Committee focus on the ways it can provide a better return for oil and gas development on public lands while ensuring any development is conducted in a responsible manner, consistent with the Department of the Interior’s obligations as steward of our shared public lands.

Sincerely,

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LEONARDITE PRODUCTS-LLC

Leonardite Products mines and processes an oxidized lignite on private surface with a 1964 federal coal lease. Leonardite is a humate; is sold to the fertilizer, foundry and oil industries. Leonardite is not used for energy – nor is it associated with coal used for energy. Our business model is completely different than coal. Yet we are subject to the unit value determination and benchmarks written for coal and our costs to get this material in marketable condition are substantial. We are expected to pay an average of \$18.66 per sold ton. We don't have that kind of margin.

There is a provision in the training manual suggesting the Office of Natural Resources Revenue and the BLM can allow some allowances, however after working on this since 2010, we've not been able to find any resolution. There is a solution here that will satisfy both the federal government and Leonardite Products- short of taking this to the IBLA that will satisfy all parties. It may require interpretation of the processing allowances and/or benchmarks.

Leonardite Products has several appeals filed with Office of Natural Resources Revenue. In February 2018, ONRR denied our first appeal submitted in September 2013 and all the following appeals submitted monthly. We have paid almost \$450,000 on 90,077 tons severed (since 2006) and less than 63,000 tons sold. ONRR suggests we pay them another \$352,866.

I believe ONRR had difficulty ruling on our appeals because they understand strictly applying rules and regulations for coal on our company is not reasonable. It is common for the ONRR personnel and me to suggest we are trying to put a square peg in a round hole. ONRR tells me the BLM could change their position. BLM refers to the Royalty Rate Reduction and suggests I talk to ONRR. Despite a long conversation and a promise to call me back, ONRR has not fulfilled that promise to return my call.

The BLM Royalty Rate Reduction petition was submitted to the Billings office in February 2014. It did not advance to DC for four years. I was told to expect a decision at the end of May. I've heard nothing.

We bought this company in 2008 and could not have discovered during due diligence the federal government would be the biggest risk to the future of this company. Leonardite Products is a small company- grossing just over \$1million in leonardite sales per year. Our ability to be profitable and attract capital to expand has been hampered by the royalties expected by the federal government. As a primary sector business we are important to the local community; providing good paying jobs and diversifying the economy.

Cherie Harms, President,
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June 6, 2018

Comments by Ryan Alexander,
President, Taxpayers for Common Sense

at the third meeting of the

U.S. Department of the Interior - Royalty Policy Committee

June 6, 2018

Good afternoon Chairman DeVito and members of the Royalty Policy Committee (RPC). I am Ryan Alexander, president of Taxpayers for Common Sense (TCS), a national, non-partisan budget watchdog organization.

Since 1995, it has been a top priority of my organization to ensure that taxpayers receive fair market compensation for natural resources extracted from federal lands and waters. An important source of revenue for the federal government, royalties and fees from resource development must be applied, collected, and accounted for in a fair and accurate manner. Taxpayers own the natural resources extracted from our nation's lands and waters and must receive a fair return for these assets.

Over the last two decades, TCS has produced detailed research and analysis documenting billions of dollars in lost taxpayer revenue due to a largely opaque leasing and royalty collection system that frequently undervalues our natural resources and keeps decisions and information from public view.

The Royalty Policy Committee has a unique opportunity to address the problems plaguing our system and propose reforms that will help get taxpayers what we are due.

The waste of taxpayer-owned natural gas. Currently, taxpayers are losing out on hundreds of millions of dollars in royalty-free natural gas that is leaked, vented, or flared from drilling operations on federal land. In 2015, operators reported losing 36 billion cubic feet of natural gas on federal land, more than three times what was lost in 2006. And by the Bureau of Land Management's (BLM's) admission, those volumes are under-reported. According to our recent analysis of Office of Natural Resources Revenue (ONRR) data, taxpayers received no royalties for roughly 90 percent of the natural gas vented or flared on all federal lands in the last decade. We have not seen the RPC address this issue yet.

The BLM recently proposed a new rule to address the royalty treatment of lost gas, but it would only perpetuate the problem. In particular, the proposed rule introduces a concept of "wasted oil and gas" whereby taxpayer-owned oil and gas isn't wasted if the cost of capturing it is more than the value of the resources captured. That is, instead of more carefully setting standards for when operators can reasonably be expected to prevent waste, the BLM chose to simply re-define "waste." To the contrary, the definition of waste is universal – it's whenever assets or resources aren't put to their most productive use. To make the concept of waste dependent on the profitability of its prevention by any operator, no matter how inefficient, is a terrible deviation from the BLM's responsibility to manage public resources in the public interest. We urge this committee to examine the issue and propose a definition of waste that prioritizes the full recovery of resources, rather than the profits of oil and gas companies.

The undervaluation of federal resources. In addition to determining when royalties should be imposed on federal resources, how to value those resources is of utmost concern to taxpayers. Last year, ONRR repealed a rulemaking regarding the valuation of federal oil, gas, and coal, which was finalized in 2016 after a five-year process. The rule was imperfect, but it would have corrected a number of problems in the current system, such as how coal sold in non-arm's-length transactions is valued, when index prices should be used for valuing natural gas, and what transportation allowances are appropriate. The rule's repeal reduced royalty collections.

Yet at its last meeting, this committee endorsed recommendations that exclusively represent the industry's objections to the rule, and would further entrench problems in the valuation system. Several pages from the justification materials for one recommendation were taken straight from one coal company's comments on the rulemaking.

Onshore and Offshore Royalty Rates. We were glad to see that the Department of the interior (DOI) has not embraced the RPC recommendation to lower offshore royalty rates. Lowering the royalty rate would have dramatically reduced taxpayer revenues for decades to come. The RPC should focus instead on applying the 18.75 percent royalty rate across all offshore leases. Additionally, the RPC should propose an onshore royalty rate increase. According to the Congressional Budget Office, "Raising the royalty rate for onshore parcels to 18.75 percent to match the rate for offshore parcels would generate \$200 million in net federal income over the next 10 years...." And, "...the subsequent decrease in production on federal lands would in all likelihood be small or negligible"

Coal Royalty Rate Decisions. In response to a 2013 inquiry from Congress, ONRR released a limited data set that indicated the BLM had granted nearly 30 royalty rate reductions to coal leases on federal lands in the prior two decades. Little is known about why these reductions were granted, how many coal leases have reduced royalty rates now, and how much this is costing taxpayers in lost royalty revenue. The RPC should examine DOI's current practice of reducing royalty rates for coal leases and propose protocol for how reductions requests should be justified and when they should be granted going forward.

Idle Oil and Gas Leases. At present, large sections of federal lands and waters set aside for oil and gas production sit idle, in part, because Interior policies don't do enough to encourage diligent development. At the end of fiscal year 2017, half of all onshore acres leased for oil and gas production sat idle. As of May of this year, the same was true for 70 percent of active offshore oil and gas leases. Some lag between a lease issuance and the beginning of exploration and development activities is expected. But allowing companies to lock up parcels of land without developing them contradicts the multiple-use principle that guides DOI's management of federal lands. It can also prevent more eager producers from bringing important energy resources to market.

Unfortunately, rather than preventing the stockpiling of idle federal lands and waters, current DOI policies encourage it. In states like New Mexico and Texas, rental rates are raised after three to five years if a lease is not yet in production. The BLM, however, sets its rental fees irrespective of a lease's producing status, and at rock bottom rates of \$1.50 and \$2.00 per acre. This committee should examine how the BLM could alter its rental pricing to better encourage oil and gas development on federal lands. To encourage offshore development, this committee should also explore setting a fee on nonproducing parcels – a policy suggested by legislators of both parties in years past. Setting such a fee could raise significant federal revenue for taxpayers. In 2016, The Congressional Budget Office estimated that a

\$6/acre fee on nonproducing leases would yield \$200 million in revenue over 10 years, with a negligible effect on production.

Oil and Gas Measurement. One of the Planning, Analysis, and Competitiveness Subcommittee recommendations presented at this meeting proposes that DOI rewrite Onshore Orders for Site Security, Oil Measurement, and Gas Measurement (43 CFR 3173-75) and adopt, as replacements, industry standards published by the American Petroleum Institute (API) and Gas Processors Association (GPA). This subcommittee recommendation is surprising because the cited Onshore Orders were recently revised in response to a recommendation from an RPC subcommittee in 2007, and specifically incorporated many of the API and GPA standards. In these recent rulemakings, furthermore, after including dozens of the API and GPA standards, the BLM was careful to note where the standards were either inadequate – neither prescribes how transducer performance specifications should be set, for example – or unsuitable for BLM’s purposes. Not only does the new recommendation fail to acknowledge this history (despite directions to the contrary), it also neglects to cite any specific reason why the extensive adoption of the API and GPA standards in the recent rulemakings was insufficient, or harmful.

In addition, the suggestion that the BLM should put aside the result of rulemakings carried out by the BLM with ample opportunity for public input, in favor of standards set by a third party with little or no opportunity for public input, seems to entail the abdication of the agency’s authority and responsibility to act on the public’s behalf.

We are not opposed to another review of the adequacy of the measurement standards, but more justification is needed to explain why such a review is necessary. If such a review is conducted, there should be a thorough assessment of whether the industry requirements are rigorous enough to meet the requirements of federal law, and why the BLM’s prior determination of the standards’ inadequacy is no longer valid. Automatically reverting to industry standards without a clear understanding of its impact is not in the taxpayer interest.

Royalty Relief. Maximizing the recovery of public oil and gas resources from a reservoir after production begins on a given lease is beneficial to oil and gas producers, energy markets, and taxpayers. We fully support the recommendation that DOI clarify the process for how operators can apply for and receive royalty relief for end-of-life assets under current statutory authority. The committee’s new recommendation that DOI’s review of the royalty relief process should examine how new technologies could factor into the justification for royalty relief also makes sense. It is imperative, however, that any review of the royalty relief process, or any subsequent changes made to that process, should not lower the standards for justifying or granting royalty relief. The benefit of royalty relief should be granted only when an operator has sufficiently demonstrated that the economic benefits of production (including previous production) are insufficient to cover documented costs. Decreasing the royalty rate on production that would have otherwise occurred is completely contrary to the taxpayer interest and we caution the RPC from insisting on any changes to current protocols that would encourage such practice.

Faulty Assumptions on Oil and Gas Revenue. The RPC’s recommendation to expedite the leasing of Arctic National Wildlife Refuge (ANWR) lands during their last meeting in Houston did not include a full debate on the potential revenue and liabilities expedited leasing would carry for taxpayers. It also ignores current market conditions and interest in development, and will likely lead to more undervalued oil and gas leases sitting idle. TCS has written extensively on the subject, and our analysis has shown that

drilling in ANWR will not provide nearly the amount of revenue for taxpayers promised. Using extremely generous assumptions for industry interest and bidding rates – both well above historical averages in Alaska’s North Slope region – taxpayers would receive less than five percent of what is currently expected. Instead of expediting oil and gas leasing in ANWR, DOI should take a step back and look at the data.

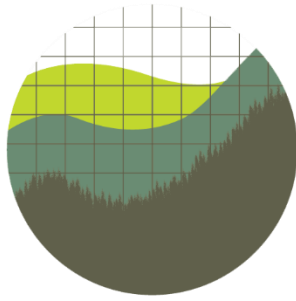
DOI Transparency. The DOI is entrusted to manage federal natural resources on the public’s behalf, but determining whether its actions actually serve the public interest is often impossible because of the department’s stunning lack of transparency. Data that would provide insight into natural resource production and management on federal lands is often inaccessible or available only at the summary level. We have abundant first-hand experience requesting data and other information from DOI sub-agencies that should be readily available and being unnecessarily shunted into the FOIA request process, where our requests have at times languished for years.

This lack of transparency has direct bearing on the return DOI achieves for the development of federal resources, and thus should be of great concern to the RPC. It’s impossible for the RPC to advise the Secretary on whether the public is receiving “the full value of the natural resources produced from Federal lands,” as its charter indicates, when the process for determining coal royalty rate reductions, the adequacy of bonus bids for onshore oil and gas leases, the fair market value of federal coal, and numerous other decisions are shrouded in mystery. To inform its future work, the RPC should immediately encourage DOI to provide more information on these resource management processes. To better safeguard the public interest through transparency into the future, the RPC should also develop disclosure standards for all DOI decisions that affect taxpayers’ return on federal resource development. Those standards should include recommendations for the breadth, depth, and availability of data that the DOI should provide the public.

Full and Balanced Debate. To ensure these issues and others receive full and fair debate, the RPC must include a diverse set of perspectives. Unfortunately, the committee’s recommendations to date solely reflect industry concerns and do not discuss or address taxpayer concerns of waste, mismanagement, and undervaluation. TCS believes industry should have a seat at the table and their concerns should be heard, but right now the RPC is only addressing and supporting industry recommendations. This is a tremendous disservice to the American taxpayer and the Department of the Interior.

We hope going forward the committee will be able to put aside their private or professional interests and put the nation’s resource owners—federal taxpayers— first.

###



Institute *for*
Policy Integrity

NEW YORK UNIVERSITY SCHOOL OF LAW

June 6, 2018

Royalty Policy Committee:

I submit the following op-ed, published today in *U.S. News*, as my public comment to the Committee for its June 6, 2018 public meeting.

Sincerely,

Jayni Hein

Policy Director
Institute for Policy Integrity
NYU School of Law

Pushing for the Public Interest

The Department of the Interior is on the verge of selling public lands for a fraction of their worth.

By Jayni Hein, Opinion contributor, *U.S. News* (June 6, 2018, at 10:26 a.m.).

Publicly owned lands in the United States contain many of the country's most iconic natural areas as well as a wealth of natural resources. But these taxpayer-owned assets are on the verge of being given away for a fraction of their [true value](#) in an effort to prop up the uneconomical mining and drilling operations of some fossil-fuel companies, who clearly have the Department of the Interior's ear.

Interior is required by [law](#) to earn "fair market value" for the use and development of public natural resources, including coal, oil and natural gas. Royalties are a significant source of revenue for the federal treasury and for states with mineral production, which receive a share of federal royalties.

An antiquated system established in the 1920's has allowed the fossil fuel industry to underpay royalties for decades and [deprive taxpayers of revenue](#) that could support infrastructure projects, [public schools](#), and environmental protection. The Obama administration took several steps to improve the system, including by closing a costly [loophole](#) that allowed coal firms to underpay royalties by selling coal to their subsidiaries at artificially low prices. The change was expected to save taxpayers up to [\\$78 million](#) every year.

But the Trump administration is working to undo these improvements. Today, the Department of Interior's Royalty Policy [Committee](#), a fraternity largely comprised of those with close ties to the fossil fuel industry, will meet in New Mexico for a regularly scheduled meeting where they will vote on policy recommendations.

The committee's [charter](#) directs it to ensure that the "public receives the full value of all natural resources produced from Federal lands," but the Committee appears intent on doing exactly the opposite. Instead, it is myopically focused on advancing the interests of fossil fuel companies at the expense of the public and our federal natural resources. In sessions led by [coal executives](#), the committee has focused on reinstating the coal valuation loophole, in order to avoid paying royalties that are owed to the public.

One of the committee's most significant recommendations to-date was a proposal to lower the deepwater offshore royalty rate, diverting more public money to fossil fuel companies. This proposal was seen as so biased and [unreasonable](#) that Interior Secretary Ryan Zinke, who chose the committee members, [rejected](#) their recommendation following political pressure and [probing](#) as to what data could support such a federal giveaway. Taxpayers may have dodged that bullet, but at today's meeting, the committee will discuss how Interior may be able to [skirt the legal requirements](#) of the National Environmental Policy Act in order to accelerate drilling, and how to encourage more discretionary royalty rate reductions for late-stage and "[challenging](#)" leases. These moves would further open the door to environmental damage, government giveaways and industry self-dealing.

The committee's fossil fuel industry members are clearly looking out for themselves, but who is looking out for the public?

When Secretary Zinke first announced the creation of the Royalty Policy Committee, he had the potential to convene a diverse, informed group of stakeholders. Instead, he stacked the committee's 20 primary and 18 alternate [members](#) with executives from fossil fuel industries, representatives from Republican states, and fossil fuel industry-[connected members](#) of Native American tribes. In a striking effort to exclude the public interest, Interior did not name a single representative from an environmental, conservation or taxpayer advocacy group, even as these organizations have been engaged in policy debates about fossil fuel leasing [policies](#) and [fiscal reform](#) for years. These groups have repeatedly [commented](#) on the need for more public interest participation on the committee; but adding insult to injury, Interior quietly [added](#) two individuals to a subcommittee to "represent the public interest" from the Heritage Foundation and Americans for Tax Reform, two organizations strongly opposed to regulation.

The make-up and focus of the Royalty Policy Committee is part of a troubling pattern by this administration that seeks to elevate fossil-fuel interests over the public interest. Secretary Zinke has established other committees to craft policies that can enrich their own bottom line, such as the "[Made in America Recreation Committee](#) whose representatives overwhelmingly hail from hotel, vehicle and hunting industries. Absent from this roster are any outdoor recreation businesses that support conservation, like Patagonia and REI, both of which have publicly [opposed](#) President Trump's [unprecedented](#) reduction of national monuments.

Interior is [required](#) to balance fossil fuel development with other equally important uses, including preservation, recreation and renewable energy development. But instead of considering these important values, the committee has recommended conducting new oil and gas lease sales in the pristine Arctic National Wildlife Refuge, a recommendation that Interior recently [embraced](#).

Ultimately, the Royalty Policy Committee's focus on "energy dominance" has translated into proposals that would reduce or avoid royalty payments, provide inefficient royalty rate reductions, and pave the way for drilling in our most sensitive public lands, without properly compensating the American people for the use of their resources. This is not government by the people, for the people; it is self-dealing in plain sight.

Jayni Hein is the policy director at the Institute for Policy Integrity at New York University School of Law, where she teaches natural resources law and policy.



RPC, DOI <rpc@ios.doi.gov>

[EXTERNAL] Tribal Royalties

1 message

Teresa Seamster <ctc.seamster@gmail.com>

Fri, Jun 8, 2018 at 11:38 AM

To: Vincent DeVito <rpc@ios.doi.gov>, Russell Begaye <russellbegaye@navajo-nsn.gov>, Jonathan Nez <jonathannez@navajo-nsn.gov>

Dear Chairman DeVito, Executive Director Schindler, Navajo President Begaye and Navajo Vice President Nez,

Please accept the findings and concerns of the Counselor Health Impact Assessment (HIA) / Hozhoogo'na'ada (HNDA) Committee as part of your public comments regarding the reduction of royalty payments to tribes from oil and gas production.

Our committee is half way through a one year study of health impacts due to well emission exposure in the tri-chapter area of Counselor, Torreon-Star Lake and Ojo Encino. As our sampling data is currently undergoing lab analysis and reports are not yet available, we are sending our preliminary summary that was presented to the NM Environment Department Air Quality Bureau hearing on new construction permits on February 12, 2018.

The several thousand residents of this area have repeatedly requested and held public meetings and reported issues to the Navajo Tribal Council and HEHS Committee, the BLM Farmington Field Office and the BLM Regional Office regarding the health and economic harms being caused by the escalating oil production around the greater Chaco area.

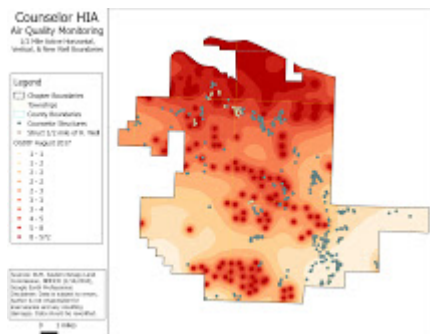
In the interests of keeping our documentation focused, we emphasize that any reduction to the tiny royalty payments actually received by the multiple allotment owners will further impoverish this area which includes Nageezi (demographically the poorest community in the state). Once oil and gas take over an area, the impact is such that other forms of rural economic development are curtailed and existing ranching and subsistence farming is severely impacted. In the case of this Chaco area, the impact extends to the World Heritage Site of Chaco Culture National Historical Park with drops in visitorship and park closures.

Please understand the ever spreading magnitude of this industry's impact on rural health, economy and culture and do not endorse a reduction in royalties.

Respectfully,

Teresa Seamster, EdS
 Medical Researcher
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3 attachments



Counselor_OGDIF_Structures.jpeg
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Air Quality Bureau_Counselor SUMMARY 08102017.pdf
2109K

6/8/2018

DEPARTMENT OF THE INTERIOR Mail - [EXTERNAL] Tribal Royalties



2018 Compendium_5FINAL.pdf
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**Compendium of Scientific, Medical, and Media Findings
Demonstrating Risks and Harms of Fracking
(Unconventional Gas and Oil Extraction)**

Fifth Edition

March 2018



Fracking industry site near Greers Ferry Lake in Quitman, Arkansas in the Fayetteville Shale region. ©2014 Julie Dermansky

The Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (the Compendium) is a fully referenced compilation of the evidence outlining the risks and harms of fracking. It is a public, open-access document that is housed on the websites of Concerned Health Professionals of New York (www.concernedhealthny.org) and Physicians for Social Responsibility (www.psr.org).

The four earlier editions of the Compendium have been used and referenced all over the world. The Compendium has been twice translated into Spanish: independently in 2014 by a Madrid-based environmental coalition, followed by an official translation of the third edition, which was funded by the Heinrich Böll Foundation and launched in Mexico City in May 2016. The Compendium has been used in the European Union, South Africa, the United Kingdom, Australia, Mexico, and Argentina.

About Concerned Health Professionals of New York

Concerned Health Professionals of New York (CHPNY) is an initiative by health professionals, scientists, and medical organizations for raising science-based concerns about the impacts of fracking on public health and safety. CHPNY provides educational resources and works to ensure that careful consideration of science and health impacts are at the forefront of the fracking debate.

About Physicians for Social Responsibility

Working for more than 50 years to create a healthy, just, and peaceful world for both present and future generations, Physicians for Social Responsibility (PSR) uses medical and public health expertise to educate and advocate on urgent issues that threaten human health and survival, with the goals of reversing the trajectory towards climate change, protecting the public and the environment from toxic chemicals, and addressing the health consequences of fossil fuels. PSR was founded by physicians concerned about nuclear weapons, and the abolition of nuclear weapons remains central to its mission.

Contents

About Concerned Health Professionals of New York	2
About Physicians for Social Responsibility.....	2
About this Report.....	4
Foreword to the Fifth Edition	7
The Compendium in Historical Context.....	7
Expanding Knowledge Base.....	9
Timeline of Bans and Moratoria.....	10
Introduction to Fracking	14
Emerging Trends.....	17
Compilation of Studies & Findings	31
Air pollution.....	31
Water contamination.....	48
Inherent engineering problems that worsen with time.....	87
Radioactive releases.....	93
Occupational health and safety hazards.....	99
Public health effects, measured directly	114
Noise pollution, light pollution, and stress	126
Earthquakes and seismic activity.....	131
Abandoned and active oil and natural gas wells as pathways for gas and fluid migration	151
Flood risks.....	160
Threats to agriculture and soil quality	163
Threats to the climate system.....	171
Threats from fracking infrastructure.....	193
Sand mining and processing	194
Wastewater treatment facilities.....	198
Pipelines and compressor stations	198
Gas storage: The Aliso Canyon leak.....	211
Liquefied natural gas (LNG) facilities	220
Inaccurate jobs claims, increased crime rates, threats to property values and mortgages, and local government burden	223
Inflated estimates of oil and gas reserves and profitability	241
Disclosure of serious risks to investors.....	248
Medical and scientific calls for more study, reviews confirming evidence for harm, and calls for increased transparency and science-based policy	251
Conclusion	266

About this Report

The Compendium is organized to be accessible to public officials, researchers, journalists, and the public at large. The reader who wants to delve deeper can consult the reviews, studies, and articles referenced herein. In addition, the Compendium is complemented by a fully searchable, near-exhaustive citation database of peer-reviewed journal articles pertaining to shale gas and oil extraction, the Repository for Oil and Gas Energy Research, that was developed by PSE Healthy Energy and which is housed on its website (<https://www.psehealthyenergy.org/our-work/shale-gas-research-library/>).

For this fifth edition of the Compendium, as before, we collected and compiled findings from three sources: articles from peer-reviewed medical or scientific journals; investigative reports by journalists; and reports from, or commissioned by, government agencies. Peer-reviewed articles were identified through databases such as PubMed and Web of Science, and from within the PSE Healthy Energy database. We included review articles when such reviews revealed new understanding of the evidence. Our entries briefly describe studies that document harm, or risk of harm, associated with fracking and summarize the principal findings. Entries do not include detailed results or a critique of the strengths and weaknesses of each study. Because much of medicine's early understanding of new diseases and previously unsuspected epidemiological correlations comes through assessment of case reports, we have included published case reports and anecdotal reports when they are data-based and verifiable.

The studies and investigations referenced in the dated entries catalogued in *Compilation of Studies & Findings* are current through December 2017. The footnoted citations here in the front matter represent studies and articles that are not referenced in the Compendium itself or which appeared as we go to press in March 2018.

Within the compiled entries, we have also provided references to articles appearing in the popular press, when available, that describe the findings of the corresponding peer-reviewed study. For this purpose, we sought out articles in the popular literature that expertly and plainly reported on studies that were highly technical, especially if those articles included comments by principal investigators on the significance of their findings. In such cases, footnotes for the peer-reviewed study and the matching popular article appear together in one entry. We hope these tandem references will make the findings more accessible to lay readers. Acronyms are spelled out the first time they appear in each section.

News articles appearing as individual entries signify investigative reports by journalists conducting original research. While advocacy organizations have compiled many useful reports on the impacts of fracking, these, with few exceptions, do not appear in our Compendium unless they provide otherwise inaccessible data. We also excluded papers that focused purely on methodologies or instrumentation. For some sources, cross-referenced footnotes are provided, as when wide-ranging government reports or peer-reviewed papers straddled two or more topics.

In our review of the data, seventeen compelling themes emerged; these serve as the organizational structure of the Compendium. Readers will notice the ongoing upsurge in reported problems and health impacts, making each section top-heavy with recent data. In accordance, the Compendium is organized in reverse chronological order within sections, with the most recent information first.

The Compendium focuses on topics most closely related to the public health and safety impacts of unconventional gas and oil drilling and fracking. Additional risks and harms arise from associated infrastructure and industrial activities that necessarily accompany drilling and fracking operations. A detailed accounting of all these ancillary impacts is beyond the scope of this document. Nevertheless, we include in this edition a section on risks from fracking infrastructure that focuses on compressor stations, pipelines, silica sand mining operations, natural gas storage facilities, and, for the first time, the manufacture and transportation of liquefied natural gas (LNG).

Many other relevant concerns—such as oil trains, ethylene cracking facilities, natural gas power plants, and use of fracked gas as a feedstock in petrochemical manufacturing—are not included here. We hope to take up these issues in future editions. Similarly, this edition of the Compendium does not examine the harms and risks posed by other forms of unconventional oil and gas extraction, such as cyclic steaming (which uses pressurized, superheated water to release oil), microwave extraction (which points microwave beams into shale formations to liquefy oil), and artificial lift (which uses gasses, chemicals, or pumps to extract natural gas).

Given the rapidly expanding body of evidence related to the harms and risks of unconventional oil and gas extraction, we plan to continue revising and updating the Compendium approximately every year. It is a living document, housed on the websites of Concerned Health Professionals of New York and Physicians for Social Responsibility, which serves as an educational tool in important ongoing public and policy dialogues.

The Compendium is generally a volunteer project and has no dedicated funding; it was written utilizing the experience and expertise of numerous health professionals and scientists who have been involved in this issue for years.

We thank our external readers for their comments and suggestions: Casey Crandall; Barbara Gottlieb; Robert Gould, MD; Jake Hayes, MA; Douglas Hendren, MD; Lee Ann Hill, MPH; Robert Howarth, PhD; Anthony Ingraffea, PhD, PE; Adam Law, MD; Ryan Miller; Pouné Saberi, MD, MPH; Todd L. Sack, MD; Seth Shonkoff, PhD, MPH.

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Suggested citation: Concerned Health Professionals of New York & Physicians for Social Responsibility. (2018, March). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (5th ed.). <http://concernedhealthny.org/compendium/>

Foreword to the Fifth Edition

The Compendium in Historical Context

The release of the first edition of the Compendium by Concerned Health Professionals of New York in July 2014 coincided with a meteoric rise in the publication of new scientific studies about the risks and harms of fracking. A second edition was released five months later, in December 2014. This updated version included dozens of new studies that further explicated the recurrent problems, data gaps, and ongoing uncertainties that natural gas and oil extraction via hydraulic fracturing brings with it.

Almost concurrently, on December 17, 2014, the New York State Department of Health (NYS DOH) released its own review of the public health impacts of fracking. This document served as the foundation for a statewide ban on high-volume hydraulic fracturing (HVHF), announced by New York Governor Andrew Cuomo on the same day. Its conclusions largely aligned with our own:

[I]t is clear from the existing literature and experience that HVHF activity has resulted in environmental impacts that are potentially adverse to public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF and whether the risks can be adequately managed, HVHF should not proceed in New York State. (See footnote 463.)

The third edition of the Compendium, released in October 2015 and compiled as a joint effort with Physicians for Social Responsibility, included more than 100 new peer-reviewed studies as well as the results of four substantive, multi-volume government reports on the impacts of fracking. One, from the U.S. Environmental Protection Agency (EPA), focused on water. Two from the state of California examined a wide array of impacts. And, from New York, the Department of Environmental Conservation's final environmental impact statement and attendant Findings Statement—which, together, implemented New York's statewide ban—incorporated the earlier health review into a larger analysis of the impacts of fracking. The Findings Statement made clear that no known regulatory framework can adequately mitigate the multiple risks of fracking:

Even with the implementation of an extensive suite of mitigation measures...the significant adverse public health and environmental impacts from allowing high-volume hydraulic fracturing to proceed under any scenario cannot be adequately avoided or minimized to the maximum extent practicable.... (See footnote 333.)

In December 2015, this third edition became the basis of invited testimony at several conferences taking place concurrently with the United Nations' climate talks in Paris. Those international negotiations resulted in an historical international accord, the Paris Agreement, which recognizes climate change as a grave threat to public health and establishes as a key goal the need to limit global temperature increases to less than 2° Celsius. As such, the treaty articulates a new vision for energy by compelling nations to monitor their greenhouse gas emissions and set increasingly

ambitious targets and timetables to reduce them. The United States ratified the Paris Agreement on September 2, 2016.

The Compendium's fourth edition was released in November 2016, just as the landmark Paris Agreement went into force and just as several new studies conclusively demonstrated that expansion of shale and oil gas extraction was incompatible with climate stability and the goal of rapid decarbonization that it requires. All together, these data show that because of increasing emissions of methane, a powerful heat-trapping gas, the United States was on track to miss its own pledge under the Paris Agreement, namely, to reduce greenhouse gas emissions 26-28 percent by 2025, as compared to 2005 levels. (See footnotes 712, 713.)

Studies published in 2016 further indicated that methane leaks from U.S. oil and gas operations were significantly higher than previously estimated, as were U.S. methane emissions overall, which increased by more than 30 percent over a twelve year period. Most of this excess methane, which is responsible for 30-60 percent of the recent upsurge of global atmospheric methane, represents leaks from U.S. gas and oil operations. (See footnotes 714-716, 724, 733, 734.)

This fifth edition is being launched in a time of deep environmental retrenchment by the United States government, with aggressive rollbacks of federal regulatory protections, sidelining of environmental scientists, and government denial of the scientific consensus on climate change. The current administration has announced a new era of “energy dominance” based on surging domestic production—and export—of oil and natural gas, much of it extracted via fracking. References to climate change have, in some cases, been removed altogether from U.S. government websites, and greenhouse gas emissions must no longer be included in National Environment Policy Act reviews.

On June 1, 2017, the White House announced its intent to withdraw from the Paris Climate Agreement and oppose the Green Climate Fund, a financial mechanism that helps developing nations fund investments that lower their dependence on fossil fuels. These changes have taken place even as the American Meteorological Society released a major report that identified climate change as a necessary condition for several recent extreme weather events¹ and even as the Fourth National Climate Assessment—a quadrennial report compiled by 13 federal agencies—confirmed that human activities, especially emissions of carbon dioxide and methane, are the dominant cause for ongoing global warming:

It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence. . . . Human emissions of carbon dioxide (CO₂), methane (CH₄), and other greenhouse gases now overwhelm the influence of natural drivers on the external forcing of Earth's climate.²

¹ Herring, S. C., Christidis, N., Hoell, A., Kossin, J. P., Schreck III, C. J., & Stott, P. A. (2017). Explaining extreme events of 2016 from a climate perspective. *Bulletin of the American Meteorological Society*, 99(1), S1–S157. Retrieved from http://www.ametsoc.net/eee/2016/2016_bams_eee_low_res.pdf

² U.S. Global Change Research Program. (2017). *Climate science special report: Fourth National Climate Assessment, Volume I*. doi: 10.7930/J0964J6

The many federal environmental rules rolled back in the United States in 2017 include those that govern drilling and fracking operations. A 2016 rule that would have increased the royalties that gas and oil companies must pay to drill on public lands was repealed. The Bureau of Land Management's Waste Prevention Rule, which requires companies drilling on public and tribal lands to reduce methane leaks and cut back on flaring and venting, was suspended. In April, the EPA canceled its Oil and Gas Methane Information Collection Request (ICR), which asked operators of existing oil and gas facilities to identify and report methane leaks. In 2016, the ICR had been the agency's first step toward regulating methane leaks from existing oil and gas sites.

Similarly, in June, the EPA delayed implementation of the Oil and Gas 111b Methane Rule, which limits methane emissions from new oil and gas drilling sites. After the D.C. Circuit Court vacated that decision, Congress defunded the rule. In October, the EPA recommended the total repeal of the Clean Power Plan, which calls for a 32 percent decrease in carbon emissions from power plants by 2030 and creates incentives for states to invest in renewable energy. In December, the U.S. Department of the Interior rescinded a 2015 rule that would have regulated fracking on public lands by requiring disclosure of chemicals in fracking fluid and tightening standards for well construction and wastewater disposal. Also in 2017, parts of the Arctic National Wildlife Refuge were opened to oil and gas drilling, and the White House revoked policies that had prevented the construction of the Dakota Access Pipeline, which now carries fracked oil from the Bakken Shale basin to an oil storage hub in Illinois.^{3, 4} In January 2018, the U.S. Department of the Interior directed its field officers to expedite the sale of federal leases to the oil and gas industry by dismantling environmental protections for public lands.^{5, 6} Plans for many recent federal environmental repeals are being contested in the courts.⁷

Expanding Knowledge Base

Even as we compiled entries for this fifth edition, the authors of the Compendium continued to see evidence of, and appreciate, the rapid expanse of our knowledge base. The Compendium exists within a moving stream of data. As is revealed in the Repository for Oil and Gas Energy Research, the database of literature maintained by PSE Healthy Energy, the number of peer-

³ Harvard University Environmental Law Program. Environmental Regulation Rollback Tracker.

<http://environment.law.harvard.edu/policy-initiative/regulatory-rollback-tracker/>

⁴ Mooney, C. (2017, December 29). To round out a year of rollbacks, the Trump administration just repealed key regulations on fracking. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2017/12/29/to-round-out-a-year-of-rollbacks-the-trump-administration-just-repealed-key-regulations-on-fracking/?utm_term=.f16b4db99128

⁵ U.S. Department of the Interior, Bureau of Land Management. (2018, January 31). Updating oil and gas leasing reforms - land use planning and lease parcel reviews. IM 2018-034. Retrieved from <https://www.blm.gov/policy/im-2018-034>

⁶ Fears, D. (2018, February 1). Trump administration tears down regulations to speed drilling on public land. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2018/02/01/trump-administration-tears-down-regulations-to-speed-drilling-on-public-land/?utm_term=.efb30819a90c

⁷ Groom, N. (2018, January 24). California to sue Trump administration for repeal of fracking rules. *Reuters*. Retrieved from <https://www.reuters.com/article/us-usa-california-fracking/california-to-sue-trump-administration-for-repeal-of-fracking-rules-idUSKBN1FD2QS>

reviewed publications relevant to assessing the environmental, socioeconomic, and public health impacts of shale gas development doubled between 2011 and 2012 and then doubled again between 2012 and 2013.⁸ More than 90 percent of these publications have been published since January 2013, with nearly one-quarter of the now more than 1,300 available studies published in 2017 alone.⁹

The available peer-reviewed literature reveals both potential and actual harms. Specifically, as demonstrated by PSE’s statistical analysis of the body of scientific literature available from 2009 to 2015, 69 percent of original research studies on water quality found potential for, or actual evidence of, water contamination; 87 percent of original research studies on air quality found significant air pollutant emissions; and 84 percent of original research studies on human health risks found signs of harm or indication of potential harm.¹⁰

Timeline of Bans and Moratoria

As a response to the proliferating evidence of the risks and harms of fracking—augmented by increasing concern about the many remaining uncertainties—various countries, states, and municipalities have instituted bans and moratoria.

France banned fracking in July 2011 and Bulgaria in January 2012. The state of Vermont banned fracking in May 2012.

Following New York’s ban in December 2014, Scotland became the first country in Great Britain to impose a formal moratorium on fracking in January 2015, after an expert panel concluded that more study of fracking’s risks was needed. (In 2016, as part of the ongoing moratorium process, the government of Scotland released a series of reports that reconfirmed the evidence for potential contamination of air and water, threats to worker health from silica dust exposure, and risks to the health of nearby residents. It further noted that the pursuit of unconventional oil and gas extraction would make more difficult Scotland’s goal of meeting its climate targets on greenhouse gas emissions.^{11, 12}) Scotland’s moratorium became an effective ban when it was extended “indefinitely” in October 2017.

⁸ PSE Healthy Energy (2016, April 20). The science on shale gas development infographic. Retrieved from http://www.psehealthyenergy.org/data/PSE_FrackingStudy_Summary_Infographic_4-20-2016_00.jpg

⁹ PSE Healthy Energy. Repository for Oil and Gas Research (ROGER). <https://www.psehealthyenergy.org/our-work/shale-gas-research-library/>

¹⁰ Hays, J., & Shonkoff, S. B. C. (2016). Toward an understanding of the environmental and public health impacts of shale gas development: An analysis of the peer-reviewed scientific literature, 2009-2015. *PLOS One*, 11(4), e0154164. doi: 10.1371/journal.pone.0154164

¹¹ Health Protection Scotland. (2016, November). *A health impact assessment of unconventional oil and gas in Scotland*, vol. 1. Retrieved from <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

¹² Committee on Climate Change. (2016, August). *Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas emissions targets*. Retrieved from <http://www.gov.scot/Resource/0050/00509324.pdf>

In February 2015 the government of Wales declared a moratorium on fracking “until it is proven safe.” The Canadian province of New Brunswick declared a moratorium for similar reasons in March 2015.

In July 2015, the Dutch government banned all shale gas fracking until 2020 on the grounds that “research shows that there is uncertainty” about impacts.

In September 2015, Northern Ireland and the Spanish region of Castile La Mancha both effectively banned fracking via strategic planning policies.

In a December 2015 vote in favor of a report, *Towards a European Energy Union*, the plenary of the European Parliament affirmed the incompatibility of shale gas extraction via hydraulic fracturing with the European Union’s commitment to decarbonization, and it acknowledged public concerns about the environmental and health impacts of fracking. While falling short of an outright EU-wide moratorium on fracking, the report states that “it is questionable whether hydraulic fracturing can be a viable technology in the European Union.”¹³

In Florida, 85 municipalities have either banned fracking outright or passed resolutions opposing it. In 2016, a bill that would have pre-empted local bans and opened the state to fracking was voted down in a Florida legislative committee.

Also, in 2016, New Brunswick extended its moratorium on fracking “indefinitely,” citing unresolved problems with the disposal of fracking wastewater, and in the Canadian province of Newfoundland and Labrador, where a moratorium had been in place since 2013, a government-appointed panel recommended that fracking remain “paused,” citing data gaps and unresolved questions about the underlying geology.

In June 2016, Germany adopted a moratorium on “unconventional fracking” until 2021 but will permit exploratory drilling research projects.

Also in 2016, California’s Butte and Alameda counties banned fracking, along with Monterey County, which also banned all new oil drilling. (Santa Cruz, San Benito, and Mendocino counties banned fracking in 2014.)

In August 2016, the Australian state of Victoria declared a permanent ban on fracking on the grounds that the risks outweighed any potential benefits.

In September 2016, a California judge, arguing that the agency had failed to consider the dangers of fracking, struck down a bid by the U.S. Bureau of Land Management to open one million acres of public land in central California to oil drilling.

In November 2016, Winona County, Minnesota banned the mining of frack sand, a decision that was upheld in district court in November 2017.

In December 2016, the Portland, Oregon City Council approved zoning code changes that banned the construction of new fossil fuel projects, including terminals for storing and

¹³ Committee on Industry, Research and Energy. (2015, November 24). *Report on Towards a European Energy Union*, A8-0341/2015. Retrieved from <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+REPORT+A8-2015-0341+0+DOC+XML+V0//EN>

transporting natural gas, and also prohibited the expansion of pre-existing facilities, including an LNG plant.

Many more bans, moratoria, and restrictions were enacted or proposed in 2017. In April 2017, Maryland became the third U.S. state to ban fracking when Governor Larry Hogan signed a ban bill that was overwhelmingly approved by the state legislature. Maryland's ban followed a two-and-a-half-year statewide moratorium.

Also in April, Entre Rio passed the first province-wide ban on fracking in Argentina. This ban follows 50 individual municipal bans and is intended to protect the Guarani Aquifer, which extends beneath parts of Argentina, Brazil, Paraguay, and Uruguay.

In June 2017, France expanded its fracking ban to include a ban on all new oil and gas exploration.

In July 2017, Ireland banned fracking when legislation was signed into law by the president. In October, as the moratorium on fracking in Scotland was extended indefinitely, Canada's Prince Edward Island included a prohibition on fracking as part of its Water Act. According to campaigners, Albania also enacted a national ban on fracking in 2017 but these reports are, as of this writing, unconfirmed by official sources.

In December 2017, Australia's North Territory government decided to delay a decision on whether or not to extend or lift its own moratorium on fracking after a draft final report identified multiple risks to water, land, tourism, and indigenous culture.

As we go to press in early 2018, the Delaware River Basin Commission (DRBC)—which consists of governors from the four states of New York, New Jersey, Pennsylvania, and Delaware together with the U.S. Army Corps of Engineers—has released a proposed rule to ban fracking in the Delaware River watershed on the grounds that fracking exposes its waters to “significant, immediate, and long-term risks” and has set a schedule for public hearings and comments. As currently drafted, the rule has two loopholes: it does not ban the importation of wastewater from fracking operations located outside the basin, nor does it prohibit water withdrawals from the Delaware River and its tributaries for export and use in such operations.¹⁴
¹⁵ The longest free-flowing river in the Northeast, the Delaware River provides drinking water to more than 15 million people (approximately 5 percent of the U.S population). About one-third of the river system flows through shale formations. A de facto moratorium on fracking in the Delaware River Basin has been in place since 2010.

In Connecticut, where no fracking takes place, ordinances prohibiting the storage or use of imported fracking waste have been passed by 34 municipalities, with more public hearings scheduled for early 2018. Vermont has banned the importation of fracking waste into the state.

¹⁴ Delaware River Basin Commission. (2017, November 30). Proposed new 18 CFR part 440—hydraulic fracturing in shale formations. Retrieved from http://www.nj.gov/drbc/library/documents/HydraulicFracturing/18CFR440_HydraulicFracturing_draft-for-comment_113017.pdf

¹⁵ Hurdle, J. (2017, November 30). Fracking ban proposed for Delaware River basin; ‘significant risks’ cited. *StateImpact Pennsylvania*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2017/11/30/fracking-ban-proposed-for-delaware-river-basin-significant-risks-cited/>

In sum, as evidence continues to mount of its environmental and public health costs, legislative and governmental bodies are increasingly apprehensive about the risks and harms of fracking.

Nevertheless, in several notable cases, hard-won bans have been overturned. In May 2016, the Colorado Supreme Court struck down local fracking bans in the cities of Fort Collins and Longmont. In June 2015, citing concerns about noise impacts and the industrialization of rural landscape, the county of Lancashire in northwest England halted plans for a major British fracking operation; years previously, two wells—the first and only pair ever drilled in Lancashire—had suffered well integrity failures and caused earthquakes. However, in 2016, the national government overturned Lancashire’s ban, and drilling began in October 2017 despite widespread, ongoing public opposition. Similarly, a fracking ban passed by the city of Denton, Texas in November 2014 was invalidated in June 2015 by a state law, pushed by the oil and gas industry, that prohibits Texas municipalities from passing local bans.

Introduction to Fracking

Since the end of the 20th century, horizontal drilling has been combined with high-volume hydraulic fracturing as novel technologies for extracting dispersed oil and natural gas, primarily from shale bedrock, that would otherwise not flow to the surface. Typically, these unconventional extraction methods (collectively known as “fracking”) take place on clustered multi-well pads where individual well bores extend vertically down into the shale formation and then turn horizontally, tunneling through the shale in various directions. These lateral tunnels can extend a mile or more underground.

To liberate the gas (methane) or oil trapped inside the shale, many small explosive charges followed by high volumes of pressurized fluid are sent into the shale layer to expand and extend its many naturally occurring cracks, bedding planes, and faults. Silica sand grains (or sometimes ceramic beads) are carried by the pressurized fluid into these spaces and remain there after the pressure is released, acting to prop open these now-widened fissures in the shale and allowing the methane or oil trapped within to flow up the well.

Fracking fluid consists of fresh water to which is added a sequence of chemicals that include biocides, friction-reducers, gelling agents, anti-scaling, and anti-corrosion agents. Some of the water used to frack wells remains trapped within the fractured zone and, as such, is permanently removed from the hydrologic cycle. The remainder travels back up to the surface. This flowback fluid contains not only the original chemical additives but also naturally occurring substances carried up from the shale zone, which often include brine, heavy metals, and radioactive elements.

Once in production, a fracked well continues to generate liquid throughout its lifetime. This produced water, which contains many of the same toxic substances as flowback fluid, is a second component of fracking waste, and it also requires containment and disposal. In addition, fracking waste includes solid drilling cuttings, which are typically laced with various chemical substances used to aid the drilling process. These cuttings, which can also contain radioactive elements, are typically disposed in landfills.

As fracking operations in the United States have increased in frequency, size, and intensity, and as the transport of extracted materials has expanded, a significant body of evidence has emerged to demonstrate that these activities are dangerous to people and their communities in ways that are difficult—and may prove impossible—to mitigate. Risks include adverse impacts on water, air, agriculture, public health and safety, property values, climate stability, and economic vitality, as well as earthquakes.

Researching these complex, large-scale industrialized activities—and the ancillary infrastructure that supports them—takes time and has been hindered by institutional secrecy. Nonetheless, research is gradually catching up to the last decade’s surge in fracking from shale. A growing body of peer-reviewed studies, accident reports, and investigative articles has detailed specific, quantifiable evidence of harm and has revealed fundamental problems with the entire life cycle of operations associated with unconventional drilling, fracking, and fracked-gas infrastructure. Industry studies, as well as independent analyses, indicate inherent engineering problems

including uncontrolled and unpredictable fracturing, induced seismicity, extensive methane leakage, and well casing and cement failures that cannot be prevented with currently available materials and technologies.

Fracking-related problems also originate from sources independent of engineering. These include habitat destruction; inadequate solutions for wastewater disposal; the presence of abandoned wells or vertical fault lines that can serve as pathways for fluid migration into aquifers; and standard operational industry norms (venting, flaring, blowdowns) that contribute to methane releases and air pollution.

Earlier scientific predictions and anecdotal evidence are now bolstered by extensive empirical data, confirming that the public health risks from unconventional gas and oil extraction are real, the range of adverse environmental impacts wide, and the negative economic consequences considerable. Our examination of the peer-reviewed medical and public health literature uncovered no evidence that fracking can be practiced in a manner that does not threaten human health.

Despite this emerging body of knowledge, industry secrecy, and government actions and inaction continue to thwart scientific inquiry, leaving many potential problems—especially cumulative, long-term risks—unidentified, unmonitored, and largely unexplored. This problem is compounded by non-disclosure agreements, sealed court records, and legal settlements that prevent families and their doctors from discussing injuries and illness. As a result, no quantitative and comprehensive inventory of human hazards yet exists.

The long-entrenched problem of secrecy shows no sign of resolving. The identity of chemicals used in fracking fluids remains proprietary and lies beyond the reach of federal right-to-know legislation that governs other industries. The nation's largest public database on chemicals used in fracking operations, FracFocus, operates on a voluntary basis, and, while 23 states have adopted it to serve as a *de facto* chemical disclosure registry, its data has, over time, become increasingly less, rather than more, comprehensive and transparent. As documented in a 2016 study by a Harvard University team, rates of withheld information and claims of trade secrecy have increased since FracFocus was first launched in 2011. (See footnotes 1082, 1083.)

The incomplete picture created by lack of transparency notwithstanding, the evidence to date indicates that fracking operations pose severe threats to health, both from water contamination and from air pollution. In the United States, more than two billion gallons of water and fracking fluids are injected daily under high pressure into the earth for the purpose of enabling oil and gas extraction via fracking or, after the fracking is finished, to flush the extracted wastewater down any of the 187,570 disposal wells across the country that accept oil and gas waste. (See footnote 542.) All of that two billion daily gallons of fluid is toxic, and it passes through our nation's groundwater aquifers on its way to the deep geological strata below where it demonstrably raises the risk for earthquakes. In the air around drilling and fracking operations and their attendant infrastructure, researchers have measured strikingly high levels of toxic pollutants, including the potent carcinogen benzene and the chemical precursors of ground-level ozone (smog). In some cases, concentrations of fracking-related air pollutants in communities where people live and work exceed federal safety standards. Research shows that air emissions from fracking can drift and pollute the air hundreds of miles downwind. (See footnotes 79-81.)

About one-third of the natural gas inventory in the United States is used to generate electricity, and, enabled by fracking, natural gas has, as of 2016, exceeded coal as the nation's leading source of electricity.¹⁶ With hydraulically fractured wells now producing more than two-thirds of U.S. natural gas and half of U.S. crude oil, fracking's "unconventional" techniques can no longer be considered atypical nor can the question of their public health risks be considered inconsequential.^{17, 18}

Drilling and fracking operations and their ancillary infrastructure have profoundly altered Earth's landscape. The flare stacks and artificial lights from major shale plays are visible from space,¹⁹ as is the upward buckling of Earth's surface that is caused by the high-pressure injection of fracking waste water into disposal wells.²⁰

The dramatic increase in fracking over the last decade in the United States has pushed oil and gas extraction operations into heavily populated areas. At least six percent of the population—17.6 million Americans—now live within a mile of an active oil or gas well, a number that includes 1.4 million young children and 1.1 million elderly people.^{21, 22} About 8.6 million people are served by a drinking water source that is located within a mile from an unconventional well. (See footnote 156.) Understanding the potential for exposure and accompanying adverse impacts is a public health necessity.

¹⁶ Magill, B. (2016, May 6). Fracking hits milestone as natural gas use rises in U.S. *Climate Central*. Retrieved from <http://www.climatecentral.org/news/fracking-milestone-as-natural-gas-use-rises-20330>

¹⁷ U.S. Energy Information Administration. (2016, May 5). Hydraulically fractured wells provide two-thirds of U.S. natural gas production. *Today in Energy*. Retrieved from <https://www.eia.gov/todayinenergy/detail.php?id=26112>

¹⁸ U.S. Energy Information Administration. (2016, March 15). Hydraulic fracturing accounts for about half of current U.S. crude oil production. *Today in Energy*. Retrieved from <https://www.eia.gov/todayinenergy/detail.php?id=26112>

¹⁹ NASA Earth Observatory. (2016, March 23). Shale revolution: As clear as night and day. Retrieved from <http://earthobservatory.nasa.gov/IOTD/view.php?id=87725&src=eo-iotd>

²⁰ Coglán, A. (2016, September 22). You can see fracking's impact on Earth's surface from space. *New Scientist*. Retrieved from <https://www.newscientist.com/article/2106886-you-can-see-frackings-impact-on-earths-surface-from-space/>

²¹ Czolowski, E. D., Santoro, R. L., Srebotnjak, T., & Shonkoff, S. B. C. (2017). Toward consistent methodology to quantify populations in proximity to oil and gas development: A national spatial analysis and review. *Environmental Health Perspectives*, 125(8). doi: 10.1289/EHP1535

²² Konkel, L. (2017). In the neighborhood of 18 million: Estimating how many people live near oil and gas wells. *Environmental Health Perspectives*, 125(8). doi: 10.1289/EHP2553

Emerging Trends

1) Growing evidence shows that regulations are simply not capable of preventing harm.

Studies reveal inherent problems in the natural gas extraction process, such as well integrity failures caused by aging or the pressures of fracking itself, and in the waste disposal process. These issues can lead to water contamination, air pollution with carcinogens and other toxic chemicals, earthquakes, and a range of environmental and other stressors inflicted on communities. Some of fracking's many component parts—which include the subterranean geological landscape itself—are simply not controllable.

Compounding the innate unpredictability of the fracking process: the number of wells and their attendant infrastructure continue to proliferate, creating burgeoning cumulative impacts, and the size of individual wells keep growing. With the horizontal portions of a single well now extending as far as two miles or more underground, fluid injections, once typically three to five million gallons per fracked well, can now easily reach 10 to 20 million gallons per well.

The injection of extreme volumes of fluids creates significant deformations in the shale that are translated upwards, a mile or more, to the surface. Along the way, these “pressure bulbs” can impact, in unpredictable ways, faults and fissures in the overlying rock strata, including strata that intersect fresh water aquifers. Such pressure bulbs may mobilize contaminants left over from previous drilling and mining activities. (See footnotes 224, 225.) No set of regulations can obviate these potential impacts to groundwater. Similarly, no set of regulations can eliminate earthquake risks. (See footnote 527.)

The state of California determined that fracking can have “significant and unavoidable” impacts on air quality, including driving pollutants above levels that violate air quality standards. (See footnote 72.) Similarly, in northeastern Colorado, ambient levels of atmospheric hydrocarbons continued to increase even with tighter emission standards. (See footnote 85.)

Well sites leak far more methane and toxic vapors than previously understood, and they continue to leak long after they are decommissioned. Abandoned wells are a significant source of methane leakage into the atmosphere, and, based on findings from New York and Pennsylvania, may exceed cumulative total leakage from oil and gas wells currently in production. Plugging abandoned wells does not always reduce methane emissions, and cement plugs themselves deteriorate over time. Further, many abandoned wells are unmapped and their locations unknown. No state or federal agency routinely monitors methane leakage from abandoned wells. (See footnotes 619, 624.)

Leakage rates among active wells are wildly variable: four percent of wells nationwide are responsible for fully half of all methane emissions from drilling and fracking-related activities. Predicting which wells will become “super-emitters” is not possible, according to a 2016 survey of 8,000 wells using helicopters and infrared cameras. Further, much of this leakage is engineered into the routine operation of fracking extraction, processing and transport infrastructure, as when vapors are vented through release valves in order to regulate pressure. (See footnotes 729, 730.)

2) Fracking and the disposal of fracking waste threaten drinking water.

Cases of drinking water sources contaminated by drilling and fracking activities, or by associated waste disposal, are now proven. EPA's assessment of fracking's impacts on drinking water resources confirmed specific instances of water contamination caused by drilling and fracking-related activities and identified the various pathways by which this contamination has occurred: spills; discharge of fracking waste into rivers and streams; and underground migration of chemicals, including gas, into drinking water wells.

Independently, researchers working in Texas found 19 different fracking-related contaminants—including cancer-causing benzene—in hundreds of drinking water samples collected from the aquifer overlying the heavily drilled Barnett Shale, thereby documenting widespread water contamination. In Pennsylvania, a solvent used in fracking fluid was found in drinking water wells near drilling and fracking operations known to have well casing problems. In California, state regulators admitted that they had mistakenly allowed oil companies to inject drilling wastewater into aquifers containing clean, potable water. (See footnotes 206, 210, 214.) A 2017 study found that fracking wastewater discharged into rivers and streams through treatment plants created dozens of brominated and iodinated disinfection byproducts that are particularly toxic and “raise concerns regarding human health.” (See footnote 141.)

As we go to press in early 2018, researchers reported on the discovery of opportunistic, pathogenic bacteria in fracking-impacted water wells in Texas and raised questions about fracking's effects on the microbial ecology of aquifers.²³ The Pennsylvania Department of Environmental Protection determined that fracking wastewater that had leaked from a storage pit contaminated groundwater and rendered a natural spring used for drinking water in Greene County undrinkable.²⁴ In Arkansas, researchers found that water withdrawals for fracking operations can deplete streams, threaten drinking water supplies, damage aquatic life, and impact recreation.^{25, 26}

3) Drilling and fracking contribute to toxic air pollution and smog (ground-level ozone) at levels known to have health impacts.

Volatile organic compounds from drilling and fracking operations, together with nitrogen oxides, are responsible for 17 percent of locally produced ozone in Colorado's heavily drilled Front

²³ Hildenbrand, Z., Santos, I., & Schug, K. (2018, January 9). Detecting harmful pathogens in water: Characterizing the link between fracking and water safety. *Science Trends*. <https://sciencetrends.com/detecting-harmful-pathogens-water-characterizing-link-fracking-water-safety/>

²⁴ Niedbala, B. (2018, January 16). W. Va. company fined \$1.7 million for violations at 14 well sites in Greene County. *Observer-Reporter*. Retrieved from https://observer-reporter.com/news/localnews/w-va-company-fined-million-for-violations-at-well-sites/article_cc1ce344-faec-11e7-84ca-076df3832f29.html

²⁵ Entekin, S., Trainor, A., Saiers, J., Patterson, L., Maloney, K., Fargione, J., . . . Ryan, J. N. (2018). Water stress from high-volume hydraulic fracturing potentially threatens aquatic biodiversity and ecosystem services in Arkansas, United States. *Environmental Science & Technology*. Advance online publication. doi: 10.1021/acs.est.7b03304.

²⁶ American Chemical Society. (2018, January 31). Potential impact of hydraulic fracturing on streams, downstream recreation, drinking water. *ScienceDaily*. Retrieved from <https://www.sciencedaily.com/releases/2018/01/180131095656.htm>

Range. (See footnote 59.) Colorado has exceeded federal ozone limits for the past decade, a period that corresponds to a boom in oil and gas drilling (See footnote 57.) Living near drilling and fracking operations significantly increases asthma attacks for residents of Pennsylvania, with those living near active gas wells 1.5-4 times more likely to suffer from asthma attacks than those living farther away, with the closest group having the highest risk. (See footnotes 444, 445.)

The New York State Department of Environmental Conservation determined that fracking could increase ozone levels in downwind areas of the state, potentially impacting the ability to maintain air quality that meets ozone standards. (See footnote 333.) In California, fracking occurs disproportionately in areas already suffering from serious air quality problems and can drive ozone and other federally regulated air pollutants to levels that violate air quality standards. (See footnotes 71, 72.) This increased air pollution and smog formation poses a serious risk to all those already suffering from respiratory issues, such as children with asthma. With an average of 203 high-ozone days a year, intensely fracked Kern County, California, is the fifth-most ozone-polluted county in the nation, according to the American Lung Association.

Several studies have documented a sharp uptick in atmospheric ethane, a gas that co-occurs with methane and whose presence is attributable to emissions from oil and gas wells. This trend reverses a previous, decades-long decline; if this rate continues, U.S. ethane levels are expected to hit 1970s levels in about three years. Ethane is a potent precursor to ground-level ozone (See footnote 56, 61-63.) Emissions from drill site flaring operations also contribute to ozone creation and include several carcinogens, including benzene and formaldehyde. In 2016, the EPA acknowledged that it had dramatically underestimated health-damaging air pollutants from flaring operations. (See footnotes 55, 56.) A 2017 study of plume samples from gas flares in North Dakota found that incomplete combustion from flaring is responsible for 20 percent of the total emissions of methane and ethane from the Bakken shale fields, which is more than double the expected value. (See footnote 51.)

4) Public health problems associated with drilling and fracking include poor birth outcomes, reproductive and respiratory impacts, cancer risks, and occupational health and safety problems.

Studies of mothers living near oil and gas extraction operations consistently find impairments to infant health, including elevated risks for low birth weight and preterm birth. A 2017 study that examined birth certificates for all 1.1 million infants born in Pennsylvania found poorer indicators of infant health and significantly lower birth weights among babies born to mothers living near fracking sites. A 2015 Pennsylvania study found a 40 percent increase in the risk of preterm birth among infants born to mothers who lived nearby active drilling and fracking sites. A 2014 Colorado study found elevated incidence of neural tube defects and congenital heart defects. New studies in Texas and Colorado likewise found associations with infant deaths, high-risk pregnancies, and low birth weight. A 2017 pilot study in British Columbia found elevated levels of muconic acid—a marker of benzene exposure—in the urine of pregnant women living near fracking sites. (See footnotes 434, 436, 450, 472.)

An emerging body of evidence, from both human and animal studies, shows harm to fertility and reproductive success from exposure to oil and gas operations, at least some of which may be linked to the dozens of known endocrine-disrupting chemicals used in hydraulic fracturing. (See footnotes 450, 1075, 1080, 1081.)

A 2017 Colorado study found higher rates of leukemia among children and young adults living in areas dense with oil and gas wells, while a Yale University research team reported that carcinogens involved in fracking operations had the potential to contaminate both air and water in nearby communities in ways that may increase the risk of childhood leukemia. The Yale team identified 55 known or possible carcinogens that may be released into air and water from fracking operations. Of these, 20 are linked to leukemia or lymphoma. (See footnotes 441, 1063.)

Other documented adverse health indicators among residents living near drilling and fracking operations variously include exacerbation of asthma as well as increased rates of hospitalization, ambulance runs, emergency room visits, self-reported respiratory problems and rashes, motor vehicle fatalities, trauma, drug abuse, and gonorrhea. Pennsylvania residents with the highest exposure to active fracked gas wells were nearly twice as likely to experience a combination of migraine headaches, chronic nasal and sinus symptoms, and severe fatigue. (See footnote 442.)

Among workers, risks include both accidents and toxic exposures. On-the-job fatalities from accidents in the oil and gas industry are four to seven times the national average, with contract workers at the highest risk. Occupational safety standards designed to minimize “the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals” in workplaces do not apply to the oil and gas industry due to legal exemptions.²⁷ Fatality rates among workers in the oil and gas extraction sector in North Dakota were seven times the national fatality rates in this industry, which itself has more deaths from fires and explosions than any other private industry. An increase in workplace deaths has accompanied the fracking boom in West Virginia. On January 22, 2018, a natural gas rig exploded in southeastern Oklahoma, killing five workers. As we go to press, the U.S. Chemical Safety Board has begun a full investigation into this fatal explosion, in which the well’s blowout preventer failed, leading to an uncontrolled release of natural gas during a pause in the drilling process.²⁸ Between 2011 and 2016, at least 60 workers at oil and gas drilling sites in Oklahoma were killed on the job.

A new study from the University of Tennessee found that workers are exposed to hazardous and carcinogenic air pollutants from multiple sources, with chemical storage tanks presenting the highest cancer risk. Benzene has been detected in the urine of well-pad workers in Colorado and Wyoming. The National Institute for Occupational Safety and Health named oil and gas extraction industry workers among those at risk for silicosis, an incurable lung disease caused by exposure to silica dust, from the silica sand that is used extensively in fracking operations. (See footnotes 377, 415, 423.)

²⁷ Jones, C. (2018, February 3). OSHA standards moot in Quinton rig explosion because of exemption for oil-and-gas industry. *Tulsa World*. Retrieved from http://www.tulsaworld.com/news/state/osha-standards-moot-in-quinton-rig-explosion-because-of-exemption/article_162d0efa-7860-5f4b-b982-ebdeb142c075.html

²⁸ U.S. Chemical Safety Board. (2018, January 31). *Update on the CSB’s ongoing investigation into the fatal gas well explosion in Oklahoma*. [Press release]. Retrieved from <http://www.csb.gov/update-on-the-csbs-ongoing-investigation-into-the-fatal-gas-well-explosion-in-oklahoma/>

5) Natural gas is a threat to the climate.

From a greenhouse gas perspective, natural gas is not a cleaner fuel than coal and may be worse. Methane is a much more potent greenhouse gas than formerly appreciated. The Intergovernmental Panel on Climate Change estimates that, over a 20-year time frame, methane can, pound for pound, trap 86 times more heat than carbon dioxide and is 34 times more potent a greenhouse gas over a 100 year period. (See footnote 780.) Further, real-world methane leakage rates from drilling and fracking operations greatly exceed earlier estimates. In the heavily drilled Barnett Shale of northeastern Texas, methane emissions were shown to be 50 percent higher than the EPA had estimated. Fracking operations and associated infrastructure contribute 71-85 percent of the methane emissions in the region.

Much of the methane emitted from drilling and fracking activities and associated infrastructure originates not from accidental leaks but from losses that are inherent to the design of the machinery or to normal operating use and are, therefore, not possible to mitigate. (See footnotes 848-850.) Inactive, abandoned wells are also significant methane emitters. Methane leakage at the levels now being documented, using multiple approaches in measurement and modeling, negates previously hypothesized benefits from burning methane instead of coal in most existing power plants.

Methane leakage from oil and gas operations makes the urgent task of limiting global warming to below levels called for in the Paris Climate Agreement increasingly difficult. Recent evidence shows that methane emissions from the fossil fuel industry are 20-60 percent higher than previously thought, and that a surge in atmospheric methane levels are now driving climate impacts of rising human-caused greenhouse gases. As we go to press, a major new study led by NASA researchers has confirmed that the sharp uptick in global methane since 2006 is largely attributable to fossil fuel sources.²⁹ Many climate researchers now call for a renewed emphasis on reducing methane emissions to combat climate change. (See footnotes 710, 711.)

6) Earthquakes are a proven consequence of drilling and fracking-related activities in many locations.

Several major studies, using different methodologies, have confirmed a causal link between the injection of fracking wastewater in disposal wells and earthquake swarms. Using structural geology analysis, a 2017 study of the Fort Worth basin showed that a recent swarm of small earthquakes in northern Texas was originating in long-inactive, ancient fault lines in deep formations where fracking wastewater is being injected; human activity is the only plausible explanation. (See footnote 499.) Another recent study using satellite-based radar imagery provided proof that the migration of fracking wastewater into faults increased pressures in ways that triggered a 4.8-magnitude earthquake in east Texas in 2012, while a third study documented the rupture of a fault plane that set off a 4.9-magnitude earthquake in Kansas in 2014

²⁹ Worden, J. R., Bloom, A. A., Pandey, S., Jiang, Z., Worden, H. M., Walker, T. W., . . . Rockmann, R. (2017). Reduced biomass burning emissions reconcile conflicting estimates of the post-2006 atmospheric methane budget. *Nature Communications*, 2227. doi: 10.1038/s41467-017-02246-0.

immediately following a rapid increase in fracking wastewater injection nearby. (See footnotes 522, 523.)

The number of earthquakes of magnitude 3.0 or higher has skyrocketed in Oklahoma since the advent of the fracking boom, with fewer than two per year before 2009 and more than 900 in 2015 alone. The 5.8 earthquake that struck near Pawnee on September 3, 2016 was the strongest in Oklahoma's history. Felt by residents in five states, the Pawnee quake prompted a state of emergency declaration and an order from state regulators to shut down 67 wastewater disposal wells in the area. (See footnote 520, 521.) In October 2016, the EPA recommended a moratorium on the underground injection of fracking wastewater in certain earthquake-prone parts of Oklahoma because regulations had not worked to solve the problem. (See footnote 519.) On November 6, 2013, a magnitude 5.0 earthquake struck Cushing, Oklahoma near the site of the nation's largest oil hub, where 60 million barrels of crude oil were stored. The quake injured one, damaged more than 40 buildings, closed a school, and triggered evacuations. Oil infrastructure was not damaged. Recent evidence shows that the process of fracking itself can trigger small earthquakes, as several confirmed cases demonstrate.

7) Fracking infrastructure poses serious potential exposure risks to those living nearby.

Drilling and fracking activities are relatively short-term operations, but compressor stations are semi-permanent facilities that pollute the air 24 hours a day as long as gas is flowing through pipelines. Day-to-day emissions from compressor stations are subject to highly episodic variations due to pressure changes and maintenance-related deliberate releases and can create periods of potentially extreme exposures. Pipelines themselves can freeze, corrode, break, and leak. Between January 2010 and November 2017, according to data from the federal Pipeline and Hazardous Materials Safety Administration, pipeline incidents killed 100 people, injured 500, prompted the evacuation of thousands, and leaked more than 17 billion cubic feet of methane.³⁰ Low-pressure flow lines alone are responsible for more than 7,000 spills and leaks since 2009. (See footnote 821.)

In the Upper Midwest, Wisconsin residents living near silica sand mining operations that service the fracking industry reported dust exposure and respiratory problems. Silica dust is a known cause of silicosis and lung cancer.

Fracking infrastructure in the United States also includes 400 underground gas storage facilities in 31 states, with scant federal oversight and aging equipment. The four-month leak at the nation's fifth largest facility, Aliso Canyon in southern California, between October 2015 and February 2016 resulted in exposures of large suburban population to an uncontrollable array of chemicals. With a release of nearly 100,000 metric tons of methane, it became the worst methane leak in U.S. history. (See footnote 873.)

³⁰ Thompson, J. (2017, November 29). A map of \$1.1 billion in natural gas pipeline leaks. *High Country News*. Retrieved from <http://www.hcn.org/issues/49.22/infographic-a-map-of-leaking-natural-gas-pipelines-across-the-nation>

A major pollution source even before the blow-out, Aliso Canyon exposed residents in the region to benzene spikes, high ongoing odorant releases, hydrogen sulfide at levels far above average urban levels, and many other contaminants of concern. More than 8,000 households were evacuated and relocated, with residents reporting multiple symptoms, including headaches, nosebleeds, eye irritation, and nausea. Contaminated house dust became a contentious issue. Measurement of airborne contaminants during the leak was intermittent and contained major gaps. The Aliso Canyon facility reopened on July 31, 2017. Four months later, a gasket failure led to a methane leak, and at least 15 residents noticed foul odors. As of early 2018, more than two years after the original blow-out, the Aliso Canyon facility operates at only 28 percent of its storage capacity, and the community still awaits the initiation of a mandated health study, which, independent researchers say, must include attention to sub-chronic, cumulative exposures.

As we go to press, the California Council of Science and Technology has released a 910-page report analyzing the safety risks of all 14 facilities in the state that store gas in depleted oil fields. Among its findings: gas companies do not disclose the chemicals they are pumping underground; state regulators lack necessary information to assess risks; and many wells servicing the storage fields are 60 to 90 years old with no regulatory limit to the age of the well.³¹

LNG facilities—and the pipelines, coastal terminals, and ships that service them—are a growing component of fracking infrastructure as the shale gas boom has allowed the United States to seek long-term supply contracts for natural gas exports. In July 2017, the United Kingdom received its first delivery of LNG from the Sabine Pass export terminal in Louisiana. The Cove Point LNG export facility in Maryland is, as we go to press, preparing its first shipments of Marcellus Shale gas, destined for Japan and India. Five other U.S. LNG export terminals are in the planning stage.

LNG is purified methane in the form of a bubbling, super-cold liquid. It is created through the capital-intensive, energy-intensive process of cryogenics and relies on evaporative cooling to keep the methane chilled during transport. Explosive and with the ability to flash-freeze human flesh, LNG creates acute security and public safety risks. Its greenhouse gas emissions are 30 percent higher than conventional natural gas due to refrigeration, venting, leaks, and flaring, used to control pressure during regasification. The need to strip volatile impurities such as benzene from the gas prior to chilling it also makes LNG liquefaction plants a source of toxic air pollutants. (See footnotes 910-26.)

8) Drilling and fracking activities can bring naturally occurring radioactive materials to the surface.

Exposure to increased radiation levels from fracking materials is a risk for both workers and residents. A study demonstrated that radon levels in Pennsylvania homes rose since the advent of the fracking boom, and buildings in heavily drilled areas had significantly higher radon readings

³¹ Birkholzer, J., & Long, J. C. S., Report Steering Committee Co-Chairs, California Council of Science and Technology. (2018, January 18). *Long-term viability of underground natural gas storage in California: an independent review of scientific and technical information*. Retrieved from <http://ccst.us/publications/2018/Full%20Technical%20Report%20v2.pdf>

than areas without well pads—a discrepancy that did not exist before 2004. University of Iowa researchers documented a variety of radioactive substances including radium, thorium, and uranium in fracking wastewater and determined that their radioactivity increased over time; they warned that radioactive decay products can potentially contaminate recreational, agricultural, and residential areas.

The New York State Department of Environmental Conservation’s “Findings Statement” noted that naturally occurring radioactive materials (NORM) are brought to the surface “in the cuttings, flowback water and production brine. . . . [T]he build-up of NORM in pipes and equipment has the potential to cause a significant adverse impact because it could expose workers handling pipes, for cleaning or maintenance, to increased radiation levels.” (See footnotes 333, 347-371.)

9) The risks posed by fracking in California are unique.

Hydraulic fracturing in California is practiced differently than in other states, making its risks different, as well. Wells are more likely to be vertical rather than horizontal, and the oil-containing rock layer is shallower. Hence, much less water is used per well for fracking as compared to other states. However, the fracking fluid used is much more chemically concentrated, the fracking zones are located closer to overlying aquifers, and the risk of a fracture reaching groundwater is higher. California is the only state that allows fracking waste to be held in unlined, open pits, which creates risks for both air and groundwater contamination. As of January 2017, 1,000 such pits were operational, with 400 lacking required state permits. The vast majority are located in Kern County.³² In 2014, the discovery that companies had, for years, been wrongly allowed to inject fracking waste directly into California’s freshwater aquifers led to the closing of 175 disposal wells. Impacts on drinking water are unknown. (See footnotes 144, 145.)

Most new fracking operations in California take place in areas with a long history of oil extraction. A high density of old and abandoned wells provides potential leakage pathways, should fractures intersect with them. And although fracking requires considerably less water per well in California, it takes place disproportionately in areas of severe water shortages and can compete with municipal and agricultural needs for freshwater.

The combination of ongoing drought and lack of disposal options has resulted in the diversion of fracking wastewater to farmers for irrigation of crops, raising concerns about contaminated water potentially affecting food crops and draining into groundwater. Investigative reports in 2015 revealed that Chevron Corporation piped 21 million gallons of recycled oil and gas wastewater per day to farmers for crop irrigation. Tests showed the presence of several volatile organic compounds, including acetone, which is linked, in lab studies, to kidney, liver, and nerve damage. (See footnotes 675-677.)

These factors project fracking’s impacts onto geographically distant populations, especially in cases when wastewater is diverted for use in crop irrigation and livestock watering. Food is a troubling possible exposure route to fracking chemicals, in part because so little is known about

³² California Water Boards. (2017, January 31). *Produced water pond status report*. Retrieved from https://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/docs/pond_rpt_0117_fnl.pdf

these chemicals. According to a hazard assessment of chemicals used in California oil drilling operations that reuse wastewater for livestock watering and other agricultural purposes, more than one-third of the 173 chemicals used are classified as trade secret. Their identities are entirely unknown. Of the remainder, ten are likely carcinogens, 22 are toxic air contaminants, and 14 had no toxicity data available. Estimating risks to consumers of the food produced with wastewater irrigation is thus not possible. (See footnote 670.)

The other area in California where fracking is concentrated, the Los Angeles Basin, is located directly under one of the most populous cities in the world. At least 1.7 million people in Los Angeles live or work within one mile of an active oil or gas well. California does not currently limit how close to residences or schools drilling and fracking activities can be conducted. A new study shows that many of the same chemicals used to stimulate wells during fracking operations are also used in urban oil wells located in densely populated areas of southern California. (See footnote 150.)

10) Fracking in Florida presents many unknowns.

Gas and oil drilling in Florida, now only a minor industry, is currently concentrated in two areas: the western Panhandle near Pensacola and the Everglades area of southwest Florida. So far, fracking has been used at least once—in 2013 at a test well located in the Corkscrew Swamp Sanctuary near Naples in Collier County. The Texas company that fracked this well, using high-pressure acid fracturing techniques to dissolve the bedrock, received a cease and desist order from the Florida Department of Environmental Protection.³³ Renewed interest in oil and gas exploration in Florida has prompted public debate about fracking and whether to promulgate state regulations or prohibit it outright.

Florida has more available groundwater than any other state; it is the drinking water source for 93 percent of Florida's population. Groundwater is also pumped to irrigate crops and provide frost protection to winter crops. Most of this water is held in the Floridan Aquifer, which extends across the entire peninsula and into parts of Georgia, Alabama, and South Carolina. This aquifer provides drinking water to ten million people in both rural and urban communities, including residents of several major cities: Gainesville, Jacksonville, Orlando, Tallahassee, and Tampa. Overlain by smaller, shallower aquifers in southern Florida, it is a highly permeable, highly interconnected subterranean system, with water moving rapidly in multiple directions through massive shelves of limestone, which represent the dissolved shells and fossilized skeletons of prehistoric marine organisms. Honeycombed with pores, fissures, joints, and caves, the

³³ Could leftover wastewater from balky oil well end up a health hazard? (2015, January 1). *Naples Daily News*. Retrieved from <http://archive.naplesnews.com/news/local/could-leftover-wastewater-from-balky-oil-well-end-up-a-health-hazard-ep-853723380-335781721.html/>

underground terrain of the Floridan Aquifer resembles a vast, brittle, sponge partly covered with sand and clay. Springs and sinkholes are common.^{34, 35}

It is not known whether fracking in Florida could induce sinkholes to open up or whether alterations in underground pressures could cause springs to go dry. Certainly, Florida's porous geology makes it vulnerable to groundwater contamination. Crumbly, soluble limestone offers pathways for contaminants spilled on the surface to travel deep into the aquifer, where they can be dispersed over great distances by the aquifer's river-like currents. A 2003 experiment with a dye tracer showed the special susceptibility of Florida's groundwater to potential contamination: within a few hours, the red dye traveled through the aquifer a distance (330 feet) that researchers had presumed would take days.³⁶

Compounding these risks, Florida's exposure to hurricanes makes it vulnerable to spills of fracking-related chemicals. In August 2017, flooding from Hurricane Harvey shut down fracking sites in Texas and triggered 31 separate spills at wells, storage tanks, and pipelines. (See footnotes 645-647.)

As of early 2018, it is unclear where Florida would send any potential fracking wastewater for treatment and/or for underground injection. Florida currently injects other types of liquid waste into disposal wells that are located above, rather than below, oil- and gas-producing zones. The injection of fracking waste in these same shallower layers may make earthquakes less likely than, for example, in Oklahoma (where it is injected into deep formations), but it would also locate that waste closer to the aquifers, which are poorly mapped. To undertake the necessary study to determine how securely Florida's geological formations could contain wastewater from drilling and fracking operations and protect drinking water would be, in the words of two geophysicists, "a monumental task requiring full-time work...for decades."³⁷ There are reasons to be concerned. In South Florida in the 1990s, 20 stringently regulated disposal wells failed and leaked sewage waste into the Upper Floridan Aquifer, a potential future source of drinking water for Miami.³⁸

11) The economic instabilities of fracking further exacerbate public health risks.

Real-life challenges to the industry's arguments that fracking is good business are increasingly apparent. Independent economic analyses show that the promise of local job creation has been

³⁴ Johnson, R. H., & Bush, P. W. (2013, September 4). *Summary of the hydrology of the Floridan Aquifer System in Florida and in parts of Georgia, South Carolina, and Alabama*. U.S. Geological Survey Professional Paper 1403-A. Retrieved from <https://sofia.usgs.gov/publications/papers/pp1403a/>

³⁵ Tihansky, A. B., & Knochenmus, L. A. (2001, February 13). *Karst features and hydrogeology in west-central Florida*. U.S. Geological Survey Water-Resources Investigations Report 01-4011. Retrieved from https://water.usgs.gov/ogw/karst/kigconference/abt_karstfeatures.htm

³⁶ Miami-Dade County Wellfield Technical Work Group. (2017, July 31). *Final Report*. Retrieved from <http://ecmrer.miamidadegov.gov:8080/reports/WellfieldTechnicalWorkgroupReportJuly2017.pdf>

³⁷ Russo, R., & Scream, E. (2016, May 9). Should Florida 'frack' its limestone for oil and gas? Two geophysicists weigh in. *University of Florida News*. Retrieved from <http://news.ufl.edu/articles/2016/05/should-florida-frack-its-limestone-for-oil-and-gas-two-geophysicists-weigh-in.php>

³⁸ Lustgarten, A. (2012, June 21). Injection wells: the poison beneath us. *ProPublica*. Retrieved from: <https://www.propublica.org/article/injection-wells-the-poison-beneath-us>

greatly exaggerated, with many jobs going to out-of-area workers. Reports show that oil and gas jobs will increasingly be lost to automation. With the arrival of drilling and fracking operations, communities have experienced steep increases in rates of crime, including sex trafficking, rape, assault, drunk driving, drug abuse, and violent victimization—all of which carry public health consequences, especially for women. Social costs include road damage, failed local businesses, and strains on law enforcement and municipal services. School districts report increased stress. Economic analyses have found that drilling and fracking threaten property values and can diminish tax revenues for local governments. Additionally, drilling and fracking pose an inherent conflict with mortgages and property insurance due to the hazardous materials used and the associated risks.

Throughout its history, the tempo of drilling and fracking operations in the United States has fluctuated markedly. Since 2014, when oil prices dropped precipitously, oil and gas operations have struggled to make a profit. In March 2016, the number of working gas rigs fell to its lowest level since record-keeping began in 1987. Downturns, however, do not necessarily translate into less risk and exposure to harm for those living in frontline communities. In spite of fewer drill rigs, injections of fracking wastewater *increased* in Ohio by 15 percent in 2015, likely because operators began drilling wells with longer lateral pipelines to access more gas or oil per well, generating more waste even as the pace of drilling slowed. (See footnote 188.) Indeed, according to data provided to investors, the average amount of water used to frack a single well has more than doubled between 2013 and 2016 due to longer laterals and more intensive fracking.

Further, orphaned wells left behind by industry during energy price downturns or after bankruptcy are poorly monitored and, as conduits for gas and fluid leakage, become health and safety threats. Some have exploded.³⁹

In 2017, the rate of active shale gas drilling in the United States was, once again, on the upswing.⁴⁰ In spite of this uptick, output from two major basins has fallen, likely because easy-to-access gas has already been extracted.⁴¹ Because the production of individual wells declines precipitously over the course of a few years, operators must continue drilling new wells at a rapid pace to maintain output.

The unstable economic fundamentals of the industry as a whole have multiple consequences for public health and safety as cumulative impacts mount from wells, both old and new. Weak prices, difficulty generating positive cash flow, short-lived well production, and falling output have led drilling companies to reduce the value of their assets by billions of dollars. Concerns arise that these losses will lead to large-scale firings, cutbacks in safety measures, and landscapes pock-marked by hastily abandoned wells in need of remediation and long-term monitoring.

³⁹ Zoffos, J. (2018, January 16). ‘Orphaned’ oil and gas wells are on the rise.” *High Country News*. Retrieved from <http://www.hcn.org/articles/energy-industry-orphaned-oil-and-gas-wells-are-on-the-rise>

⁴⁰ Sisk, A. (2017, December 29). Pennsylvania’s gas fields ramp up for more drilling in 2018. *StateImpact Pennsylvania*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2017/12/29/pennsylvanias-gas-fields-ramp-up-for-more-drilling-in-2018/>

⁴¹ Montgomery, J. B., & O’Sullivan, F. M. (2017). Spatial variability of tight oil well productivity and the impact of technology. *Applied Energy*, 195, 344-55. doi: 10.1016/j.apenergy.2017.03.038.

12) Fracking raises issues of environmental justice.

Inequalities in opportunities to participate in environmental decision-making and uneven impacts of environmental hazards along racial and socioeconomic lines are signature issues of environmental justice. Although not yet fully characterized, emerging evidence reveals that, in several regions where fracking is practiced, well pads and associated infrastructure are disproportionately sited in non-white and low-income communities.

A pattern of racially biased permitting was documented in the heavily fracked Eagle Ford area of southern Texas where a public health research team showed that disposal wells for fracking wastewater were more than twice as common in areas where residents are more than 80 percent people of color than in majority white communities.⁴² Since 2007, more than 1,000 waste disposal wells have been permitted in the Eagle Ford Shale region where groundwater is the primary source of drinking water.⁴³ Another recent study looked at economic disparities in the intensely drilled northern Texas city of Denton and found that those benefiting most from Denton's mineral wealth tended to live elsewhere, while the environmental burdens remained local and fell hardest on those who did not have a voice in mineral-leasing decisions. "Non-mineral owners are essentially excluded from the private decisions, as the mineral owners not only receive the direct monetary benefits, but also hold a great deal of state-sanctioned power to decide if and how [shale gas development] proceeds."⁴⁴

Poor communities of color are disproportionately affected by drilling activities in California. Of Los Angeles residents living within a quarter mile of a well, more than 90 percent are people of color. In November 2015, civic groups led by youth sued the city of Los Angeles for racial discrimination based on allegations of a preferential permitting process and unequal regulatory enforcement for oil wells located in neighborhoods of color. Together, these differential practices have resulted in a higher concentration of wells with fewer environmental protections in black and Latino communities.⁴⁵ South Coast Air Quality Management District records show that oil-drilling operations in Los Angeles neighborhoods released into the air 21 million pounds of toxic chemicals between June 2013 and February 2017. These emissions included crystalline silica, hydrofluoric acid, and formaldehyde.⁴⁶ Across California, gas-fired power plants are disproportionately located in disadvantaged communities, as classified by an environmental justice screening tool developed by the state Office of Environmental Health Hazard Assessment.⁴⁷

⁴² Johnston, J. E., Werder, E., & Sebastian, D. (2016). Wastewater disposal wells, fracking, and environmental justice in southern Texas. *American Journal of Public Health*, 106(3). doi: 10.2105/AJPH.2015.303000

⁴³ Bienkowski, B. (2016, February 3). Poor, minorities carry the burden of frack waste in South Texas. *Environmental Health News*. Retrieved from <http://www.environmentalhealthnews.org/ehs/news/2016/feb/fracking-waste-eagle-ford-texas-hispanic-environmental-justice>

⁴⁴ Fry, M., Briggie, A., & Kincaid, J. (2015). Fracking and environmental (in)justice in a Texas city. *Ecological Economics*, 117. doi: 10.1016/j.ecolecon.2015.06.012

⁴⁵ Reyes, E. A. (2015, November 6). Environmental advocates sue L.A., accusing it of "rubber stamping" oil drilling plans. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/lanow/la-me-ln-lawsuit-oil-drilling-20151106-story.html>

⁴⁶ Fleming, J. C., & Kim, C. (2017, December 13). *Danger next door: The top 12 air toxics used for neighborhood oil drilling in Los Angeles*. Retrieved from <http://www.biologicaldiversity.org/publications/papers/DangerNextDoor.pdf>

⁴⁷ PSE Healthy Energy. (2017, April). *Natural gas power plants in California's disadvantaged communities*. Retrieved from https://www.psehealthyenergy.org/wp-content/uploads/2017/04/CA.EJ_Gas_Plants.pdf

Another study found a higher concentration of drilling and fracking operations in impoverished communities throughout the state of Pennsylvania as well as in localized areas of West Virginia, but it did not find differences with respect to race. “The results demonstrate that the environmental injustice occurs in areas with unconventional wells in Pennsylvania with respect to the poor population.”⁴⁸ These findings are supported by census tract data in western Pennsylvania showing that among nearly 800 gas wells, only two were drilled in communities where home values exceeded \$200,000.⁴⁹

13) Health professionals are increasingly calling for bans or moratoria on fracking, based on a range of potential health hazards and as reviews of the data confirm evidence for harm.

In May 2015, the Medical Society of the State of New York passed a resolution recognizing the potential health impacts of natural gas infrastructure and pledging support for a governmental assessment of the health and environmental risks associated with natural gas pipelines. (See footnote 856.) The American Medical Association (AMA) adopted a similar resolution that supports legislation requiring all levels of government to seek a comprehensive Health Impact Assessment regarding the health and environmental risks associated with natural gas pipelines. (See footnote 855.)

In May 2016, Physicians for Social Responsibility called for a ban on fracking. (See footnote 1079.) In July 2016, the UK health professional organization Medact released an updated assessment of the potential health impacts of shale fracking in England, concluding that the United Kingdom should abandon its policy to encourage shale gas extraction, and urged an “indefinite moratorium” on fracking. (See footnote 1077.) In October 2016, a group of health care professionals in Massachusetts called for an immediate moratorium on major new natural gas infrastructure until the impact of these projects on the health of the communities affected can be adequately determined through a comprehensive Health Impact Assessment. (See footnote 1074.) The group noted that the operation of natural gas facilities risks human exposures to toxic, cancer-causing, and radioactive pollution due to the presence of naturally co-occurring contaminants, toxic additives to the hydraulic fracturing process used to produce much of the country’s natural gas supply, and through the operation of transmission pipelines.

Also in 2016, in a unanimous vote of the society’s 300-member House of Delegates, the Pennsylvania Medical Society called for a moratorium on new shale gas drilling and fracking in Pennsylvania and an initiation of a health registry in communities with pre-existing operations. (See footnotes 1071, 1072). In February 2017, health officials in Los Angeles called for a comprehensive health study in the aftermath of the massive methane leak in Aliso Canyon. (See footnote 1068.)

⁴⁸ Ogneva-Himmelberger, Y., & Huang, L. (2015). Spatial distribution of unconventional gas wells and human populations in the Marcellus Shale in the United States: vulnerability analysis. *Applied Geography*, 60, 165-174. doi: 10.1016/j.apgeog.2015.03.011

⁴⁹ Frazier, R. (2016, June 30). Is fracking an environmental justice issue? *The Allegheny Front*. Retrieved from <https://www.alleghenyfront.org/is-fracking-an-environmental-justice-issue/>

Concerned Health Professionals of New York, which provided scientific and medical guidance for the successful effort to ban fracking in New York State, has inspired affiliations of like-minded public health scientists and health care providers that have been advocating for moratoria or bans on fracking in various other regions. These include Concerned Health Professionals of Maryland, Concerned Health Professionals of Ireland, and Concerned Health Professionals of Neuquén, Argentina. Other U.S. medical groups calling for bans or moratoria include Chesapeake PSR and the Alliance of Nurses for Healthy Environments.

Compilation of Studies & Findings

Air pollution

Air pollution associated with fracking is a grave concern with a range of impacts. Researchers have documented dozens of air pollutants from drilling and fracking operations that pose serious health hazards. Areas with substantial drilling and fracking build-out show high levels of ground-level ozone (smog), striking declines in air quality, and, in several cases, increased rates of health problems with known links to air pollution. Air sampling surveys find high concentrations of volatile organic compounds (VOCs), especially carcinogenic benzene and formaldehyde, both at the wellhead and at distances that exceed legal setback distances from wellhead to residence. In some cases, VOC concentrations exceeded federal safety standards by several orders of magnitude. Exposure to emissions from natural gas flares and diesel exhaust from the 4,000-6,000 truck trips per well pad are also respiratory health risks for those living near drilling operations. Evidence implicates the U.S. shale gas boom in the recent global spike in atmospheric ethane. Drilling and fracking operations in North Dakota's Bakken oil and gas field alone contribute two percent of global ethane emissions and directly impact air quality across North America. Like methane, ethane is both a greenhouse gas and a precursor for ozone formation. The accelerating pace of drilling and fracking activities and the current policy plan to reverse course on proposed regulations to reduce methane emissions are likely to exacerbate the air pollution problems that fracking creates, along with attendant health risks.

- November 2, 2017 – In a review paper that explores how the U.S. fracking boom has contributed to air pollution in impacted communities, Texas A&M atmospheric scientist Gunnar W. Schade identified ozone and benzene as two important chemicals of concern. Documenting trends is challenging because fracking-related air pollutants typically originate in rural places without routine air pollution monitoring. A new air monitor in the Eagle Ford Shale region allowed researchers to use fingerprinting analysis to show that 60 percent of ambient benzene in the air now comes from drilling and fracking operations, including gas flares. Before the shale boom, the majority of benzene in the region came from tailpipe emissions. “In some areas, decades-long progress on ozone air quality has stalled; in others, particularly the Uintah basin in Utah, a new ozone problem has emerged due to the fracking industry’s emissions.” Downwind of the Eagle Ford Shale, San Antonio’s ozone levels are now trending close to 75 ppb, which exceeds the new recommended limit of 70 ppb. “The shale boom has create a new source of large-scale, diffuse hydrocarbon emissions that adversely affect air toxics levels. . . . The continued growth of the fracking industry as well as plans to remove regulations on methane emissions will not alleviate high hydrocarbon emissions and associated regional ozone problems.”⁵⁰

⁵⁰ Schade, G. W. (2017, November 2). How has the US fracking boom affected air pollution in shale areas? *The Conversation*. Retrieved from <https://theconversation.com/how-has-the-us-fracking-boom-affected-air-pollution-in-shale-areas-66190>

- April 12, 2017 – Using aircraft, a University of Michigan-led team collected plume samples from 37 flare stacks in the Bakken Shale region of North Dakota to calculate emissions of black carbon (soot), methane, and ethane from natural gas flares. They determined that flares contribute almost 20 percent of the total emissions of methane and ethane from the Bakken region, as measured by field studies.⁵¹
- December 29, 2016 – Exposure to air pollutants from well pads decreases quickly with distance. However, according to recent studies, people living kilometers away from actual drilling and fracking operations also show elevated risk of disease known to be linked to air pollution. This review paper investigated the possible role that exposure to diesel exhaust from fracking-related road traffic is playing in creating public health impacts in surrounding communities. “Road traffic generated by hydraulic fracturing operations is one possible source of environmental impact whose significance has, until now, been largely neglected . . . with 4,000-6,000 vehicles visiting the well pad during the operations.” As a starting point for exposure assessment, the author recommended GIS modeling studies with a focus on traffic patterns and exacerbation of pediatric asthma.^{52, 53}
- October 16, 2016 – A review of recent studies documenting harm to both public health and agricultural yields from rising ozone levels identified oil and gas fields as “a major and growing source of ozone in the United States.”⁵⁴
- October 16, 2016 – In response to a lawsuit, the EPA acknowledged that its 33-year-old formula for estimating emissions from flaring operations requires revision as it may dramatically underestimate levels of health-damaging air pollutants. Emissions from flare stacks typically include carbon monoxide, nitrogen oxides, benzene, formaldehyde, and xylene, but levels of these smog-forming compounds are seldom measured directly.^{55, 56}
- October 5, 2016 – A review of recent studies documented connections between oil and gas development and worsening ozone levels in western states. Drilling and fracking operations have pushed Pinedale, Wyoming out of compliance with federal ozone

⁵¹ Gvakharia, A., Kort, E. A., Brandt, A., Peischl, J., Ryerson, T. B., Schwarz, J. P., . . . Sweeney, C. (2017). Methane, black carbon, and ethane emissions from natural gas flares in the Bakken Shale, North Dakota. *Environmental Science & Technology*, 51(9), 5317-5325. doi: 10.1021/acs.est.6b05183

⁵² McCawley, M. A. (2017). Does increased traffic flow around unconventional resource development activities represent the major respiratory hazard to neighboring communities?: Knowns and unknowns. *Current Opinion in Pulmonary Medicine*, 23(2), 161-166. doi: 10.1097/MCP.0000000000000361

⁵³ Frazier, R. (2017, June 16). On health effects, blame the trucks, not the fracking? *Allegheny Front*. Retrieved from <https://www.alleghenyfront.org/on-health-effects-blame-the-trucks-not-the-fracking/>

⁵⁴ Robbins, J. (2016, October 16). In new ozone alert, a warning of harm to plants and to people. *Yale Environment 360*. Retrieved from http://e360.yale.edu/feature/ground_level_ozone_harming_plants_humans/3044/

⁵⁵ United States District Court for the District of Columbia. (2016, October 16). Air Alliance Houston, et al. v. Gina McCarthy, Administrator, United States Environmental Protection Agency. Consent decree. Case 1:16-cv01998. Retrieved from <https://www.documentcloud.org/documents/3127584-Consent-Decree-on-Flares.html>

⁵⁶ Hasemyer, D. (2016, October 13). EPA agrees that its emissions estimates from flaring may be flawed. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/12102016/epa-natural-gas-oil-drilling-flaring-emissions-estimates-flawed-fracking>

standards. Colorado has exceeded federal ozone limits for the past decade, a period that corresponds to a statewide boom in oil and gas drilling.⁵⁷

- September 1, 2016 – A NASA-led research team collected whole air samples throughout the Barnett Shale basin in Texas. Chemical analysis showed that they contained benzene, hexane, and toluene at levels 2-50 times greater than the local background and similar to those seen in other intensely drilled shale basins in Colorado and Utah. There is “some evidence to suggest that public concerns for potential chronic health risks are not unwarranted.”⁵⁸
- July 23, 2016 – A study conducted at the Boulder Atmospheric Observatory examined sources of summertime ozone formation (smog) in Colorado’s Front Range and found that 17 percent of locally created ozone was created by VOCs from drilling and fracking operations.⁵⁹ Colorado has exceeded the federal ozone standard for the past nine years, a period of time that corresponds to a boom in oil and gas drilling in the Wattenberg Gas Field where the number of active wells has nearly doubled.⁶⁰
- June 13, 2016 – Between 2009 and 2014, ethane emissions in the Northern Hemisphere increased by about 400,000 tons annually, the bulk of it from North American oil and gas activity, according to research by an international team led by the University of Colorado Boulder.⁶¹ After peaking in the 1970s, global ethane emissions began declining, primarily due to stricter air quality emission controls. In 2009, however, that downward trend reversed itself. “About 60 percent of the drop we saw in ethane levels over the past 40 years has already been made up in the past five years. . . . If this rate continues, we are on track to return to the maximum ethane levels we saw in the 1970s in only about three more years. We rarely see changes in atmospheric gases that quickly or dramatically,” said lead researcher Detlev Helmig.⁶² Samples were collected from locations around the world, but the largest increases in ethane were documented over areas of heavy oil and gas activity in the central and eastern United States. Ethane contributes to the creation of ground-level ozone pollution (smog), a known human health hazard. The authors noted that “. . . ozone production from these emissions has led to air quality standard

⁵⁷ Boiko-Weyrauch, A. (2016, October 5). Ozone, asthma and the oil and gas connection. *Inside Energy*. Retrieved from <http://insideenergy.org/2016/10/05/ozone-asthma-and-the-oil-and-gas-connection/>

⁵⁸ Marrero, J. E., Townsend-Small, A., Lyon, D. R., Tsai, T. R., Meinardi, S., & Blake, D. R. (2016). Estimating emissions of toxic hydrocarbons from natural gas production sites in the Barnett Shale Region of Northern Texas. *Environmental Science & Technology*, 50(19), 10756-10764. doi: 10.1021/acs.est.6b02827

⁵⁹ McDuffie, E.E., Edwards, P.M., Gilman, J.B., Lerner, B.M., Dubé, W.P., Trainer, M., . . . Brown, S.S. (2016). Influence of oil and gas emissions on summertime ozone in the Colorado Northern Front Range. *Journal of Geophysical Research: Atmospheres*. doi: 10.1002/2016JD025265

⁶⁰ University of Colorado at Boulder. (2016, August 8). Accounting for ozone: Study first to quantify impact of oil and gas emissions on Denver's ozone problem. *ScienceDaily*. Retrieved from <https://www.sciencedaily.com/releases/2016/08/160808123832.htm>

⁶¹ Helmig, D., Rossabi, S., Hueber, J., Tans, P., Montzka, S. A., Masarie, K., . . . Pozzer, A. (2016). Reversal of global atmospheric ethane and propane trends largely due to US oil and natural gas production. *Nature Geoscience*, 9, 490–495. doi: 10.1038/ngeo2721

⁶² Helmig, D. & Scott, J. (2016, June 13). Global ethane concentrations rising again, says study. *News Center University of Colorado Boulder*. Retrieved from <http://www.colorado.edu/news/releases/2016/06/13/global-ethane-concentrations-rising-again-says-study>

exceedances in the Uintah Basin, Utah, and Upper Green River Basin, Wyoming, [oil and natural gas] regions.” Two scientists not involved in the study published an accompanying commentary, concluding, “There is a danger that these non-methane hydrocarbon emission changes can offset emission policies and controls aimed at reducing ozone concentrations,” and “[t]hese oil and gas operations are threatening to reverse what had been an important success story: decades of declining air pollution in North America.”⁶³ (See also the entry dated April 2, 2016 in Threats to the Climate System.)

- June 1, 2016 – Existing data on air pollutants emitted from drilling and fracking operations “support precautionary measures to protect the health of infants and children,” according to a review by a team of researchers (members of which include co-authors of this Compendium). Researchers focused on exposures to ozone, particulate matter, silica dust, benzene, and formaldehyde—all of which are associated with drilling and fracking operations—noting that all are linked to adverse respiratory health effects, particularly in infants and children. Benzene, for example, emitted from gas wells, production tanks, compressors, and pipelines, is a carcinogen also linked to serious respiratory outcomes in infants and children, including pulmonary infections in newborns. As the authors emphasized, this review did not consider other air pollutants commonly associated with drilling and fracking activities, namely hydrogen sulfide, polycyclic aromatic hydrocarbons, and oxides of nitrogen. Although improved exposure assessment, air monitoring, and long-term studies are still lacking, existing evidence was sufficient for the authors to “strongly recommend precautionary measures at this time.”⁶⁴
- April 26, 2016 – About two percent of global ethane emissions originate from the Bakken shale oil and gas field, which, according to research led by University of Michigan researchers, emits 250,000 tons of ethane per year.⁶⁵ “Two percent might not sound like a lot, but the emissions we observed in this single region are 10 to 100 times larger than reported in inventories. They directly impact air quality across North America. And they’re sufficient to explain much of the global shift in ethane concentrations,” according to Eric Kort, first author of the study.⁶⁶ Ethane is a gas that affects climate and decreases air quality. As a greenhouse gas, ethane is the third-largest contributor to human-caused climate change. Ethane contributes to ground-based ozone pollution as it breaks down and reacts with sunlight to create smog. This surface-level ozone is linked to respiratory problems, eye irritation, and crop damage. Global ethane levels were decreasing until 2009, leading the researchers to suspect that the U.S. shale gas boom may be responsible for the global increase in levels since 2010.

⁶³ Hakola, H. & Hellén, H. (2016). The return of ethane. *Nature Geoscience*, 9, 475-476. doi: 10.1038/ngeo2736

⁶⁴ Webb, E., Hays, J., Dyrszka, L., Rodriguez, B., Cox, C., Huffling, K., & Bushkin-Bedient, S. (2016). Potential hazards of air pollutant emissions from unconventional oil and natural gas operations on the respiratory health of children and infants. *Reviews on Environmental Health*, 31(2), 225-243. doi: 10.1515/reveh-2014-0070

⁶⁵ Kort, E. A., Smith, M. L., Murray, L. T., Gvakharia, A. Brandt, A. R., Peischl, J., . . . Travis, K. (2016). Fugitive emissions from the Bakken shale illustrate role of shale production in global ethane shift. *Geophysical Research Letters*, 43, 4617–4623. doi: 10.1002/2016GL068703

⁶⁶ Moore, C. S., & Human K. (2016, April 26). One oil field a key culprit in global ethane gas increase. *Michigan News*. Retrieved from <http://ns.umich.edu/new/multimedia/videos/23735-one-oil-field-a-key-culprit-in-global-ethane-gas-increase>

- April 5, 2016 – Helicopter-based infrared camera surveys of more than 8,000 oil and gas wells in seven U.S. regions found that well pads emit considerably more methane and VOCs than captured by earlier inventories. Moreover, these emissions were widely and unpredictably variable from site to site and from well to well. Over 90 percent of total airborne emissions from well pads originated with vents and hatches on aboveground storage tanks.⁶⁷ The inability to predict which well sites were “superemitters” (meaning that they leaked into the air more than 200 cubic feet of methane and VOCs per hour) implies that continuous, site-specific monitoring is required to regulate methane leaks from drilling and fracking operations. In a comment about the findings to *InsideClimate News*, Cornell University engineer Anthony Ingraffea, who was not an author of the paper, said, “It makes regulation very difficult. If you have all these possible sites where you can have leaks, you can never have enough inspectors with all the right equipment being in all the right places at all the right times. It’s too complex a system.”⁶⁸
- February 19, 2016 – Legally enforced minimal distances between well sites and residences are based on political compromises rather than peer-reviewed science and “may not be sufficient to reduce potential threats to human health in areas where hydraulic fracturing occurs,” according to the findings of an interdisciplinary team including medical professionals and other researchers. The team incorporated geography, current regulations, historical records of blowout incidents and evacuations, thermal modeling, direct air pollution measurement, and vapor cloud modeling within the Marcellus (PA), Barnett (TX), and Niobrara (Northeastern and Northwestern Colorado and parts of Wyoming, Kansas, and Nebraska) Shale regions. The authors focused solely on well sites and excluded pipelines and compressor stations, which limited the data on explosions and evacuations and restricted air pollution results. Even so, the results showed that current natural gas well setbacks in the three areas “cannot be considered sufficient in all cases to protect public health and safety.” People living within setback distances are potentially vulnerable to thermal injury during a well blowout, and they are also susceptible to exposures of benzene and hydrogen sulfide at levels above those known to cause health risks.⁶⁹
- August 1, 2015 – “[C]linicians should be aware of the potential impact of fracking when evaluating their patients,” concluded a team writing on behalf of the Occupational and Environmental Health Network of the American College of Chest Physicians. Their article stated that the over 200,000 U.S. workers employed by well-servicing companies “... are exposed to silica, diesel exhaust, and VOCs, and, at some sites, hydrogen sulfide and radon, raising concerns about occupational lung diseases, including silicosis, asthma,

⁶⁷ Lyon, D. R., Alvarez, R. G., Zavala-Araiza, D., Brandt, A. R., Jackson, R. B., & Hamburg, S. P. (2016). Aerial surveys of elevated hydrocarbon emissions from oil and gas production sites. *Environmental Science & Technology* 50(9). doi: 10.1021/acs.est.6b00705

⁶⁸ McKenna, P. (2016, April 8). Researchers find no shortcuts for spotting wells that leak the most methane. *InsideClimate News*. Retrieved from: <https://insideclimatenews.org/news/07042016/big-methane-leaks-superemitters-oil-gas-production-climate-change-edf>

⁶⁹ Haley, M., McCawley, M., Epstein, A. C., Arrington, B., & Bjerke, E. F. (2016). Adequacy of current state setbacks for directional high-volume hydraulic fracturing in the Marcellus, Barnett, and Niobrara Shale plays. *Environmental Health Perspectives*. Advance online publication. doi: 10.1289/ehp.1510547

and lung cancer.” The authors went on to say, “[i]n addition to occupational exposures, workers and nearby residents are also exposed to air pollutants emitted from various stages of fracking, including nitrogen oxides (NO_x), VOCs, ozone, hazardous air pollutants, methane, and fine particulate matter.” Authors pointed to several recent reversals in progress on air quality owed to fracking-related activity, including significant emissions of nitrogen oxides, a precursor of ozone, and spikes in fine particulate matter in fracking-intensive areas of Pennsylvania.⁷⁰

- July 9, 2015 – The California Council on Science and Technology, in collaboration with the Lawrence Berkeley National Laboratory, released the second and third volumes of an extensive, peer-reviewed assessment of fracking in California. Air quality impacts are the focus of volume 2, chapter 3. The assessment found that current inventory methods underestimate methane and volatile organic chemical emissions from oil and gas operations and that fracking occurs in areas of California—most notably in the San Joaquin Valley and South Coast Air Basins—that already suffer from serious air quality problems. Further, no experimental studies of air emissions from drilling and fracking operations have ever been conducted in California. Although California has well-developed air quality inventory methods, they are “not designed to estimate well stimulation emissions directly, and it is not possible to determine well stimulation emissions from current inventory methods.”⁷¹
- July 1, 2015 – In accordance with California Senate Bill No. 4, the California Division of Oil, Gas, and Geothermal Resources released a three-volume environmental impact report on oil and gas well stimulation treatments in the state (which, in California, include fracking along with acidizing and other unconventional extraction technologies that break up oil- or gas-containing rock). The Division determined that fracking and related operations can have “significant and unavoidable” impacts on air quality, including increasing ozone and other federally regulated pollutants to levels that violate air quality standards or that would make those violations worse.^{72, 73}
- May 29, 2015 – Each of stage of the drilling and fracking process “... has distinct operations that occur and particular sets of air emissions that may affect the respiratory tract,” wrote West Virginia University researcher Michael McCawley. Some states do have setback requirements, which “... may provide a margin of safety for fire and explosions but [do] not necessarily assure complete dilution or negligible exposure from air emissions.” His paper described the specific air contaminants associated with respiratory effects for each stage of operations. For example, the actual fracking stage

⁷⁰ Evans, R. B., Prezant, D., & Huang, Y. C. (2015). Hydraulic fracturing (fracking) and the Clean Air Act. *Chest*, 148(2), 298-300. doi: 10.1378/chest.14-2582

⁷¹ Brandt, A., Millstein, D., Jin, L., & Englander, J. (2015, July 9). Air quality impacts from well stimulation. In: California Council on Science and Technology, *An Independent Scientific Assessment of Well Stimulation in California*, volume 2, chapter 3. Retrieved from <http://ccst.us/publications/2015/vol-II-chapter-3.pdf>

⁷² California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (2015, July 1). *Analysis of Oil and Gas Well Stimulation Treatments in California, Volume II*. Retrieved from http://www.conservation.ca.gov/dog/SB4DEIR/Pages/SB4_DEIR_TOC.aspx

⁷³ Cart. J. (2015, July 1). State issues toughest-in-the-nation fracking rules. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/lanow/la-me-ln-state-issues-fracking-rules-20150701-story.html>

potentially emits diesel exhaust, VOCs, particulate matter, ozone precursors, silica, and acid mists. McCawley reviewed the health effects linked to each of the contaminant types. Though many long-term effects may not yet be apparent in shale gas regions, “[a]t a minimum, one would expect to see similar rates of respiratory disease to that found near highways with heavy traffic flow.”⁷⁴

- April 21, 2015 – In a study funded by the electric power industry, a research team found that fracking had diminished air quality in rural areas downwind of gas sites in two heavily drilled Pennsylvania counties but that concentrations of VOCs were not as high as expected based on results in other states. Methane levels were higher than previous research had found.⁷⁵ The extent to which the results can be generalized to the Marcellus basin as a whole, the authors emphasized, remains uncertain.⁷⁶
- April 15, 2015 – In a review of the literature, Colorado researchers demonstrated that four common chemical air pollutants from drilling and fracking operations—benzene, toluene, ethylbenzene, and xylene (BTEX)—are endocrine disruptors commonly found in ambient air that have the ability to interfere with human hormones at low exposure levels, including at concentrations well below U.S. Environmental Protection Agency (EPA) recommended exposure limits. Among the health conditions linked to ambient level exposures to the BTEX family of air pollutants: sperm abnormalities, reduced fetal growth, cardiovascular disease, respiratory dysfunction, and asthma.⁷⁷ “This review suggests that BTEX may...have endocrine disrupting properties at low concentrations, presenting an important line of inquiry for future research. BTEX are used globally in consumer products, and are released from motor vehicles and oil and natural gas operations that are increasingly in close proximity to homes, schools, and other places of human activity.”⁷⁸
- March 26, 2015 – Fracking can pollute air hundreds of miles downwind from the well pad, according to the results of a study from University of Maryland. Researchers took hourly measurements of ethane in the air over Maryland and the greater Washington, DC area, where fracking does not occur, and compared them to ethane data from areas of West Virginia, Pennsylvania, and Ohio where it does. They found month-to-month correlations, indicating that the ethane pollution in the air over Maryland appears to be coming from drilling and fracking operations in these other states. Ethane, a minor

⁷⁴ McCawley, M. (2015). Air contaminants associated with potential respiratory effects from unconventional resource development activities. *Seminars in Respiratory and Critical Care Medicine* 36(3), 379-387. doi: 10.1055/s-0035-1549453

⁷⁵ Phillips, S. (2015, May 19). Study: Lower than expected air pollutants detected at Marcellus drilling sites. *State Impact Pennsylvania*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2015/05/19/study-lower-than-expected-air-pollutants-from-gas-drilling-sites/>

⁷⁶ Goetz, J. D., Floerchinger, C., Fortner E. C., Wormhoudt, J., Massoli, P., Knighton, W. B., . . . DeCarlo, P.F. (2015). Atmospheric emission characterization of Marcellus Shale natural gas development sites. *Environmental Science & Technology*, 49, 7012-20. doi: 10.1021/acs.est.5b00452

⁷⁷ Bienkowski, B. (2015, April 15). Scientists warn of hormone impacts from benzene, xylene, other common solvents. *Environmental Health News*. Retrieved from <http://www.environmentalhealthnews.org/ehs/news/2015/apr/endocrine-disruption-hormones-benzene-solvents>

⁷⁸ Bolden, A. L., Kwiatkowski, C. F., & Colborn, T. (2015). New look at BTEX: Are ambient levels a problem? *Environmental Science & Technology*, 49, 5261-76. doi: 10.1021/es505316f

component of natural gas, rose 30 percent in the air over the Baltimore and Washington DC area since 2010, even as other air pollutants declined in concentration. By contrast, no increase in ethane levels were found in Atlanta, Georgia, which is not downwind of fracking operations.^{79, 80} Given this evidence for widespread ethane leakage, the paper's lead author asked how much methane and other, more reactive emissions might be escaping from wells, noting that "a substantial amount of hydrocarbons" are emitted as a result of flowback procedures following the fracturing process.⁸¹

- February 27, 2015 – A team of researchers from University of Texas, funded in part by the gas industry, examined ozone (smog) production resulting from natural gas extraction and use in Texas. Previous research by this team had found that the increased use of natural gas for generating electricity, as a replacement for coal, contributed to overall reductions in daily maximum ozone concentrations in northeastern Texas. By contrast, the results of this study found an increase in ozone in the Eagle Ford Shale area of south Texas. The Eagle Ford Shale is upwind from both Austin and San Antonio.⁸² A potent greenhouse gas, methane is also a precursor for ground-level ozone and hence a contributor to smog formation.
- January 16, 2015 – Researchers from a number of universities, including the University of New Hampshire and Appalachian State University, used a source apportionment model to estimate the contribution of natural gas extraction activities to overall air pollution, including ozone, in heavily drilled southwest Pennsylvania. This regional air sampling effort demonstrated significant changes in atmospheric chemistry from drilling and fracking operations there. The researchers found that drilling and fracking operations may affect compliance with ozone standards.⁸³
- November 20, 2014 – The Texas Commission on Environmental Quality confirmed high levels of benzene emissions and other VOCs around an oil and gas facility in the Eagle Ford Shale. Symptoms reported by local residents were consistent with those known to be associated with exposure to such chemicals.⁸⁴

⁷⁹ Vinciguerra, T. Yao, S., Dadzie, J., Chittmans, A., Deskins, T., Ehrman, S., & Dickerson, R. R. (2015). Regional air quality impacts of hydraulic fracturing and shale natural gas activities: evidence from ambient VOC observations. *Atmospheric Environment*, 110, 144-50. doi: 10.1016/j.atmosenv.2015.03.056

⁸⁰ Valentine, K. (2015, April 30). Fracking wells could pollute the air hundreds of miles away. *ClimateProgress*. Retrieved from <http://thinkprogress.org/climate/2015/04/30/3653252/fracking-air-pollution-downwind/>

⁸¹ Levine, F. & Tune, L. (2015, April 30). Emissions from natural gas wells may travel far downwind. *University of Maryland: UMD Right Now*. Retrieved from <http://www.umdrightnow.umd.edu/news/emissions-natural-gas-wells-may-travel-far-downwind>

⁸² Pacsi, A. P., Kimura, Y., McGaughey, G., McDonald-Buller, E. C., & Allen, D. T. (2015). Regional ozone impacts of increased natural gas use in the Texas power sector and development in the Eagle Ford Shale. *Environmental Science & Technology*, 49, 3966-73. doi: 10.1021/es5055012

⁸³ Swarthout, R. F., Russo, R.S., Zhou, Y., Miller, B.M., Mitchell, B., Horsman, E., . . . Sive, B.C. (2015). Impact of Marcellus Shale natural gas development in southwest Pennsylvania on volatile organic compound emissions and regional air quality. *Environmental Science & Technology*, 49, 3175-84. doi: 10.1021/es504315f

⁸⁴ Davis, B. (2014, November 20). TCEQ memo proves toxic chemicals are being released in the Eagle Ford Shale. *KENS 5 Eyewitness News*. Retrieved from <http://www.kens5.com/story/news/investigations/i-team/2014/11/20/benzene-oil-toxic-fumes/70020596/>

- November 14, 2014 – A University of Colorado at Boulder research team found that residential areas in intensely drilled northeastern Colorado have high levels of fracking-related air pollutants, including benzene. In some cases, concentrations exceed those found in large urban centers and are within the range of exposures known to be linked to chronic health effects. According to the study, “High ozone levels are a significant health concern, as are potential health impacts from chronic exposure to primary emissions of non-methane hydrocarbons (NMHC) for residents living near wells.” The study also noted that tighter regulations have not resulted in lower air pollution levels, “Even though the volume of emissions per well may be decreasing, the rapid and continuing increase in the number of wells may potentially negate any real improvements to the air quality situation.”⁸⁵
- October 30, 2014 – A research team assembled by University at Albany Institute for Health and the Environment identified eight highly toxic chemicals in air samples collected near fracking and associated infrastructure sites across five states: Arkansas, Colorado, Pennsylvania, Ohio, and Wyoming. The most common airborne chemicals detected included two proven human carcinogens (benzene and formaldehyde) and two potent neurotoxicants (hexane and hydrogen sulfide). In 29 out of 76 samples, concentrations far exceeded federal health and safety standards, sometimes by several orders of magnitude. Further, high levels of pollutants were detected at distances exceeding legal setback distances from wellheads to homes. Highly elevated levels of formaldehyde, for example, were found up to a half-mile from a wellhead. In Arkansas, seven air samples contained formaldehyde at levels up to 60 times the level known to raise the risk for cancer.⁸⁶ “This is a significant public health risk,” said lead author David O. Carpenter, MD, in an accompanying interview: “Cancer has a long latency, so you’re not seeing an elevation in cancer in these communities. But five, 10, 15 years from now, elevation in cancer is almost certain to happen.”⁸⁷
- October 21, 2014 – Responding to health concerns by local residents, a research team from University of Cincinnati and Oregon State University found high levels of air pollution in heavily drilled areas of rural Carroll County, Ohio. Air monitors showed 32 different hydrocarbon-based air pollutants, including the carcinogens naphthalene and benzo[a]pyrene.⁸⁸ The researchers plan additional monitoring and analysis.
- October 21, 2014 – Using a mobile laboratory designed by the National Oceanic and Atmospheric Administration (NOAA), a research team from the University of Colorado

⁸⁵ Thompson C. R., Hueber J., & Helmig D. (2014). Influence of oil and gas emissions on ambient atmospheric non-methane hydrocarbons in residential areas of Northeastern Colorado. *Elementa: Science of the Anthropocene*, 2. doi: 10.12952/journal.elementa.000035

⁸⁶ Macey, G. P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D. O. (2014). Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study. *Environmental Health*, 13(82). doi: 10.1186/1476-069X-13-82

⁸⁷ Neuhauser, A. (2014, October 30). Toxic chemicals, carcinogens skyrocket near fracking sites. *U.S. News and World Report*. Retrieved from <http://www.usnews.com/news/articles/2014/10/30/toxic-chemicals-and-carcinogens-skyrocket-near-fracking-sites-study-says>

⁸⁸ Environmental Health Sciences Center, Oregon State University. (2014). List of 62 PAH analyzed in Carroll County, OH. Retrieved from <http://ehsc.oregonstate.edu/air/62PAH>

at Boulder, the NOAA Earth System Research Laboratory, and the Karlsruhe Institute of Technology looked at air pollution from drilling and fracking operations in Utah's Uintah Basin. The researchers found that drilling and fracking emit prodigious amounts of volatile organic air pollutants, including benzene, toluene, and methane, all of which are precursors for ground-level ozone (smog). Multiple pieces of equipment on and off the well pad, including condensate tanks, compressors, dehydrators, and pumps, served as the sources of these emissions. This research shows that drilling and fracking activities are the cause of the extraordinarily high levels of winter smog in the remote Uintah basin—which regularly exceed air quality standards and rival that of downtown Los Angeles.⁸⁹

- October 2, 2014 – A joint investigation by *InsideClimate News* and the Center for Public Integrity found that toxic air emissions wafting from fracking waste pits in Texas are unmonitored and unregulated due to federal exemptions that classify oil and gas field waste as non-hazardous.⁹⁰
- October 1, 2014 – In a major paper published in *Nature*, an international team led by the National Oceanic and Atmospheric Administration demonstrated that exceptionally high emissions of VOCs explain how drilling and fracking operations in Utah's Uintah Basin create extreme wintertime ozone events even in the absence of abundant ultraviolet light and water vapor, which are typically required to produce ground-level ozone (smog). Current air pollution trends in the United States are toward lower nitrogen oxides from urban sources and power generation, but increasing methane and VOCs from oil and gas extraction activities threaten to reverse decades of progress in attaining cleaner air. According to the study, the consequences for public health are “as yet unrecognized.”⁹¹
- September 6, 2014 – As part of a comparative lifecycle analysis, a British team from the University of Manchester found that shale gas extracted via fracking in the United Kingdom would generate more smog than any other energy source evaluated (coal, conventional and liquefied gas, nuclear, wind, and solar). Leakage of vaporous organic compounds during the necessary removal of hydrogen sulfide gas, along with the venting of gas both during drilling and during the process of making the well ready for production, were major contributors. “In comparison to other technologies, shale gas has high [photochemical smog]. In the central case, it is worse than solar PV, offshore wind

⁸⁹ Warneke, C., Geiger, F., Edwards, P. M., Dube, W., Pétron, G., Kofler, J., . . . Roberts, J. M. (2014). Volatile organic compound emissions from the oil and natural gas industry in the Uintah Basin, Utah: oil and gas well pad emissions compared to ambient air composition. *Atmospheric Chemistry and Physics*, 14, 10977-10988. doi: 10.5194/acp-14-10977-2014

⁹⁰ Hasemyer, D. & Hirji, Z. (2014, October 2). Open piles offer cheap disposal for fracking sludge, but health worries mount. *InsideClimate News* and the Center for Public Integrity. Retrieved from <http://www.publicintegrity.org/2014/10/02/15826/open-pits-offer-cheap-disposal-fracking-sludge-health-worries-mount>

⁹¹ Edwards, P. M., Brown, S. S., Roberts, J. M., Ahmadov, R., Banta, R. M., deGouw, J.A., . . . Zamora, R. (2014). High winter ozone pollution from carbonyl photolysis in an oil and gas basin. *Nature*, 514(7522), 351-354. doi: 10.1038/nature13767

and nuclear power by factors of 3, 26 and 45, respectively. Even in the best case, wind and nuclear power are still preferable (by factors of 3.3 and 5.6 respectively).⁹²

- September 2014 – ShaleTest Environmental Testing conducted ambient air quality tests and gas-finder infrared video for several children’s play areas in North Texas that are located in close proximity to shale gas development. The results showed a large number of compounds detected above the Method Reporting Limit (the minimum quantity of the compound that can be confidently determined by the laboratory). Air sampling found three known/suspected carcinogens, and a number of other compounds associated with significant health effects. Benzene results from Denton, Dish, and Fort Worth are particularly alarming since they exceeded the long-term ambient air limits set by the Texas Commission on Environmental Quality, and benzene is a known carcinogen. “Benzene was found at all but one sampling location This is particularly noteworthy as benzene is a known carcinogen (based on evidence from studies in both people and lab animals), AND because it exceeds [levels above which effects have the potential to occur.]”⁹³
- August 24, 2014 – A *Salt Lake City Tribune* investigation found that evaporation from 14 fracking waste pits in western Colorado has added tons of toxic chemicals to Utah’s air in the last six years. Further, the company responsible operated with no permit, underreported its emissions and provided faulty data to regulators.⁹⁴
- August 2014 – A four-part investigation by the *San Antonio Express-News* found that natural gas flaring in the Eagle Ford Shale in 2012 contributed more than 15,000 tons of VOCs and other contaminants to the air of southern Texas—which is roughly equivalent to the pollution that would be released annually by six oil refineries. No state or federal agency is tracking the emissions from individual flares.⁹⁵
- June 26, 2014 – Public health professionals at the Southwest Pennsylvania Environmental Health Project reported significant recurrent spikes in the amount of particulate matter in the air inside of residential homes located near drilling and fracking operations. Captured by indoor air monitors, the spikes tend to occur at night when stable atmospheric conditions hold particulate matter low to the ground. Director Raina Ripple emphasized that spikes in airborne particulate matter are likely to cause acute health impacts in community members. She added, “What the long-term effects are going to be, we’re not certain.”⁹⁶

⁹² Stamford, L. & Azapagic, A. (2014). Life cycle environmental impacts of UK shale gas. *Applied Energy*, 134, 506-518. doi: 10.1016/j.apenergy.2014.08.063

⁹³ ShaleTest Environmental Testing. (2014, September). Project playground: Cleaner air for active kids. Retrieved from <http://www.shaletest.org/wp-content/uploads/2014/09/ProjectPlaygroundPatagoniaReport-5-1.pdf>

⁹⁴ Maffly, B. (2014, August 24). Utah grapples with toxic water from oil and gas industry. *Salt Lake City Tribune*. Retrieved from <http://www.sltrib.com/sltrib/news/58298470-78/danish-flats-ponds-company.html>

⁹⁵ Hiller, J., & Tedesco, J. (2014, August). Up in flames: Flare in Eagle Ford Shale wasting natural gas. *San Antonio Express News*. Retrieved from: <http://www.expressnews.com/business/eagleford/item/Up-in-Flames-Day-1-Flares-in-Eagle-Ford-Shale-32626.php>

⁹⁶ McMahon, J. (2014, June 26). Air pollution spikes in homes near fracking wells. *Forbes*. Retrieved from <http://www.forbes.com/sites/jeffmcmahon/2014/06/26/air-pollution-spikes-in-homes-near-fracking-wells/>

- May 8, 2014 – Researchers at the National Oceanic and Atmospheric Administration (NOAA) found high levels of methane leaks as well as benzene and smog-forming VOCs in the air over oil and gas drilling areas in Colorado. Researchers found methane emissions three times higher than previously estimated and benzene and VOC levels seven times higher than estimated by government agencies. The *Denver Post* noted that Colorado’s Front Range has failed to meet federal ozone air quality standards for years.⁹⁷
- April 26, 2014 – A Texas jury awarded a family \$2.8 million because, according to the lawsuit, a fracking company operating on property nearby had “created a ‘private nuisance’ by producing harmful air pollution and exposing [members of the affected family] to harmful emissions of volatile organic compounds, toxic air pollutants and diesel exhaust.” The family’s 11-year-old daughter became ill, and family members suffered a range of symptoms, including “nosebleeds, vision problems, nausea, rashes, blood pressure issues.”⁹⁸ Because drilling did not occur on their property, the family had initially been unaware that their symptoms were caused by activities around them.
- April 16, 2014 – Reviewing the peer-review literature to date of “direct pertinence to the environmental public health and environmental exposure pathways,” a U.S. team of researchers concluded: “[a] number of studies suggest that shale gas development contributes to levels of ambient air concentrations known to be associated with increased risk of morbidity and mortality.”⁹⁹
- April 11, 2014 – A modeling study commissioned by the state of Texas made striking projections about worsening air quality in the Eagle Ford Shale. Findings included the possibility of a 281 percent increase in emissions of VOCs. Some VOCs cause respiratory and neurological problems; others, like benzene, are also carcinogens. Another finding was that nitrogen oxides—which react with VOCs in sunlight to create ground-level ozone, the main component of smog—increased 69 percent during the peak ozone season.¹⁰⁰
- March 29, 2014 – Scientists warn that current methods of collecting and analyzing emissions data do not accurately assess health risks. Researchers with the Southwest Pennsylvania Environmental Health Project showed that methods do not adequately measure the intensity, frequency, or durations of community exposure to the toxic chemicals routinely released from drilling and fracking activities. They found that exposures may be underestimated by an order of magnitude, mixtures of chemicals are

⁹⁷ Finley, B. (2014, May 8). Scientists flying over Colorado oil boom find worse air pollution. *The Denver Post*. Retrieved from http://www.denverpost.com/environment/ci_25719742/scientists-flying-over-colorado-oil-boom-find-worse

⁹⁸ Morris, J. (2014, April 26). Texas family plagued with ailments gets \$3M in 1st-of-its-kind fracking judgment. *CNN*. Retrieved from <http://www.cnn.com/2014/04/25/justice/texas-family-wins-fracking-lawsuit/>

⁹⁹ Shonkoff, S. B., Hays, J., & Finkel, M. L. (2014). Environmental public health dimensions of shale and tight gas development. *Environmental Health Perspectives*, 122, 787–795. doi: 10.1289/ehp.1307866

¹⁰⁰ Morris, J., Song, L., & Hasemayer, D. (2014, April 11). Report: Air quality to worsen in Eagle Ford shale. *The Texas Tribune*. Retrieved from <http://www.texastribune.org/2014/04/11/report-air-quality-worsen-eagle-ford-shale/>

not taken into account, and local weather conditions and vulnerable populations are ignored.¹⁰¹

- March 27, 2014 – University of Texas research pointed to “potentially false assurances” in response to community health concerns in shale gas development areas. Dramatic shortcomings in air pollution monitoring to date include no accounting for cumulative toxic emissions or children’s exposures during critical developmental stages, and the potential interactive effects of mixtures of chemicals. Chemical mixtures of concern include benzene, toluene, ethylbenzene, and xylenes.^{102, 103}
- March 13, 2014 – VOCs emitted in Utah’s heavily drilled Uintah Basin led to 39 winter days exceeding the EPA’s eight-hour National Ambient Air Quality Standards level for ozone pollutants the previous winter. “Levels above this threshold are considered to be harmful to human health, and high levels of ozone are known to cause respiratory distress and be responsible for an estimated 5,000 premature deaths in the U.S. per year,” according to researchers at the University of Colorado. Their observations “reveal a strong causal link between oil and gas emissions, accumulation of air toxics, and significant production of ozone in the atmospheric surface layer.”¹⁰⁴ Researchers estimated that total annual VOC emissions at the fracking sites are equivalent to those of about 100 million cars.¹⁰⁵
- March 3, 2014 – In a report summarizing “the current understanding of local and regional air quality impacts of natural gas extraction, production, and use,” a group of researchers from NOAA, Stanford, Duke, and other institutions described what is known and unknown with regard to air emissions including greenhouse gases, ozone precursors (VOCs and nitrogen oxides), air toxics, and particulates. Crystalline silica was also discussed, including as a concern for people living near well pads and production staging areas.¹⁰⁶
- February 18, 2014 – An eight-month investigation by the *Weather Channel*, the *Center for Public Integrity*, and *InsideClimate News* into fracking in the Eagle Ford Shale in Texas revealed that fracking is “releasing a toxic soup of chemicals into the air.” They

¹⁰¹ Brown, D., Weinberger, B., Lewis, C., & Bonaparte, H. (2014). Understanding exposure from natural gas drilling puts current air standards to the test. *Reviews on Environmental Health*, 29(4), 277-92. doi: 10.1515/reveh-2014-0002

¹⁰² Rawlins, R. (2013). Planning for fracking on the Barnett shale: Urban air pollution, improving health based regulation, and the role of local governments. *Virginia Environmental Law Journal*, 31, 226-306. Retrieved from http://www.velj.org/uploads/1/2/7/0/12706894/2._rawlins_-_barnett_shale.pdf

¹⁰³ University of Texas at Austin. (2014, March 27). Air pollution and hydraulic fracturing: Better monitoring, planning and tracking of health effects needed in Texas. Retrieved from <http://www.utexas.edu/news/2014/03/27/hydraulic-fracturing-texas/>

¹⁰⁴ Helmig, D., Thompson, C. R., Evans, J., Boylan, P., Hueber, J., & Park, J. (2014). Highly elevated atmospheric levels of volatile organic compounds in the Uintah Basin, Utah [Abstract]. *Environmental Science & Technology*, 48(9), 4707-4715. doi: 10.1021/es405046r

¹⁰⁵ Lockwood, D. (2014, March 25). Harmful air pollutants build up near oil and gas fields. *Chemical & Engineering News*. Retrieved from <http://cen.acs.org/articles/92/web/2014/03/Harmful-Air-Pollutants-Build-Near.html>

¹⁰⁶ Moore, C. W., Zielinska, B., Petron, G., & Jackson, R. B. (2014). Air impacts of increased natural gas acquisition, processing, and use: A critical review. *Environmental Science & Technology*. doi: 10.1021/es4053472

noted very poor monitoring by the state of Texas and reported on hundreds of air complaints filed relating to air pollution associated with fracking.¹⁰⁷

- December 18, 2013 – An interdisciplinary group of researchers in Texas collected air samples in residential areas near shale gas extraction and production, going beyond previous Barnett Shale studies by including emissions from the whole range of production equipment. They found that most areas had “atmospheric methane concentrations considerably higher than reported urban background concentrations,” and many toxic chemicals were “strongly associated” with compressor stations.¹⁰⁸
- December 10, 2013 – Health department testing at fracking sites in West Virginia revealed dangerous levels of benzene in the air. Wheeling-Ohio County Health Department Administrator Howard Gamble stated, “The levels of benzene really pop out. The amounts they were seeing were at levels of concern. The concerns of the public are validated.”¹⁰⁹
- October 11, 2013 – Air sampling before, during, and after drilling and fracking of a new natural gas well pad in rural western Colorado documented the presence of the toxic solvent methylene chloride, along with several polycyclic aromatic hydrocarbons (PAHs) at “concentrations greater than those at which prenatally exposed children in urban studies had lower developmental and IQ scores.”¹¹⁰
- September 19, 2013 – In Texas, air monitoring data in the Eagle Ford Shale area revealed potentially dangerous exposures of nearby residents to hazardous air pollutants, including cancer-causing benzene and the neurological toxicant, hydrogen sulfide.¹¹¹
- September 13, 2013 – A study by researchers at the University of California at Irvine found dangerous levels of VOCs in Canada’s “Industrial Heartland” where there are more than 40 oil, gas, and chemical facilities. The researchers noted high levels of

¹⁰⁷ Morris, J., Song, L., & Hasemayer, D. (2014, February 18). Fracking the Eagle Ford Shale. *The Weather Channel*. Retrieved from <http://stories.weather.com/fracking>

¹⁰⁸ Rich, A., Grover, J. P., & Sattler, M. L. (2014). An exploratory study of air emissions associated with shale gas development and production in the Barnett Shale. *Journal of the Air & Waste Management Association*, 64(1), 61-72. doi: 10.1080/10962247.2013.832713

¹⁰⁹ Junkins, C. (2013, December 10). Health dept. concerned about benzene emissions near local gas drilling sites. *The Intelligencer, Wheeling News-Register*. Retrieved from <http://www.theintelligencer.net/page/content.detail/id/593209/Health-Dept--Concerned-About-Benzene-Emissions-Near-Local-Gas-Drilling-Sites.html?nav=510>

¹¹⁰ Colborn, T., Schultz, K., Herrick, L., & Kwiatkowski, C. (2014). An exploratory study of air quality near natural gas operations. *Human and Ecological Risk Assessment: An International Journal*, 20(1), 86-105. doi: 10.1080/10807039.2012.749447

¹¹¹ Wilson, S., Sumi, L., & Subra, W. (2013, September 19). Reckless endangerment while fracking the Eagle Ford shale. *Earthworks*. Retrieved from http://www.earthworksaction.org/library/detail/reckless_endangerment_in_the_eagle_ford_shale#.UkGi-4Y3uSo.

hematopoietic cancers (leukemia and non-Hodgkin's lymphoma) in men who live closer to the facilities.¹¹²

- April 29, 2013 – Using American Lung Association data, researchers with the Environmental Defense Fund determined that air quality in rural areas with fracking was worse than air quality in urban areas.¹¹³
- March 2013 – A review of regional air quality damages in parts of Pennsylvania in 2012 from Marcellus Shale development found that air pollution was a significant concern, with regional damages ranging from \$7.2-\$32 million in 2011.¹¹⁴
- February 27, 2013 – In a letter from Concerned Health Professionals of New York to Governor Andrew Cuomo, a coalition of hundreds of health organizations, scientists, medical experts, elected officials, and environmental organizations noted serious health concerns about the prospects of fracking in New York State, making specific note of air pollution.¹¹⁵ Signatory organizations included the American Academy of Pediatrics of New York, the American Lung Association of New York, and Physicians for Social Responsibility. The New York State Medical Society, representing 30,000 medical professionals, has issued similar statements.¹¹⁶
- January 2, 2013 – A NOAA study identified emissions from oil and gas fields in Utah as a significant source of pollutants that contribute to ozone problems.¹¹⁷ Exposure to elevated levels of ground-level ozone is known to worsen asthma and has been linked to respiratory illnesses and increased risk of stroke and heart attack.¹¹⁸
- December 3, 2012 – A study linked a single well pad in Colorado to more than 50 airborne chemicals, 44 of which have known health effects.¹¹⁹

¹¹² Simpson, I. J., Marrero, J. E., Batterman, S. & Blake, D. R. (2013) Air quality in the Industrial Heartland of Alberta, Canada and potential impacts on human health. *Atmospheric Environment*, 81, 702-709. doi: 10.1016/j.atmosenv.2013.09.017

¹¹³ Grossman, D. (2013, April 29). Clean air report card: CO, WY Counties get F's due to oil and gas pollution. *Environmental Defense Fund*. Retrieved from <http://blogs.edf.org/energyexchange/2013/04/29/clean-air-report-card-co-wy-counties-get-fs-due-to-oil-and-gas-pollution/#sthash.FXRv6Nxi.dpuf>

¹¹⁴ Litovitz, A., Curtright, A., Abramzon, S., Burger, N., & Samaras, C. (2013). Estimation of regional air-quality damages from Marcellus Shale natural gas extraction in Pennsylvania. *Environmental Research Letters*, 8(1). doi: 10.1088/1748-9326/8/1/014017

¹¹⁵ Concerned Health Professionals of NY. (2013, February 27). Letter to Governor Cuomo. Retrieved from <http://concernedhealthny.org/letters-to-governor-cuomo/>

¹¹⁶ Campbell, J. (2013, April 17). Fracking roundup: Gas prices up; Medical society wants moratorium. *Politics on the Hudson*. Retrieved from <http://polhudson.lohudblogs.com/2013/04/17/fracking-roundup-gas-prices-up-medical-society-wants-moratorium/>

¹¹⁷ Tollefson, J. (2013). Methane leaks erode green credentials of natural gas. *Nature*, 493(7430), 12-12. doi: 10.1038/493012a

¹¹⁸ American Lung Association. (2013). American Lung Association state of the air 2013 - Ozone pollution. Retrieved from <http://www.stateoftheair.org/2013/health-risks/health-risks-ozone.html>

¹¹⁹ Colborn, T., Schultz, K., Herrick, L., & Kwiatkowski, C. (2014). An exploratory study of air quality near natural gas operations. *Human and Ecological Risk Assessment: An International Journal*, 20(1), 86-105. doi: 10.1080/10807039.2012.749447

- July 18, 2012 – A study by the Houston Advanced Research Center modeled ozone formation from a natural gas processing facility using accepted emissions estimates and showed that regular operations could significantly raise levels of ground-level ozone (smog) in the Barnett Shale in Texas and that gas flaring further contributed to ozone levels.¹²⁰
- March 19, 2012 – A Colorado School of Public Health study found air pollutants near fracking sites linked to neurological and respiratory problems and cancer.^{121, 122} The study, based on three years of monitoring at Colorado sites, found a number of “potentially toxic petroleum hydrocarbons in the air near gas wells including benzene, ethylbenzene, toluene, and xylene.” Lisa McKenzie, PhD, MPH, lead author of the study and research associate at the Colorado School of Public Health, said, “Our data show that it is important to include air pollution in the national dialogue on natural gas development that has focused largely on water exposures to hydraulic fracturing.”¹²³
- December 12, 2011 – Cancer specialists, cancer advocacy organizations, and health organizations summarized the cancer risks posed by all stages of the shale gas extraction process in a letter to New York Governor Andrew Cuomo.¹²⁴
- October 5, 2011 – More than 250 medical experts and health organizations reviewed the multiple health risks from fracking in a letter sent to New York Governor Andrew Cuomo.¹²⁵
- April 21, 2011 – *Environment & Energy (E&E)* reported that ozone levels exceeding federal health standards in Utah’s Uintah Basin, as well as wintertime ozone problems in other parts of the Intermountain West, stem from oil and gas extraction. Levels reached nearly twice the federal standard, potentially dangerous even for healthy adults to breathe. Keith Guille, spokesman for the Wyoming Department of Environmental Quality, said, “We recognize that definitely the main contributor to the emissions that are out there is the oil and gas industry....”¹²⁶

¹²⁰ Olaguer, E. P. (2012). The potential near-source ozone impacts of upstream oil and gas industry emissions.

Journal of the Air & Waste Management Association, 62(8), 966-977. doi: 10.1080/10962247.2012.688923

¹²¹ Kelly, D. (2012, March 19). Study shows air emissions near fracking sites may pose health risk. *University of Colorado Denver*. Retrieved from <http://www.ucdenver.edu/about/newsroom/newsreleases/Pages/health-impacts-of-fracking-emissions.aspx>

¹²² McKenzie, L. M., Witter, R. Z., Newman, L. S., & Adgate, J. L. (2012). Human health risk assessment of air emissions from development of unconventional natural gas resources. *Science of the Total Environment*, 424, 79-87. doi: 10.1016/j.scitotenv.2012.02.018

¹²³ Banerjee, N. (2012, March 20). Study: 'Fracking' may increase air pollution health risks. *Los Angeles Times*. Retrieved from <http://articles.latimes.com/2012/mar/20/local/la-me-gs-fracking-increases-air-pollution-health-risks-to-residents-20120320>

¹²⁴ Physicians, Scientists & Engineers for Healthy Energy. (2011, December 12). Appeal to Gov. Cuomo to consider cancer risks re: High volume hydraulic fracturing for natural gas [Letter to A. Cuomo].

¹²⁵ Physicians, Scientists & Engineers for Healthy Energy. (2011, October 5). Letter to Governor Cuomo [Letter to A. Cuomo].

¹²⁶ Streater, S. (2011, April 21). Air pollution: Winter ozone problem continues to mystify regulators, industry. *E&E Publishing, LLC*. Retrieved from <http://www.eenews.net/stories/1059948108>

- March 8, 2011 – The Associated Press reported that gas drilling in some remote areas of Wyoming caused a decline of air quality from pristine mountain air to levels of smog and pollution worse than Los Angeles on its worst days, resulting in residents complaining of watery eyes, shortness of breath, and bloody noses.¹²⁷
- November 18, 2010 – A study of air quality in the Haynesville Shale region of east Texas, northern Louisiana, and southwestern Arkansas found that shale oil and gas extraction activities contributed significantly to ground-level ozone (smog) via high emissions of ozone precursors, including VOCs and nitrogen oxides.¹²⁸ Ozone is a key risk factor for asthma and other respiratory and cardiovascular illnesses.^{129, 130, 131, 132}
- September 2010 – A health assessment by the Colorado School of Public Health for gas development in Garfield County, Colorado determined that air pollution will likely “be high enough to cause short-term and long-term disease, especially for residents living near gas wells. Health effects may include respiratory disease, neurological problems, birth defects and cancer.”^{133, 134}
- January 27, 2010 – Of 94 drilling sites tested for benzene in air over the Barnett Shale, the Texas Commission on Environmental Quality discovered two well sites emitting what they determined to be “extremely high levels” and another 19 emitting elevated levels.¹³⁵

¹²⁷ Gruver, M. (2011, March 8). Wyoming is beset by a big-city problem: Smog. *USA Today*. Retrieved from http://usatoday30.usatoday.com/money/industries/energy/2011-03-08-natural-gas-ozone-wyoming_N.htm

¹²⁸ Kembal-Cook, S., Bar-Ilan, A., Grant, J., Parker, L., Jung, J., Santamaria, W., . . . Yarwood, G. (2010). Ozone impacts of natural gas development in the Haynesville Shale. *Environmental Science & Technology*, 44(24), 9357-9363. doi: 10.1021/es1021137

¹²⁹ U.S. Environmental Protection Agency. (2013). Integrated science assessment for ozone and related photochemical oxidants. Retrieved from <http://www.epa.gov/ncea/isa/ozone.htm>

¹³⁰ Shah, A. S., Lee, K. K., McAllister, D. A., Hunter, A., Nair, H., Whiteley, W., . . . Mills, N. L. (2015). Short term exposure to air pollution and stroke: systematic review and meta-analysis. *British Medical Journal*, 24(1295). doi: 10.1136/bmj.h1295

¹³¹ Shah, A. S., Langrish, J. P., Nair, H., McAllister, D. A., Hunter, A., L., Donaldson, K., . . . Mills, N. L. (2013). Global association of air pollution and heart failure: a systematic review and meta-analysis. *The Lancet*, 382(9897), 1039-1048. doi: 10.1016/S0140-6736(13)60898-3.

¹³² Myers, O., Flowers, H., Kang, H., Bedrick, E., Whorton, B., Cui, X., & Stidley, C. A. (2007). The association between ambient air quality ozone levels and medical visits for asthma in San Juan County. New Mexico Department of Health, Environmental Health Epidemiology Bureau Epidemiology and Response Division. Retrieved from <http://www.nmenv.state.nm.us/aqb/4C/Documents/SanJuanAsthmaDocBW.pdf>

¹³³ Witter, R., McKenzie, L., Towle, M., Stinson, K., Scott, K., Newman, L., & Adgate, J. (2010). Health impact assessment for Battlement Mesa, Garfield County Colorado. *Colorado School of Public Health*. Retrieved from <http://www.garfield-county.com/public-health/documents/1%20%20Complete%20HIA%20without%20Appendix%20D.pdf>

¹³⁴ Battlement Mesa HIA/EHMS. (2013, November 30). Retrieved from <http://www.garfield-county.com/environmental-health/battlement-mesa-health-impact-assessment-draft2.aspx>

¹³⁵ The Associated Press. (2010, January 27). Texas agency finds high benzene levels on Barnett Shale. Retrieved from http://www.nola.com/business/index.ssf/2010/01/texas_agency_finds_high_benzen.html

Water contamination

Substantial evidence shows that drilling and fracking activities, and associated wastewater disposal practices, inherently threaten groundwater and have polluted drinking water sources, as confirmed by the 2016 final report of the U.S. Environmental Protection Agency (EPA) on the impacts of fracking on the nation's drinking water. Repudiating industry claims of risk-free fracking, studies from across the United States present irrefutable evidence that groundwater contamination occurs as a result of fracking activities and is more likely to occur close to well pads. In Pennsylvania alone, the state has determined that more than 300 private drinking water wells have been contaminated or otherwise impacted as the result of drilling and fracking operations over an eight-year period. As determined by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), the chemical contamination of some private water wells in Dimock, Pennsylvania posed demonstrable health risks, rendering the water unsuitable for drinking.

Evidence on instances and pathways of water contamination exist even though scientific inquiry is impeded by industry secrecy and regulatory exemptions. The 2005 Energy Policy Act exempts hydraulic fracturing from key provisions of the Safe Drinking Water Act. As a result, fracking chemicals have been protected from public scrutiny as "trade secrets." The oil and gas sector is the only U.S. industry permitted to inject known hazardous materials near, or directly into, underground drinking water aquifers. At the same time, in most states where fracking occurs, routine monitoring of groundwater aquifers near drilling and fracking operations is not required, nor are companies compelled to fully disclose the identity of chemicals used in fracking fluid, their quantities, or their fate once injected underground.

Nevertheless, of the more than 1,000 chemicals that are confirmed ingredients in fracking fluid, an estimated 100 are known endocrine disruptors, acting as reproductive and developmental toxicants. Adding to this mix are heavy metals, radioactive elements, brine, and volatile organic compounds (VOCs), which occur naturally in deep geological formations and which can be carried up from the fracking zone with the flowback fluid. As components of the fracking waste stream, these toxic substances also pose threats to surface water and groundwater. A 2017 study found that spills of fracking fluids and fracking wastewater are common, documenting 6,678 significant spills occurring over a period of nine years in four states alone. In these states, between 2 and 16 percent of wells report spills each year. About 5 percent of all fracking waste is lost to spills, often during transport. Spills and intentional discharges of fracking waste into surface water have profoundly altered the chemistry and ecology of streams throughout entire watersheds, increasing downstream levels of radioactive elements, heavy metals, endocrine disruptors, toxic disinfection byproducts, and acidity, and decreasing aquatic biodiversity and populations of sensitive fish species, such as brook trout. New studies documenting changes in the bacterial flora in groundwater following drilling and fracking operations represent an emerging area of concern.

- December 11, 2017 – A report by the *Texas Observer* investigated groundwater depletion by fracking operations in west Texas at the southern edge of the Ogallala Aquifer. Groundwater conservation districts lack legal financial resources to restrict groundwater pumping or even compel metering on water wells that would monitor exactly how much

water is pumped. In Howard County alone, water used for fracking is now believed to constitute about 20 percent of average annual water use.¹³⁶

- November 16, 2017 – The 2005 Energy Policy Act prohibited the EPA from regulating fracking under the Safe Drinking Water Act and from requiring that operators disclose their chemicals. According to an investigation by *InsideClimate News*, the scientific study that justified this provision (which is widely known as the Halliburton loophole) was the subject of a whistleblower complaint. The study was also disavowed by its authors, who said the conclusion of the report—that fracking posed no risk to groundwater—was not supported by the evidence. These authors removed their names from the final document. Interviewed for the story, one of these authors said that the belief that fracking was safe for water was a foregone conclusion at the EPA under George W. Bush. “What we would have said in the conclusion is that there is some form of risk from hydraulic fracturing to groundwater. How you quantify it would require further analyses, but, in general, there is some risk.”¹³⁷
- November 9, 2017 – As part of a preliminary study, a Texas team assessed the groundwater microbiome in a rural area of southern Texas where farming and fracking co-exist. Each of the sampled water wells had a unique community of microorganisms living in the water. The dominant bacteria were denitrifying species that transform nitrates into gaseous nitrogen or those that break apart hydrocarbon molecules. Earlier studies have postulated that fracking can alter the chemical composition of groundwater and change the species composition of the microbial communities living within it. The results of this study “do not provide a definitive link between [fracking] or agricultural activities and the groundwater microbiome; however, they do provide a baseline measurement of bacterial diversity and quantity in groundwater located near these anthropogenic activities.”¹³⁸
- November 1, 2017 – In Oklahoma, horizontal wells can be fracked within 600 feet of older, vertical wells that do not use fracking. Oil companies in Oklahoma that extract oil using conventional, vertical wells alleged that hundreds of their wells have been inundated by fluids from nearby horizontal wells that use high-volume hydraulic fracturing, as documented by *E&E News*. Vertical well operators have raised questions about whether these “frack hits” from nearby horizontal wells that have flooded their own wells have also reached the groundwater. “Logic said it will impact [groundwater],” said one driller. “There was water coming up out of the ground. There was enough pressure to bring it to the surface.” Small operators of vertical wells, organized as the Oklahoma Energy Producers Alliance (OEPA), released a study estimating that, in just one county

¹³⁶ Collins, C. (11 December, 2017). Big spring vs. big oil. *Texas Observer*. Retrieved from <https://www.texasobserver.org/big-spring-vs-big-oil/>

¹³⁷ Banerjee, N. (16 November, 2017). Industrial strength: How the U.S. government hid fracking's risks to drinking water. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/16112017/fracking-chemicals-safety-epa-health-risks-water-bush-cheney>

¹³⁸ Santos, I. C., Martin, M. S., Reyes, M. L., Carlton Jr., D. D., Stigler-Granados, P., Valerio, M. A., ... & Schug, K. A. (2017). Exploring the links between groundwater quality and bacterial communities near oil and gas extraction activities. *Science of the Total Environment*. 618, 165-173. doi: 10.1016/j.scitotenv.2017.10.264

alone, there were 400 cases of frack fluid from horizontal wells flooding nearby vertical wells.^{139, 140}

- October 31, 2017 – A study of fracking wastewater disposed of in rivers and streams found that chemical contaminants in the waste were transformed into more toxic substances when they chemically reacted with chlorinated compounds discharged from downstream drinking water treatment plants. The result was dozens of different, brominated and iodinated disinfection byproducts (DBPs). A lab analysis found that all were highly toxic to mammalian cells. Conventional water treatment practices do not remove these chemicals. “It is likely that in oil- and gas-impacted drinking water sources, iodo-phenolic DBPs could form at significant levels, particularly in cases in which chloramination is used.”¹⁴¹
- October 18, 2017 – Researchers concerned about reports of skin rashes, gastrointestinal distress, and breathing problems among people who live near drilling and fracking operations found increased levels of certain harmful bacteria in private water wells impacted by fracking in the Barnett and Eagle Ford Shale areas in Texas. These results raise questions about whether drilling and fracking activities could alter the communities of microorganisms in groundwater in ways that pose health risks. According to one of the lead authors of the study, interviewed in the *Dallas News*, “the potential contribution of these microbes to these health effects is probably understudied, underappreciated, unknown.”^{142, 143}
- August 3, 2017 – Due to permitting errors and a mix-up in records 30 years ago, wastewater from drilling operations in California was mistakenly injected directly into drinking water aquifers. Six years after the discovery of the problem, 175 wastewater wells that were illegally injecting into protected aquifers have been shut down, but hundreds more are still operating. An investigation by KQED Science revealed that California state water regulators know very little about the actual impact of those injections on the state’s drinking water reserves. “State water regulators say they hope to figure out what the larger impacts have been in years ahead, but have no set timeline. The risk is that they’ve allowed oil companies to contaminate drinking water aquifers to such

¹³⁹ Soraghan, M. (1 November, 2017). Now it’s oilmen who say fracking could harm groundwater. *E&E News*. Retrieved from <https://www.eenews.net/stories/1060065209>

¹⁴⁰ OEPA. (2017, September 14). Are vertical wells impacted by horizontal drilling? A study of Kingfisher County. *E&E News*. Retrieved from https://www.eenews.net/assets/2017/10/27/document_pm_07.pdf

¹⁴¹ Liberatore, H. K., Plewa, M. J., Wagner, E. D., VanBriesen, J. M., Burnett, D. B., Cizmas, L. H., & Richardson, S. D. (2017). Identification and comparative mammalian cell cytotoxicity of new iodo-phenolic disinfection byproducts in chloraminated oil and gas wastewaters. *Environmental Science & Technology Letters*, 4(11), 475–480. doi: 10.1021/acs.estlett.7b00468

¹⁴² Martin, M. S., Santos, I. C., Carlton Jr. D. D., Stigler-Granados, P., Hildenbrand, Z. L., & Schug, K. A. (2017). Characterization of bacterial diversity in contaminated groundwater using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry. *Science of the Total Environment*. Advance online publication. doi: 10.1016/j.scitotenv.2017.10.027

¹⁴³ Mosier, J. (2017, December 1). UTA research finds dangerous bacteria in groundwater near Texas gas drilling sites. *Dallas News*. Retrieved from <https://www.dallasnews.com/business/energy/2017/12/01/uta-study-finds-dangerous-bacteria-groundwater-near-texas-gas-drilling-sites>

an extent that Californians may have permanently lost those sources of fresh water.”¹⁴⁴
An earlier investigation by KQED Science revealed that illegal wastewater wells would still be allowed to operate while the necessary paperwork was filed.¹⁴⁵

- July 12, 2017 – In western Pennsylvania, a team of researchers looked at sediments in the Conemaugh River watershed downstream of a treatment plant that was specially designed to treat fracking wastewater. The researchers found contamination for many miles downstream with fracking-related chemicals that included radium, barium, strontium, and chloride, as well as endocrine-disrupting and carcinogenic compounds. The peak concentrations were found in sediment layers that had been deposited during the years of peak fracking wastewater discharge. Elevated concentrations of radium were detected as far as 12 miles downstream of the treatment plant and were up to 200 times greater than background. Some stream sediment samples were so radioactive that they approached levels that would, in some U.S. states, classify them as radioactive waste and necessitate special disposal.^{146, 147}
- May 31, 2017 – A U.S. Geological Survey (USGS) team sampled drinking water wells near drilling and fracking sites in the Eagle Ford, Fayetteville, and Haynesville Shale basins and found detectable levels of methane and benzene. However, the sources of these contaminants were unclear, and, given the slow travel time of groundwater, “decades or longer may be needed to fully assess the effects of potential subsurface and surface releases of hydrocarbons on the wells.”¹⁴⁸
- May 1, 2017 – A study examining the impacts of drilling and fracking operations on public drinking water in Pennsylvania found evidence of contamination when drinking water source intakes were located within one kilometer (.62 miles) of a well pad. Noting that many Pennsylvanians living near well pads drink bottled water, the authors concluded, “our results suggest that these perceived risks may in fact be justified.”¹⁴⁹
[See also entry below for October 13, 2016.]

¹⁴⁴ Sommer, L. (17 August, 2017). How much drinking water has California lost to oil industry waste? No one knows. *KQED Science*. Retrieved from <https://ww2.kqed.org/science/2017/08/03/how-much-drinking-water-has-california-lost-to-oil-industry-waste-no-one-knows/>

¹⁴⁵ Sommer, L. (17 January, 2017). California says oil companies can keep dumping wastewater during state review. *KQED Science*. Retrieved from <https://ww2.kqed.org/science/2017/01/17/california-says-oil-companies-can-keep-dumping-wastewater-during-state-review/>

¹⁴⁶ Burgos, W. D., Castillo-Meza, L., Tasker, T. L., Geeza, T. J., Drohan, P. J., Liu, X., ... Warner, N. R. (2017). Watershed-scale impacts from surface water disposal of oil and gas wastewater in Western Pennsylvania. *Environmental Science & Technology*, 51(15), 8851–8860. doi: 10.1021/acs.est.7b01696

¹⁴⁷ Johnston, I., (2017, July 12). Fracking can contaminate rivers and lakes with radioactive material, study finds. *The Independent*. Retrieved from <http://www.independent.co.uk/news/science/fracking-dangers-environment-water-damage-radiation-contamination-study-risks-a7837991.html>

¹⁴⁸ McMahon, P., Barlow, J. R. B., Engle, M. A., Belitz, K., Ging, P. B., Hunt, A. G., ... & Kresse, T. M. (2017). Methane and benzene in drinking-water wells overlying the Eagle Ford, Fayetteville, and Haynesville Shale hydrocarbon production areas. *Environmental Science & Technology*, 51(12), 6727–6734. doi: 10.1021/acs.est.7b00746

¹⁴⁹ Hill, E., & Ma, L. (2017). Shale gas development and drinking water quality. *American Economic Review: Papers & Proceedings*, 107(5), 522–525. doi: 10.1257/aer.p20171133

- April 19, 2017 – Using data from the South Coast Air Quality Monitoring District, a team of researchers in California compared chemicals used in fracking operations with those used in the routine maintenance of conventional oil and gas wells where chemicals are used to aid in drilling, for corrosion control, to clean the well bore, and to enhance oil recovery. They found significant overlap in both the types and amounts of chemicals used. “The results of this study indicate regulations and risk assessments focused exclusively on chemicals used in well-stimulation activities may underestimate potential hazard or risk from overall field chemical-use. . . . Our analysis shows that hydraulic fracturing is just one of many applications of hazardous chemicals on oil and gas fields.”¹⁵⁰
- April 5, 2017 – A three-year study in West Virginia led by scientists at Duke University assessed surface water and groundwater drawn from drinking water wells both before and after drilling and fracking began in the region. Using geochemical techniques, including a suite of tracers that help distinguish naturally occurring methane and salts from those contained in fracking fluid, the researchers found no evidence of groundwater contamination. They did, however, document threats to surface water from fracking wastewater spills.¹⁵¹ In an accompanying statement, the researchers noted, “What we found in the study area in West Virginia after three years may be different from what we see after 10 years because the impact on groundwater isn’t necessarily immediate.”¹⁵²
- Feb 21, 2017 – Between 2005 and 2014, researchers surveyed spill record data from drilling and fracking operations in four states (Colorado, New Mexico, North Dakota, and Pennsylvania). During these nine years, they documented 6,678 total spills, or about five spills each year for every 100 wells. Between 2 and 16 percent of wells reported a spill each year. Half of all spills were related to storage and transport of fluids through flow lines. The authors also found that the chances of spills are highest during the first three years of a well’s life and that spill reporting requirements differ markedly from state to state, making impossible the task of comparing states or creating a national picture.^{153, 154}
- December 14, 2016 – To better understand the impact of fracking fluid spills on aquatic animals, scientists at the University of Alberta exposed rainbow trout in laboratory tanks to various dilutions of fracking fluids. Even at very low exposures, the fish experienced

¹⁵⁰ Stringfellow, W. T., Camarillo, M. K., Domen, J. K., & Shonkoff, S. B. C. (2017) Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development. *PLoS ONE*, 12(4), e0175344. doi: 10.1371/journal.pone.0175344

¹⁵¹ Harkness, J. S., Darrah, T. H., Warner, N. R., Whyte, C. J., Moore, M. T., Millot, R., . . . Vengosh, A. (2017). The geochemistry of naturally occurring methane and saline groundwater in an area of unconventional shale gas development. *Geochimica et Cosmochimica Acta*, 208, 302–334. doi: 10.1016/j.gca.2017.03.039

¹⁵² Lucas, T. (2017, April 24). *West Virginia groundwater not affected by fracking, but surface water is* [Press release]. Retrieved from <https://nicholas.duke.edu/about/news/west-virginia-groundwater-not-affected-fracking-surface-water>

¹⁵³ Patterson, L., Konschnik, K., Wiseman, H., Fargione, J., Maloney, K. O., Kiesecker, J., . . . Saiers, J. E. (2017). Unconventional oil and gas spills: Risks, mitigation priorities and states reporting requirements. *Environmental Science & Technology*, 51(5), 2563–2573. doi: 10.1021/acs.est.05749

¹⁵⁴ Kusnetz, N. (2017, February 21). Fracking well spills poorly reported in most top-producing states, study finds. *InsideClimate News*. Retrieved from: <https://insideclimatenews.org/news/21022017/fracking-spills-north-dakota-colorado>

adverse effects, including alterations in liver functioning and disruption of hormonal pathways. [This study was partially funded by industry.]¹⁵⁵

- December 13, 2016 – The final version of the EPA’s six-year, \$29 million study on the impacts of hydraulic fracturing on the nation’s drinking water confirmed that fracking activities have caused contamination of water resources in the United States, and it traced the various routes by which drinking water can be impacted by fracking. Documented cases of drinking water contamination have resulted from spills of fracking fluid and fracking wastewater; discharge of fracking waste into rivers and streams; and underground migration of fracking chemicals, including gas, into drinking water wells. Depletion of aquifers caused by water withdrawals has created other impacts.^{156, 157, 158, 159} The final EPA report detailed the problem of fracking-related drinking water contamination in three communities—Pavillion, Wyoming; Dimock, Pennsylvania; and Parker County, Texas.¹⁶⁰ Summing up the report, then-EPA Deputy Administrator Tom Burke said in a statement to *American Public Media*, “We found scientific evidence of impacts to drinking water resources at each stage of the hydraulic fracturing cycle.”¹⁶¹ [See also the entry for June 5, 2015, which describes the contents of the 2015 draft report.]
- December 1, 2016 – According to a review paper that examines the potential environmental impacts of oil and gas wastewater, about 5 percent of fracking waste is accidentally or illegally spilled. Almost all of the rest is transported off site and injected into disposal wells that are drilled into porous geological formations. In North Dakota’s Bakken Shale, disposal wells are located within miles of the well pad, and the wastewater

¹⁵⁵ He, Y., Folkerts, E. J., Zhang, Y., Martin, J. W. Alessi, D. S., & Goss, G. G. (2017). Effects on biotransformation, oxidative stress, and endocrine disruption in rainbow trout (*Oncorhynchus mykiss*) exposed to hydraulic fracturing flowback and produced water. *Environmental Science & Technology*, 51(2), 940-947. doi: 10.1021/acs.est.6b04695

¹⁵⁶ U.S. EPA. (2016). *Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States*. U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-16-236Fa. Retrieved from <https://www.epa.gov/hfstudy>

¹⁵⁷ U.S. EPA. (2016). *Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States* (Appendices). U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-16-236Fb. Retrieved from <https://www.epa.gov/hfstudy>

¹⁵⁸ U.S. EPA. (2016). *Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States* (Executive Summary). U.S. Environmental Protection Agency, Washington, DC, EPA-600-R-16-236ES. Retrieved from <https://www.epa.gov/hfstudy>

¹⁵⁹ Tong, S., & Scheck, T. (30 November, 2016). EPA's late changes to fracking study downplay risk of drinking water pollution. *Marketplace.org*. Retrieved from <https://www.marketplace.org/2016/11/29/world/epa-s-late-changes-fracking-study-portray-lower-pollution-risk>

¹⁶⁰ U.S. Environmental Protection Agency Science Advisory Board. (2016, August 11). *SAB review of the EPA’s draft assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources*. EPA-SAB-16-005. Retrieved from [https://yosemite.epa.gov/sab/sabproduct.nsf/LookupWebReportsLastMonthBOARD/BB6910FEC10C01A18525800C00647104/\\$File/EPA-SAB-16-005+Unsigned.pdf](https://yosemite.epa.gov/sab/sabproduct.nsf/LookupWebReportsLastMonthBOARD/BB6910FEC10C01A18525800C00647104/$File/EPA-SAB-16-005+Unsigned.pdf)

¹⁶¹ Scheck, T. & Tong, S. (2016, December 13). EPA reverses course, highlights fracking contamination of drinking water. *APM Reports*. Retrieved from <https://www.apmreports.org/story/2016/12/13/epa-fracking-contamination-drinking-water>

can travel there via pipeline. In Pennsylvania's Marcellus Shale, drilling activity exceeds the capacity for disposal of waste in local wells and must be trucked out of state.¹⁶²

- November 4, 2016 – A critical review of potential routes of water contamination from drilling and fracking operations in the Bakken Shale noted that the high salinity of fracking wastewater minimizes its recycling options and thus contributes to the need for disposal wells. Transportation of large volumes of waste to these wells, via truck or pipeline, presents opportunities for large spills that can threaten groundwater.¹⁶³
- October 16, 2016 – A team of scientists led by researchers at the Lawrence Berkeley National Laboratory evaluated chemicals used for fracking in California oil fields. Chemical additives included a wide variety of solvents in large amounts, as well as other toxic substances, including biocides and corrosion inhibitors.¹⁶⁴
- October 14, 2016 – One of the first studies to investigate the impacts of fracking on the ecology of streams found that fracking “has the potential to alter aquatic biodiversity and methyl mercury concentrations at the base of food webs.” The researchers sampled 27 remote streams in the Marcellus Shale basin of Pennsylvania where drilling and fracking is taking place. They showed that methyl mercury levels in stream sites where fracking occurs were driven upwards by higher acidity and lower numbers of macroinvertebrates. In streams with the highest numbers of fracking fluid spills, “fish diversity was nil,” and in some cases, there were no fish at all, including in streams previously classified as high-quality brook trout habitat. “Fracking and flowback fluids can contain various highly acidic agents, organic and inorganic compounds, and even Hg [mercury]. The flowback fluids can reach nearby streams through leaking wastewater hoses, impoundments, and lateral seepage and blowouts, as well as by backflow into the wellhead. Flowback water reaching streams can . . . decrease aquatic biodiversity. . . . Lowered stream pH increases Hg solubility, leading to increased bioaccumulation in food webs.”¹⁶⁵
- October 13, 2016 – Researchers at Pennsylvania State University and Ohio State University combined GIS data on drilling and fracking activities in Pennsylvania and Ohio with household data on bottled water purchases. They found that yearly household purchases of bottled water increased as local drilling and fracking intensity increased. This “averting behavior” is a measure of perceived risk. In 2010, averting-behavior expenditures in the form of bottle water purchases by people living in Pennsylvania's

¹⁶² Konkel, L. (2016). Salting the earth: The environmental impact of oil and gas wastewater spills. *Environmental Health Perspectives*, 124(12), A230-A235. doi: 10.1289/ehp.124-A230

¹⁶³ Shrestha, N., Chilkoor, G., Wilder, J., Gadhamshetty, V., & Stone, J. J. (2016). Potential water resource impacts of hydraulic fracturing from unconventional oil production in the Bakken shale. *Water Research*, 108, 1-24. doi: 10.1016/j.watres.2016.11.006

¹⁶⁴ Stringfellow, W. T., Camarillo, M. K., Domen, J. K., Sandelin, W. L., Varadharajan, C., Jordan, P. D., & ... Birkholzer, J. T. (2017). Identifying chemicals of concern in hydraulic fracturing fluids used for oil production. *Environmental Pollution*, 220, Part A, 413-420. doi: 10.1016/j.envpol.2016.09.082

¹⁶⁵ Grant, C. J., Lutz, A. K., Kulig, A. D., & Stanton, M. R. (2016). Fracked ecology: Response of aquatic trophic structure and mercury biomagnification dynamics in the Marcellus Shale Formation. *Ecotoxicology*, 25, 1739-1750. doi: 10.1007/s10646-016-1717-8

shale counties totaled \$19 million.¹⁶⁶ [A subsequent study suggests that those engaged in tapwater averting behaviors in Pennsylvania have evidence-based reasons to be concerned. See entry above, for May 1, 2017.]

- September 22, 2016 – Using the agency’s list of 1076 chemicals that have reported use as ingredients in hydraulic fracturing fluid, EPA scientists developed a framework to analyze and rank subsets of chemicals in order to better understand which fracking-related chemicals pose the greatest risk to drinking water. Their model collates multiple lines of evidence. For example, data on inherent toxicity are combined with data on occurrence and propensity for environmental transport. In the absence of local data on actual human exposures, this model can serve as a qualitative metric to “identify chemicals that may be more likely than others to impact drinking water resources.”¹⁶⁷
- September 16, 2016 – A reconnaissance analysis of groundwater in the Eagle Ford Shale region in southern Texas found sporadic detections of multiple VOCs and dissolved gas, providing evidence that “groundwater quality is potentially being affected by neighboring [drilling and fracking] activity, or other anthropogenic activities, in an episodic fashion.” The authors called for a more extensive investigation of possible groundwater contamination in the Eagle Ford basin.^{168, 169}
- July 11, 2016 – An interdisciplinary team led by University of Colorado researchers found methane in 42 water wells in the intensely drilled Denver-Julesburg Basin where high volume, horizontal fracking operations began in 2010. By examining isotopes and gas molecular ratios, the researchers determined that the gas contaminating these wells was thermogenic in origin, rather than microbial, and therefore had migrated up into the groundwater from underlying oil- and gas-containing shale. The steady rate of well contamination over time—two cases per year from 2001 to 2014—suggests that well failures, rather than the process of hydraulic fracturing itself, was the mechanism that created migration pathways for the stray gas to reach drinking water sources. Of the 42 affected wells, 11 had already been identified by state regulators as suffering from “barrier failures.”¹⁷⁰ Duke University geochemist Avner Vengosh, who was not an author

¹⁶⁶ Wrenn, D. H., Klaiber, H. A., & Jaenicke, E. C. (2016). Unconventional shale gas development, risk perceptions, and averting behavior: evidence from bottled water purchases. *Journal of the Association of Environmental and Resource Economists*, 3(4), 770-817. doi: 10.1086/688487

¹⁶⁷ Yost, E. E., Stanek, J., & Burgoon, L. D. (2016). A decision analysis framework for estimating the potential hazards for drinking water resources of chemicals used in hydraulic fracturing fluids. *Science of the Total Environment*, 574, 1544–1558. doi: 10.1016/j.scitotenv.2016.08.167

¹⁶⁸ Hildenbrand, Z. L., Carlton Jr., D. D., Meik, J. M., Taylor, J. T., Fontenot, B. E., Walton, J. L., ... Schug, K. A. (2016). A reconnaissance analysis of groundwater quality in the Eagle Ford shale region reveals two distinct bromide/chloride populations. *Science of the Total Environment*, 575, 672–680. doi: 10.1016/j.scitotenv.2016.09.070

¹⁶⁹ Hildenbrand, Z. L., Carlton Jr., D. D., Meik, J. M., Taylor, J. T., Fontenot, B. E., Walton, J. L., ... Schug, K. A. (2017). Corrigendum to “A reconnaissance analysis of groundwater quality in the Eagle Ford shale region reveals two distinct bromide/chloride populations.” *Science of the Total Environment*, 603–604, 834-835. doi: 10.1016/j.scitotenv.2017.05.200

¹⁷⁰ Sherwood, O. A., Rogers, J. D., Lackey, G., Burke, T. L., Osborn, S. G. & Ryan, J. N. (2016). Groundwater methane in relation to oil and gas development and shallow coal seams in the Denver-Julesburg Basin of Colorado. *Proceedings of the National Academy of Sciences* 113(30). doi: 10.1073/pnas.1523267113

of the paper, commented on the study in an accompanying article in *InsideClimate News*: “The bottom line here is that industry has denied any stray gas contamination: that whenever we have methane in a well, it is always preexisting. The merit of this is that it’s a different oil and gas basin, a different approach, and it’s saying that stray gas could happen.” In this same article, *InsideClimate News* reported that national standards for well construction do not exist, nor are there laws governing the type of cement that is used to seal the wellbore and prevent leaks.¹⁷¹

- May 24, 2016 – ATSDR conducted a public health evaluation using groundwater data gathered in 2012 by the EPA from 64 private drinking water wells in Dimock, Pennsylvania where natural gas drilling and fracking activities began in 2008 and where residents began reporting problems with their water shortly thereafter. The agency found that water samples collected from 27 Dimock wells contained contaminants “at levels high enough to affect human health.” These included methane, salts, organic chemicals, and arsenic. In 17 wells, levels of methane were high enough to create risk of fire or explosion.¹⁷² Methane levels were not assessed in wells prior to the start of fracking activities in the area. Hence, the study is limited by lack of pre-drilling baseline data, and investigators did not attempt to determine the source of the contaminants. However, in its focus on identifying health impacts, ATSDR’s evaluation is a more comprehensive study than that conducted four years earlier by the EPA and calls into question its earlier, more reassuring conclusions.^{173, 174}
- May 9, 2016 – Sampling downstream of a fracking wastewater disposal facility in West Virginia, a USGS team documented changes in microbial communities and found evidence indicating the presence of fracking waste in water and sediment samples collected from Wolf Creek in West Virginia. Specifically, the researchers documented increased concentrations of barium, bromide, calcium, sodium, lithium, strontium, iron, and radium downstream of the disposal well.¹⁷⁵ In a *Washington Post* story about this study, lead author Denise Akob said that the key take-away message “is really that we’re demonstrating that facilities like this can have an environmental impact.”¹⁷⁶ (This study

¹⁷¹ Banerjee, N. (2016, July 11). Colorado fracking study blames faulty wells for contamination. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/11072016/water-contamination-near-colorado-fracking-tied-well-failures>

¹⁷² U.S. Agency for Toxic Substances and Disease Registry (2016, May 24). *Health Consultation: Dimock Groundwater Site*. Retrieved from http://www.atsdr.cdc.gov/hac/pha/DimockGroundwaterSite/Dimock_Groundwater_Site_HC_05-24-2016_508.pdf

¹⁷³ Lustgarten, A. (2016, June 9). Federal report appears to undercut EPA assurances on water safety in Pennsylvania. *ProPublica*. Retrieved from <https://www.propublica.org/article/federal-report-appears-to-undercut-epa-assurances-water-safety-pennsylvania>

¹⁷⁴ U.S. Environmental Protection Agency. (2012, July 25). *EPA completes drinking water sampling in Dimock, Pa.* [Press release]. Retrieved from <https://yosemite.epa.gov/opa/admpress.nsf/0/1A6E49D193E1007585257A46005B61AD>

¹⁷⁵ Akob, D. M., Mumford, A. C., Orem, W. H., Engle, M. A., Klinges, J. G., Kent, D. B., & Cozzarelli, I. M. (2016). Wastewater disposal from unconventional oil and gas development degrades stream quality at a West Virginia injection facility. *Environmental Science and Technology*, 50(11). doi: 10.1021/acs.est.6b00428

¹⁷⁶ Fears, D. (2016, May 11). This mystery was solved: scientists say chemicals from fracking wastewater can taint fresh water nearby. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/05/11/this-mystery-was-solved-scientists-say-chemicals-from-fracking-wastewater-can-taint-fresh-water-nearby/?utm_term=.c27045b60338

was done in collaboration with Susan Nagel's team, which studied endocrine-disrupting activity in this same stream. See entry below for April 6, 2016.)

- April 30, 2016 – As part of an investigation based on aerial photographs taken by emergency responders during spring 2016 flooding, the *El Paso Times* documented plumes and sheens of chemicals from tipped-over storage tanks and inundated oil wells and fracking sites entering rivers and streams. “Many of the photos shot during Texas’ recent floods show swamped wastewater ponds at fracking sites, presumably allowing wastewater to escape into the environment—and potentially into drinking-water supplies.”¹⁷⁷
- April 27, 2016 – Using geochemical and isotopic tracers to identify the unique chemical fingerprint of Bakken region brines, a Duke University study found that accidental spills of fracking wastewater have contaminated surface water and soils throughout North Dakota where more than 9,700 wells have been drilled in the past decade. Contaminants included salts as well as lead, selenium, and vanadium. In the polluted streams, levels of contaminants often exceeded federal drinking water guidelines. Soils at spill sites showed elevated levels of radium.¹⁷⁸ The study concluded that “inorganic contamination associated with brine spills in North Dakota is remarkably persistent, with elevated levels of contaminants observed in spill sites up to 4 years following the spill events.” In a comment about this study, lead author and Duke University geochemist Avner Vengosh said, “Until now, research in many regions of the nation has shown that contamination from fracking has been fairly sporadic and inconsistent. In North Dakota, however, we find it is widespread and persistent, with clear evidence of direct water contamination from fracking.”¹⁷⁹
- April 6, 2016 – A research team led by Susan Nagel at the University of Missouri traced a spike in endocrine-disrupting activity in a West Virginia stream, Wolf Creek, to an upstream facility that stores fracking wastewater. Levels detected downstream of the waste facility were above levels known to create adverse health effects and alter the development of fish, amphibians, and other aquatic organisms. Endocrine-disrupting compounds were not elevated in upstream sections of the creek.^{180, 181} (See also entry for May 9, 2016 above.)

¹⁷⁷ Schladen, M. (2016, April 30). Flooding sweeps oil, chemicals into rivers. *El Paso Times*. Retrieved from <http://www.elpasotimes.com/story/news/2016/04/30/flooding-sweeps-oil-chemicals-into-rivers/83671348/>

¹⁷⁸ Lauer, N. E., Harkness, J. S., & Vengosh A. (2016). Brine spills associated with unconventional oil development in North Dakota. *Environmental Science & Technology*, 50(10). doi: 10.1021/acs.est.5b06349

¹⁷⁹ Nicholas School of the Environment, Duke University. (2016, April 27). *Contamination in North Dakota linked to fracking spills* [Press release]. Retrieved from <https://nicholas.duke.edu/about/news/ContaminationinNDLinkedtoFrackingSpills>

¹⁸⁰ Kassotis, C. D., Iwanowicz, L. R., Akob, D. M., Cozzarelli, I. M., Mumford, A. C., Orem, W. H., & Nagel, S. C. (2016). Endocrine disrupting activities of surface water associated with West Virginia oil and gas industry wastewater disposal site. *Science of the Total Environment* 557-558. doi: 10.1016/j.sci.tenv.2016.03.113

¹⁸¹ Bienkowski, B. (2016, April 6). In W. Virginia, frack wastewater may be messing with hormones. *Environmental Health News*. Retrieved from <http://www.environmentalhealthnews.org/ehs/news/2016/april/in-w.-virginia-frack-wastewater-may-be-messing-with-hormones>

- March 29, 2016 – A study by Stanford University scientists determined that fracking and related oil and gas operations have indeed contaminated drinking water in the town of Pavillion, Wyoming where residents have long complained about foul-tasting water. The researchers found substances in the water that match those used in local fracking operations or found in nearby pits used for the disposal of drilling waste. Chemical contaminants included benzene, a known carcinogen, and toluene, a neurotoxicant. Possible mechanisms for contamination include defective cement well casings; spills and leaks from disposal pits; and underground migration of chemicals into aquifers from the fracked zone, which, in this area, is quite shallow. Also, in the Pavillion area, operators sometimes fracked directly into underground sources of water.¹⁸² One of the authors of this study, Dominic DiGiulio, was also a lead scientist on the EPA’s earlier aborted investigation of Pavillion’s drinking water. (See entry for December 6, 2015 below.) In an interview about his new research, DiGiulio said that his findings raise concerns about similar water pollution in other heavily fracked regions. “Pavillion isn’t geologically unique in the West, and I’m concerned about the Rocky Mountain region of the U.S. The impact on [underground drinking water sources] could be fairly extensive. Pavillion is like a canary in a coal mine and we need to look at other fields.”¹⁸³ Co-author Rob Jackson noted, “There are no rules that would stop a company from doing this anywhere else.”¹⁸⁴
- February 22, 2016 – Relying on voluntary disclosures reported to the FracFocus registry and a list compiled by the U.S. Congress, a German team surveyed the physiochemical properties of chemicals used in hydraulic fracturing fluid to evaluate their environmental fate and potential toxicity. Common ingredients included those known to contaminate groundwater, such as solvents, as well as those known to react strongly with other chemicals, such as biocides and strong oxidants, indicating that almost certainly, new chemical products are formed during the process of fracking and its aftermath. Hence, non-toxic additives could potentially react with other substances to create harmful byproducts. The authors conclude that a comprehensive assessment of risks would require an unabridged list of the chemical additives used for fracking, and they call for full disclosure.^{185,186}
- February 9, 2016 – An investigation of water contamination in the Barnett Shale by ABC-affiliate station WFAA in Dallas found numerous violations by operators who

¹⁸² DiGiulio, D. C. & Jackson, R. B. (2016). Impact to underground sources of drinking water and domestic wells from production well stimulation and completion practices in the Pavillion, Wyoming, Field. *Environmental Science & Technology*, 50(8). doi: 10.1021/acs.est.5b04970

¹⁸³ Banerjee, N. (2016, March 29). Fracking study finds toxins in Wyoming town’s groundwater and raises broader concerns. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/29032016/fracking-study-pavillion-wyoming-drinking-water-contamination-epa>

¹⁸⁴ Jordan, R. (2016, March 29). Stanford researchers show fracking’s impact to drinking water sources. *Stanford News*. Retrieved from <http://news.stanford.edu/2016/03/29/pavillion-fracking-water-032916/>

¹⁸⁵ Elsner, M. & Hoelzer, K. (2016). Quantitative survey and structural classification of hydraulic fracturing chemicals reported in unconventional gas production. *Environmental Science & Technology*, 50(7). doi:10.1021/acs.est.5b02818

¹⁸⁶ Phys.Org. (9 March 2016). How to get a handle on potential risks posed by fracking fluids. Retrieved from <http://phys.org/news/2016-03-potential-posed-fracking-fluids.html>

ignored regulations that require sealing vertical well pipes with a cement sheath to protect groundwater from stray gas and other vapors that might escape and migrate upwards into overlying aquifers. The WFAA report said that the Texas Railroad Commission, which oversees drilling and fracking operations in Texas, has failed to respond to alleged violations of a rule that requires cement seals around steel well casings in geological zones where drilling has penetrated layers of rock containing oil and gas deposits.¹⁸⁷

- February 8, 2016 – An investigation by the *Columbus Dispatch* revealed that the amount of water that operators use for hydraulic fracturing in Ohio gas wells increased steadily from 2011 to 2015. The total amount of water increased, as did the volume of water used per well—from an average of 5.6 million gallons per well in 2011 to 7.6 million in 2014. The reason is that the horizontally drilled holes beneath each well have become longer, and these require more water during the fracking process.¹⁸⁸
- February 2016 – In a lengthy account to Congress on the status of the underground waste injection well program that is overseen by the EPA, the U.S. Government Accountability Office (GAO) reported that the agency “has not consistently conducted oversight activities necessary to assess whether state and EPA-managed programs are protecting underground sources of drinking water” from contamination by fracking waste. Specifically, the GAO took the EPA to task for failure to require well-specific inspections, collect data on enforcement actions, review permitting requirements by state regulatory agencies, or analyze the resources the agency would need to do all the above to adequately oversee the Underground Injection Control program. The GAO noted that it had once before, in 2014, previously found the EPA negligent in its responsibilities to monitor drinking water sources for possible contamination with fracking waste.¹⁸⁹ (See entry below for September 23, 2014.)
- January 6, 2016 – Yale School of Public Health researchers analyzed more than 1,021 chemicals either used in fracking fluid or created during the process of hydraulic fracturing. They found that 781 of these chemicals lacked basic toxicity data. Of the 240 that remained, 157 were reproductive or developmental toxicants. These included arsenic, benzene, cadmium, formaldehyde, lead, and mercury.¹⁹⁰ Commenting on this study, lead author Nicole Deziel said, “This evaluation is a first step to prioritize the vast array of potential environmental contaminants from hydraulic fracturing for future exposure and health studies. Quantification of the potential exposure to these chemicals, such as by

¹⁸⁷ Shipp, B. (2016, February 9). Drilling records suggest lax state enforcement. WFAA, Dallas. Retrieved from <http://www.wfaa.com/mb/news/local/investigates/rules-ignored-water-fouled-in-barnett-shale/38337835>

¹⁸⁸ Arenschiold, L. (2016, February 8). Drillers using more water to frack Ohio shale. *The Columbus Dispatch*. Retrieved from <http://www.dispatch.com/content/stories/local/2016/02/07/drillers-using-more-water-to-frack-ohio-shale.html>

¹⁸⁹ U.S. Government Accountability Office. (2016, February). *Drinking Water: EPA Needs to Collect Information and Consistently Conduct Activities to Protect Underground Sources of Drinking Water*. GAO-16-281. Retrieved from <http://gao.gov/assets/680/675439.pdf>

¹⁹⁰ Elliot, E. G., Ettinger, A. S., Leaderer, B. P., Bracken, M. B., Deziel, N. (2016). A systematic evaluation of chemicals in hydraulic-fracturing fluids and wastewater for reproductive and developmental toxicity. Advance online publication. *Journal of Exposure Science & Environmental Epidemiology*. doi: 10.1038/jes.2015.81

monitoring drinking water in people's homes, is vital for understanding the public health impact of hydraulic fracturing."¹⁹¹

- December 15, 2015 – A research team led by geologist Mukul Sharma from Dartmouth College discovered that chemical reactions between fracking fluid and rock can contribute to the toxicity of fracking wastewater. Specifically, the researchers found that fracking fluid can chemically react with the fractured shale in ways that cause barium, a toxic metal, to leach from clay minerals in the Marcellus Shale.^{192, 193}
- December 6, 2015 – The *Caspar Star Tribune* investigated the EPA's decision to transfer its study of possible fracking-related drinking water contamination in Pavillion, Wyoming to a state agency in 2013. Preliminary data from the EPA suggested that drilling and fracking operations had contaminated drinking water supplies. To date, the state study has found no definitive link between drilling and water contamination. Interviews with officials and documents obtained under the Freedom of Information Act revealed that the EPA had bowed to political pressure from state officials and industry representatives and that Wyoming regulators narrowed the scope of the study considerably and conducted little fieldwork.¹⁹⁴ (See also entry above for March 29, 2016.)
- November 19, 2015 – The Science Advisory Board (SAB) for the EPA reviewed the EPA's June 2015 draft assessment of fracking's impacts on drinking water, and challenged some of the summary statements that accompanied it, saying that they were over-generalized and not always aligned with the data in the report itself. Specifically, the SAB said, in a draft review, that the data cited by the report were too limited to support the headlined claim in the executive summary that drinking water impacts were neither "widespread" nor "systemic." The SAB also critiqued the study for downplaying local impacts in its conclusions, noting that these impacts can sometimes be severe.¹⁹⁵
- October 19, 2015 – A six-month investigation by *Penn Live* found long-standing "systemic failures" on the part of the Pennsylvania Department of Environmental Protection (PA DEP) to enforce regulations governing drilling and fracking operations. Lack of oversight and reliance on industry self-policing have been the hallmarks of Marcellus Shale development for the past ten years, in violation of Pennsylvanians'

¹⁹¹ Greenwood, M. (2016, January 6). Toxins found in fracturing fluid and wastewater, study shows. *Yale News*. Retrieved from: <http://news.yale.edu/2016/01/06/toxins-found-fracking-fluids-and-wastewater-study-shows>

¹⁹² Renock, D., Landis, J. D., & Sharma, M. (2016). Reductive weathering of black shale and release of barium during hydraulic fracturing. *Applied Geochemistry*, 65. doi: 10.1016/j.apgeochem.2015.11.001

¹⁹³ Dartmouth College. (15 December 2015). Fracking plays active role in generating toxic metal wastewater, study finds. *Science Daily*. Retrieved from <https://www.sciencedaily.com/releases/2015/12/151215134653.htm>

¹⁹⁴ Storrow, B. (2015, December 6). Pavillion today an EPA in retreat, a narrow state inquiry and no answers. *Caspar Star Tribune*. Retrieved from http://trib.com/business/energy/pavillion-today-an-epa-in-retreat-a-narrow-state-inquiry/article_403f84de-830c-5558-9f3f-ea48fd48d7ca.html?utm_medium=social&utm_source=facebook&utm_campaign=user-share

¹⁹⁵ Banerjee, N. (2015, November 19). EPA finding on fracking's water pollution disputed by its own scientists. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/19112015/fracking-water-pollution-epa-study-natural-gas-drilling>

constitutional right to clean air and water. Among the findings of this investigation: chronically leaking wastewater impoundments for which no fines or notices were issued to the operator; laboratory coding systems designed to obscure possible detections of certain chemical contaminants in residents' drinking water; and lack of inspections at well sites.¹⁹⁶

- October 13, 2015 – An international team of researchers found detectable levels of multiple organic chemical contaminants in private drinking water wells in northeastern Pennsylvania where fracking is practiced. One of the compounds was a known additive of fracking fluid. Chemical fingerprinting and noble gas isotopes were used to determine if the contaminants most likely originated from surface spills at the well site or via upward transport from the shale itself. The organic pollutants found in the water did not contain chemical markers—certain elements and salts—that would indicate migration from deep geological strata. The authors concluded that “the data support a transport mechanism...to groundwater via accidental release of fracturing fluid chemicals derived from the surface rather than subsurface flow of these fluids from the underlying shale formation.”^{197, 198}
- September 23, 2015 – A team of researchers, examining how natural gas drilling and fracking operations across the nation affect creeks, streams and rivers, developed a predictive model and vulnerability index for surface water. They found that “all shale plays, regardless of location, had a suite of catchments that spanned highly degraded to those that are less altered and naturally sensitive to alteration.” Surface water in Pennsylvania’s Marcellus Shale region is classified by this model as vulnerable to fracking-related impacts because of steep slopes and loose, erodible soils within the watersheds.¹⁹⁹
- July 30, 2015 – As reported by the *Los Angeles Times*, unlined waste pits and hillside spraying of oil-field wastewater have contaminated groundwater in Kern County, California. Five of six monitoring wells in the 94-acre waste site showed high levels of salt, boron, and chloride, but it is not known how far and fast the contaminated plume has traveled.²⁰⁰

¹⁹⁶ Woodwell, C. (2016, October 19). Pa. regulators fail to protect environment during Marcellus Shale boom. *Penn Live*. Retrieved from http://www.pennlive.com/midstate/index.ssf/2015/10/state_regulators_fail_to_prote.html

¹⁹⁷ Drollette, B. D., Hoelzer, K., Warner, N. R., Darrah, T. H., Karatum, O., O’Connor, M. P. ... Plata, D. L. (2015). Elevated levels of diesel range organic compounds in groundwater near Marcellus gas operations are derived from surface activities. *Proceedings of the National Academy of Sciences*, 112(43). doi: 10.1073/pnas.1511474112

¹⁹⁸ Drollette B. D. & Plata, D. A. (2015, October 13). Hydraulic fracturing components in Marcellus groundwater likely from surface operations, not wells. *Phys.Org*. Retrieved from <http://phys.org/news/2015-10-hydraulic-fracturing-components-marcellus-groundwater.html>

¹⁹⁹ Entrekin, S. A., Maloney, K. O., Kapo, K. E., Walters, A. W., Evan-White, M. A., & Klemow, K. M. (2015). Stream vulnerability to widespread and emergent stressors: a focus on unconventional oil and gas. *PLoS One*, 10(9). doi:10.1371/journal.pone.0137416

²⁰⁰ Cart, J. (2015, July 30). Central valley wastewater disposal to continue despite contamination. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/california/la-me-oil-waste-pits-20150731-story.html>

- July 21, 2015 – By surveying records for 44,000 wells fracked between 2010 and 2013, researchers from Stanford University, Duke University, and Ohio State University attempted a first-ever assessment of the range of depths at which fracking occurs across the United States. They found that many wells are shallower than widely presumed.²⁰¹ As the authors noted, vertical fractures are able to propagate 2,000 feet upward, and hence, “shallow hydraulic fracturing often has greater potential risks of contamination than deeper hydraulic fracturing does.” This study showed that drinking water sources may be more vulnerable from upward migration of fracking contaminants than previously presumed. Surprisingly, the researchers found no strong relationship between depth and the volume of water and chemicals used for fracking. Many wells were both shallow and water-intensive, with significant variation in water use from state to state.²⁰²
- July 9, 2015 – A multi-volume report from the California Council of Science and Technology (CCST) found threats to groundwater in California from several parts of the fracking lifecycle, most notably from toxic wastewater. First, wastewater from California fracking operations is sometimes used for crop irrigation, in which case contaminants may seep from the surface of agricultural areas into groundwater. Second, nearly 60 percent of fracking wastewater in California is disposed of in unlined, open-air pits, a practice that is banned in almost all other states. There are 900 such waste disposal pits in the state, most of which are located in Kern County. Third, for many years, fracking wastewater in California has been mistakenly sent, via injection wells, directly into protected aquifers containing clean freshwater.²⁰³ California’s Division of Oil, Gas and Geothermal Resources allowed fracking wastes to be injected into aquifers that it believed were exempt from the U.S. Safe Drinking Water Act. Conceding this mistake, the agency has shut down 23 injection wells for fracking waste disposal and established a two-year timetable for phasing out other wells injecting waste into aquifers that should have been protected.²⁰⁴ Fracking also threatens California’s groundwater resources through water consumption, according to the CCST study. While this volume of water represents a small percentage of overall annual water consumption in California, fracking-related water use is, the study noted, disproportionately concentrated in areas of the state already suffering from water shortages. Further drawdowns of these aquifers may interfere with agricultural and municipal water needs.²⁰⁵ In addition, because the oil-

²⁰¹ Jordon, R. (2015, July 21). *Shallow fracking raises questions for water, new Stanford research shows*. [Press release]. Retrieved from http://news.stanford.edu/news/2015/july/fracking_water-jackson-072115.html

²⁰² Jackson, R. B., Lowry, E. R., Pickle, A., Kang, M., DiGiullo, D., & Zhao, K. (2015). The depths of hydraulic fracturing and accompanying water use across the United States. *Environmental Science & Technology*, 49(15), 8969–8976. doi: 10.1021/acs.est.5b01228

²⁰³ Shonkoff, S. B. C., Jordan, P., Hays, J., Stringfellow, W. T., Wettstein, Z. S., Harrison, R., Sandelin, W., & McKone, T. E. (2015, July 9). Volume II, Chapter 6: Potential impacts of well stimulation on human health in California. In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from <http://ccst.us/publications/2015/vol-II-chapter-6.pdf>

²⁰⁴ Baker, D. R. (2015, July 16). U.S. likely to bar oil-waste dumping into 10 California aquifers. *San Francisco Chronicle*. Retrieved from <http://www.sfchronicle.com/business/article/U-S-likely-to-bar-oil-waste-dumping-into-10-6389677.php>

²⁰⁵ Stringfellow, W. T., Cooley H., Varadharajan, C., Heberger, M., Reagan, M. T., Domen, J.K., . . . Houseworth, J. E. (2015, July 9). Volume II, Chapter 2: Impacts of well stimulation on water resources. In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from <http://ccst.us/publications/2015/vol-II-chapter-2.pdf>

containing rock layers in California are located closer to the surface than in other states, the state's groundwater is potentially vulnerable to chemical contamination through vertical faults and fissures and via old and abandoned wells. The absence of evidence for direct contamination of groundwater by fracking, the study concluded, reflects absence of investigation rather than evidence of safety.²⁰⁶

- June 30, 2015 – The USGS released the first nationwide map of water usage for hydraulic fracturing. It shows wide geographic and temporal variation in the amount of water used to frack a single well. In general, gas wells consume more water per well (5.1 million gallons on average) than oil wells (4 million gallons). Median annual water volumes needed to frack a single horizontal oil or gas well increased dramatically—by a factor of 25 or more—between 2000 and 2014. A typical gas or oil well that is horizontally fracked now requires between six and eight Olympic-sized swimming pools of water. In 2014, the majority (58 percent) of new hydraulically fracked oil and gas wells were horizontally drilled. The watersheds where the most water was consumed for hydraulic fracturing are mostly located in southern or southwestern states and correspond to the following shale formations: the Eagle Ford and Barnett Shales in Texas; the Haynesville-Bossier Shale in Texas and Louisiana; the Fayetteville Shale in Arkansas; the Tuscaloosa Shale in Louisiana and Mississippi; and the Woodford Shale in Oklahoma. The Marcellus and Utica Shales—which underlie watersheds in parts of Ohio, Pennsylvania, West Virginia, and New York—were also in the top seven water-consuming shale plays in the United States.²⁰⁷
- June 26, 2015 – A decade-long USGS study of 11,000 public drinking water wells in California—nearly all the groundwater used for public supply—found high levels of potentially toxic contaminants in about 20 percent of the wells, affecting about 18 percent of the state's population.²⁰⁸ Although the study did not specifically investigate contaminants from oil and gas extraction, it does provide evidence for farm irrigation draining into groundwater, raising questions about the possible contamination of drinking water aquifers from the reuse of fracking wastewater for crop irrigation.²⁰⁹
- June 16, 2015 – A University of Texas research team documented widespread drinking water contamination throughout the heavily drilled Barnett Shale region in northern Texas. The study, which analyzed 550 water samples from public and private water wells, found elevated levels of 19 different hydrocarbon compounds associated with fracking (including the carcinogen benzene and the reproductive toxicant, toluene),

²⁰⁶ Long, J. C. S., Birkholzer, J. T., & Feinstein, L. C. (2015, July 9). Summary report. In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from: <http://ccst.us/publications/2015/2015SB4summary.pdf>

²⁰⁷ Gallegos, T. J., Varela, B. A., Haines, S. S., & Engle, M. A. (2015). Hydraulic fracturing water use variability in the United States and potential environmental implications. *Water Resources Research*. Accepted author manuscript. doi: 10.1002/2015WR017278

²⁰⁸ Belitz, K., Fram, M. S., & Johnson, T. D. (2015). Metrics for assessing the quality of groundwater used for public supply, CA, USA: equivalent-population and area. *Environmental Science & Technology*, 9(14), 8330–8338. doi: 10.1021/acs.est.5b00265

²⁰⁹ Knickmeyer E., & Smith, S. (2015, July 15). Study finds contaminants in California public-water supplies. *Associated Press*. Retrieved from <http://abcnews.go.com/Health/wireStory/study-finds-contaminants-california-public-water-supplies-32476456>

detections of methanol and ethanol, and strikingly high levels of 10 different metals.²¹⁰ “In the abstract, we can’t state that unconventional oil and gas techniques are responsible,” the lead author, Zachariah Hildenbrand, said in a media interview. “But when you get into areas where drilling is happening, you find more instances of contamination. It’s not coincidental. There are causes for concern.”²¹¹

- June 5, 2015 – The EPA’s long-awaited 600-page draft report on the potential impacts of fracking for drinking water resources confirmed specific instances of drinking water contamination linked to drilling and fracking activities. The report also identified potential mechanisms, both above and below ground, by which drinking water resources can be contaminated by fracking. In some cases, drinking water was contaminated by spills of fracking fluid and wastewater. In other cases, “[b]elow ground movement of fluids, including gas . . . have contaminated drinking water resources.” The EPA investigators documented 457 fracking-related spills over six years but acknowledged that they do not know how many more may have occurred. Of the total known spills, 300 reached an environmental receptor such as surface water or groundwater. The EPA also conceded that insufficient baseline drinking water data and a lack of long-term systematic studies limited the power of its findings. The EPA investigation confirmed a number of specific instances where these potential mechanisms did indeed lead to drinking water contamination. An assertion in the EPA’s accompanying press release that it had not found “widespread, systemic impacts to drinking water resources” was quoted out of context by many media sources as proof that fracking poses little threat to drinking water. To the contrary, this report confirmed that drilling and fracking activities have contaminated drinking water in some cases and acknowledged that it cannot ascertain how widespread the problem was due to insufficient data.²¹² EPA Science Advisor Thomas A. Burke later clarified that the report does not show that fracking is safe. Burke said, “That is not the message of this report. The message of this report is that we have identified vulnerabilities in the water system that are really important to know about and address to keep risks as low as possible.”²¹³
- May 19, 2015 – A Pennsylvania State University research team documented the presence of a fracking-related solvent, 2-n-Butoxyethanol, in the drinking water from three homes in Bradford County, Pennsylvania, as part of an investigation of private drinking water wells near drilling and fracking operations that contained methane and foam. This finding represents the first fully documented case of a commonly used fracking chemical entering a drinking water source. “The most likely explanation of the incident is that stray natural gas and drilling or [hydrofracking] compounds were driven ~1-3 km along shallow to

²¹⁰ Hildenbrand, Z. L., Carlton, D. D., Fontenot, B. E., Meik, J. M., Walton, J.L., Taylor, J. T., . . . Schug, K.A. (2015) A comprehensive analysis of groundwater quality in the Barnett Shale region. *Environmental Science & Technology*, 49(13), 8254-8262. doi: 10.1021/acs.est.5b01526

²¹¹ McPhate, C. (2015, June 18). New study reveals potential contamination. *Denton Record-Chronicle*. Retrieved from <http://www.dentonrc.com/local-news/local-news-headlines/20150618-new-study-reveals-potential-contamination.ece>

²¹² U.S. EPA. (2015). *Assessment of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources* (External review draft). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/047, 2015. Retrieved from <http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651>

²¹³ Ward Jr., K. (2015, June 7). EPA says new study doesn’t show fracking is safe. *Charleston Gazette*. Retrieved from <http://www.wvgazette.com/article/20150607/GZ01/150609432>

intermediate depth fractures to the aquifer used as a potable water source.”²¹⁴ In an accompanying *New York Times* story, lead author Susan Brantley described the geology in northern Pennsylvania “as being similar to a layer cake with numerous layers that extend down thousands of feet to the Marcellus Shale. The vertical fractures are like knife cuts through the layers. They can extend deep underground, and can act like superhighways for escaped gas and liquids from drill wells to travel along, for distances greater than a mile away.”²¹⁵

- May 15, 2015 – A research team from the University of Colorado Boulder and California State Polytechnic Institute developed a model for identifying which fracking fluid chemicals are most likely to contaminate drinking water. Of 996 fracking fluid compounds known to be in use, researchers screened 659 of them for their ability to persist, migrate, and reach groundwater aquifers over a short time scale. Of the fifteen compounds so identified, two were commonly used in fracking operations: naphthalene and 2-butoxyethanol. Both are ingredients in surfactants and corrosion inhibitors. The authors noted that 2-butoxyethanol has been detected in drinking water in a heavily fracked area of Pennsylvania. Exposure to 2-butoxyethanol has been linked to birth defects in animals. Naphthalene is a possible human carcinogen that is toxic to red blood cells and contributes to kidney and liver damage. Researchers did not consider the impact of mixtures, interactions between contaminants, or chemical transformations during the fracking or flowback process and noted, “the need for data on the degradation of many compounds used in fracturing fluids under conditions relevant for groundwater transport.”²¹⁶
- May 7, 2015 – A survey of streams in Arkansas, led by the University of Central Arkansas, found alterations in macroinvertebrate communities to be related to drilling and fracking operations in the Fayetteville Shale. Fracking activity near streams was associated with greater sediment and more chlorophyll. “This study suggests that land disturbance from gas development affected stream communities.”²¹⁷
- April 20, 2015 – A USGS team analyzed water brought to the surface during natural gas extraction at 13 fracked wells in northern Pennsylvania. They found large variability in the VOCs and microorganisms in the water samples from different wells. Organic chemical contaminants included benzene, toluene, and perchloroethylene, chloroform, and methylene chloride. The presence of microbes was associated with concentrations of

²¹⁴ Llewellyn, G. T., Dorman, F., Westland, J. L., Yoxtheimer, D., Grieve, P. Sowers, T., . . . Brantley, S. L. (2015). Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development. *Proceedings of the National Academies of Science*, 112, 6325-30. doi: 10.1073/pnas.1420279112/-/DCSupplemental

²¹⁵ St. Fleur, N. (2015, May 4). Fracking chemicals detected in Pennsylvania drinking water. *The New York Times*. Retrieved from http://www.nytimes.com/2015/05/05/science/earth/fracking-chemicals-detected-in-pennsylvania-drinking-water.html?_r=0#addendums

²¹⁶ Rogers, J. D., Burke, T. L., Osborn, S. G., & Ryan, J. N. (2015). A framework for identifying organic compounds of concern in hydraulic fracturing fluids based on their mobility and persistence in groundwater. *Environmental Science & Technology Letters*, 2, 158-64.

²¹⁷ Johnson, E., Austin, B. J., Inlander, E., Gallipeau, C., Evans-White, M. A., & Entekin, S. (2015). Stream macroinvertebrate communities across a gradient of natural gas development in the Fayetteville Shale. *Science of the Total Environment*, 530-531, 323-32. doi: 10.1016/j.scitotenv.2015.05.027

benzene and acetate. Despite the addition of biocides during the fracking process, hydrogen sulfide-producing bacteria were present at culturable levels, along with methanogenic and fermenting bacteria. The source of these microorganisms was not determined. “Therefore, we cannot exclude the possibility that these microorganisms are native to the shale formation and reactivated by [hydrofracking] activities, as their physiology does not indicate a terrestrial surficial source.”²¹⁸

- April 8, 2015 – A University of Colorado Boulder research team’s analysis of the organic chemicals found in liquid waste that flowed out of gas wells in Colorado after they had been fracked revealed the presence of many fracking fluid additives, including biocides, which are potentially harmful if they leak into groundwater. According to the authors, treatment of fracking wastewater must include aeration, precipitation, disinfection, a biological treatment to remove dissolved organic matter, and reverse osmosis desalination in order for it to be appropriate for non-fracking uses, such as crop irrigation.²¹⁹
- March 18, 2015 – Using a new stream-based monitoring method, a team of scientists with USGS, Pennsylvania State University, and University of Utah found elevated levels of methane in groundwater discharging into a stream near drilling and fracking operations in Pennsylvania. In this same area, several private water wells contained high levels of methane as a result of gas migration near a gas well with a defective casing. The monitoring technique used by the scientists allowed them to demonstrate that the source of the methane was shale gas from the Middle Devonian period, which is the kind of gas found in the Marcellus Shale.²²⁰ Researcher Susan Brantley said, “I found it compelling that using this new method for a reconnaissance of just 15 streams in Pennsylvania, we discovered one instance of natural gas entering the stream, perhaps from a nearby leaking shale gas well.”²²¹
- March 12, 2015 – A team led by geologist Donald Siegel of Syracuse University found no relationship between methane levels in drinking water wells and proximity to oil or gas wells in a heavily fracked area of northeastern Pennsylvania.²²² However, Siegel

²¹⁸ Akob, D. M., Cozzarelli, I. M., Dunlap, D. S., Rowan, E. L., & Lorah, M. M. (2015). Organic and inorganic composition and microbiology of produced waters from Pennsylvania shale gas wells. *Applied Geochemistry*, in press, corrected proofs online April 20. doi: 10.1016/j.apgeochem.2015.04.011

²¹⁹ Lester, Y., Ferrer, I., Thurman, E. M., Sitterley, K. A., Korak, J. A., Aiken, G., & Linden, K. G. (2015). Characterization of hydraulic fracturing flowback water in Colorado: Implications for water treatment. *Science of the Total Environment*, 512-513, 637-644. doi: 10.1016/j.scitotenv.2015.01.043

²²⁰ Heilweil, V. M., Grieve, P. L., Hynek, S. A., Brantley, S. L., Solomon, D. K., & Risser, D. W. (2015). Stream measurements locate thermogenic methane fluxes in groundwater discharge in an area of shale-gas development. *Environmental Science & Technology*, 49, 4057-4065. doi: 10.1021/es503882b

²²¹ U.S. Geological Survey. (2015, April 1). New stream monitoring method locates elevated groundwater methane in shale-gas development area. Retrieved from

http://www.usgs.gov/newsroom/article.asp?ID=4176&from=rss&utm_source=dlvr.it&utm_medium=facebookhttp://www.readcube.com/articles/10.1002%2F2014WR016382?r3_referer=wol&tracking_action=preview_click&show_checkout=1&purchase_site_license=LICENSE_DENIED_NO_CUSTOMER#.VaPKNYsqdyA

²²² Siegel, D. I., Azzolina, N. A., Smith, B. J., Perry, A. E., & Bothun, R. L. (2015). Methane concentrations in water wells unrelated to proximity to existing oil and gas wells in northeastern Pennsylvania. *Environmental Science & Technology*, 49, 4106-12. doi: 10.1021/es505775c

failed to reveal in his paper — as is required by the journal — that he had received industry funding from the Chesapeake Energy Corporation. Subsequently, the journal published a lengthy correction that revealed that Chesapeake had not only privately funded the lead author but had provided the baseline groundwater data set. A second author was revealed to be a former employee of Chesapeake, and another had worked as a consultant in the energy sector.²²³

- March 3, 2015 – A Duquesne University study of private drinking water wells in an intensely drilled southwestern Pennsylvania community compared pre-drill and post-drill data on water quality and found changes in water chemistry that coincided with the advent of drilling and fracking activities. Levels of chloride, iron, barium, strontium, and manganese were elevated. In some cases, concentrations exceeded health-based maximum contaminant levels. Methane was detected in most houses tested. Surveys of residents revealed widespread complaints about changes in water quality that began after drilling and fracking operations commenced. Violation records from the PA DEP uncovered possible pathways for water contamination. The researchers concluded that alterations of local hydrology caused by the injection of large volumes of hydraulic fracturing fluids may have mobilized contaminants left over from legacy oil, gas, and mining operations as well as opened pathways for the migration of fracking fluids themselves.²²⁴
- March 3, 2015 – A research team from Duquesne University reviewed the evidence for environmental impacts to air and water from activities related to shale gas extraction in Pennsylvania and explored potential mechanisms for contamination of air and water related to the drilling and fracking process itself. Among them: deformations of the shale bedrock caused by the injection of large volumes of fluid result in “pressure bulbs” that are translated through rock layers and can impact faults and fissures, so affecting groundwater.²²⁵
- February 23, 2015 – The arrival of drilling and fracking activities coincided with an increase in salinity in a creek that drains public land in a semi-arid region of Wyoming, determined a USGS study. The dissolved minerals associated with the rise in salinity matched those found in native soil salts, suggesting that disturbance of naturally salt-rich soils by ongoing oil and gas activities, including pipeline, road, and well pad construction, was the culprit. “As [shale gas and oil] development continues to expand in semiarid lands worldwide, the potential for soil disturbance to increase stream salinity should be considered, particularly where soils host substantial quantities of native

²²³ Siegel, D. I., Azzolina, N. A., Smith, B. J., Perry, A. E., & Bothun, R. L. (2015). Correction to Methane concentrations in water wells unrelated to proximity to existing oil and gas wells in northeastern Pennsylvania. *Environmental Science & Technology*, 49, 4106-12. doi: 10.1021/es505775c

²²⁴ Alawattegama, S. K., Kondratyuk, T., Krynock, R., Bricker, M., Rutter, J. K., Bain, D. J., & Stolz, J. F. (2015). Well water contamination in a rural community in southwestern Pennsylvania near unconventional shale gas extraction. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, 50, 516-528. doi: 10.1080/10934529.2015.992684

²²⁵ Lampe, D. J., & Stolz, J. F. (2015). Current perspectives on unconventional shale gas extraction in the Appalachian Basin. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, 50(5), 434-446. doi: 10.1080/10934529.2015.992653

salts.”²²⁶

- February 14, 2015 – A review by a *Dickinson Press* news reporter of disposal well files and more than 2,090 mechanical integrity tests revealed that North Dakota frack waste injection wells were often leaky and that state regulators continued to allow fluid injection into wells with documented structural problems even though the wells did not meet EPA guidelines for well bore integrity. Officials with the North Dakota Division of Oil and Gas said they had primary enforcement responsibilities and that EPA guidance did not apply to these wells. The investigation noted, “... a review of state and federal documents, as well as interviews with geologists, engineers, environmental policy experts and lawyers who have litigated under the Safe Drinking Water Act, suggests the agency is loosely interpreting guidance and protocols that are meant to maintain the multiple layers of protection that separate aquifers from the toxic saltwater.” *The Dickinson Press* is the daily newspaper for Stark County in southwest North Dakota.²²⁷
- February 11, 2015 – The *Los Angeles Times* analyzed self-reported testing results on fracking wastewater that California drillers were required to submit to the state. Samples of wastewater collected from 329 fracked oil wells found that virtually all—98 percent—contained benzene at levels that exceeded standards for permissible concentrations in drinking water. This finding likely underrepresents the extent of the problem, according to the newspaper investigation, because many operators failed to comply with reporting requirements. The discovery that fracking wastewater is high in benzene is particularly alarming in light of the admission by the state of California that it had inadvertently allowed frack waste disposal directly into aquifers containing clean water that could potentially be used for drinking. Those wells are now the subject of federal and state review.²²⁸
- February 1, 2015 – An investigation of the chemical make-up of fracking fluid found that the compositions of these mixtures vary widely according to region and company, making the process of identifying individual compounds difficult. Classes of hydrocarbon-based chemicals include solvents, gels, biocides, scale inhibitors, friction reducers, and surfactants. Chemical analysis identified around 25 percent of the organic compounds that are believed to be present in fracking fluid and that are necessary to test for in identifying groundwater and drinking water contamination.²²⁹ Dr. Imma Ferrer, lead author, explained in a *Science Daily* article about her research that “[b]efore we can

²²⁶ Bern, C. R., Clark, M. L., Schmidt, T. S., Nolloway, J. M., & McDougal, R. R. (2015). Soil disturbance as a driver of increased stream salinity in a semiarid watershed undergoing energy development. *Journal of Hydrology*, 524, 123-136. doi: doi.org/10.1016/j.jhydrol.2015.02.020

²²⁷ Brown, A. (2015, February 14). Lacking integrity? State regulatory officials don't follow EPA guidance on saltwater disposal wells. *The Dickinson Press*. Retrieved from <http://www.thedickinsonpress.com/energy/bakken/3679507-lacking-integrity-state-regulatory-officials-dont-follow-epa-guidance>

²²⁸ Cart. J. (2015, February 11). High levels of benzene found in fracking waste water. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/california/la-me-fracking-20150211-story.html#page=1>

²²⁹ Ferrer, I. & Thurman, E.M. (2015), Chemical constituents and analytical approaches for hydraulic fracturing waters. *Trends in Environmental Analytical Chemistry*, 5, 18-25, doi: 10.1016/j.teac.2015.01.003

assess the environmental impact of the fluid, we have to know what to look for.”²³⁰

- January 30, 2015 – A USGS review of national water quality databases found that insufficient data exist to understand the impact of fracking on drinking water.²³¹ In a media interview, lead author Zack Bowen said, “There are not enough data available to be able to assess the potential effects of oil and gas development over larger geographic areas.”²³²
- January 21, 2015 – A team of researchers from the USGS and Virginia Tech University established that petroleum-based hydrocarbons can break down underground in ways that promote the leaching of naturally occurring arsenic into groundwater. Arsenic is a known human carcinogen that causes bladder, lung, and skin cancer. Elevated levels of arsenic in drinking water represent a public health threat.²³³ Researchers found that arsenic concentrations in a hydrocarbon plume can reach 23 times the current drinking water standard of 10 micrograms per liter. The authors of the study said that the metabolism of carbon-rich petroleum products by subterranean microbes is involved in a complex geochemical process that leads to mobilization of arsenic into aquifers.²³⁴
- January 14, 2015 – Researchers from Duke University, Dartmouth College, and Stanford University found high levels of iodide, bromide, and ammonium in samples of wastewater from fracking operations in both the Marcellus and Fayetteville Shales. These same chemicals were present when fracking wastewater was discharged into rivers and streams at three treatment sites in Pennsylvania and during an accidental spill in West Virginia. Iodide and bromide are known to create toxic disinfection byproducts when downstream water is subsequently chlorinated for drinking water. In water, ammonium can convert to ammonia, which is toxic to aquatic life. The authors noted that this is the first study to identify ammonium and iodide as widespread in fracking waste discharges.²³⁵ In an interview with the *Pittsburgh Post-Gazette*, lead author Avner Vengosh said that the findings raise new concerns about the environmental and health

²³⁰ Elsevier. (2015 April 8). Fracking fluids contain potentially harmful compounds if leaked into groundwater. *ScienceDaily*. Retrieved from

http://www.sciencedaily.com/releases/2015/04/150408090323.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Fearth+climate%2Frecycling+and+waste+%28Recycling+and+Waste+News+-+

²³¹ Bowen, Z. H., Oeisner, G. P., Cade, B., Gallegos, T. J., Farag, A. M., Mott, D. N., . . . Varela, B. A. (2015). Assessment of surface water chloride and conductivity trends in areas of unconventional oil and gas development—why existing national data sets cannot tell us what we would like to know. *Water Resources Research*, 51, 704-15. doi: 10.1002/2014WR016382

²³² Phillips, S. (2015, March 3). USGS: fracking water quality data “scarce.” *StateImpact Pennsylvania*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2015/03/03/usgs-fracking-water-quality-data-scarce/>

²³³ U.S. Geological Survey (2015, January. 26). Natural breakdown of petroleum underground can lace arsenic into groundwater. Retrieved from http://www.usgs.gov/newsroom/article.asp?ID=4110&from=rss&utm_source=dlvr.it&utm_medium=facebook#.VavGXIsqdyA

²³⁴ Cozzarelli, I. M. Schreiber, M. D., Erickson, M. L., & Ziegler, B. A. (2015). Arsenic cycling in hydrocarbon plumes: secondary effects of natural attenuation. *Groundwater*. doi: 10.1111/gwat.12316

²³⁵ Harkness, J. S., Dwyer, G. S., Warner, N. R., Parker, K. M., Mitch, W. A., & Vengosh, A. (2015). Iodide, bromide, and ammonium in hydraulic fracturing and oil and gas wastewaters: environmental implications. *Environmental Science & Technology*, 49, 1955-63. doi: 10.1021/es504654n

impacts of wastewater from drilling and fracking operations.²³⁶

- November 27, 2014 – An interdisciplinary team of researchers found methane contamination in drinking water wells located in eight areas above the Marcellus Shale in Pennsylvania and the Barnett Shale in Texas, with evidence of declining water quality in the Barnett Shale area. By analyzing noble gases and their isotopes (helium, neon, argon), the investigators were able to isolate the origin of the fugitive methane in drinking water. The results implicate leaks through cement well casings as well as via naturally occurring cracks and fissures in the surrounding rock.²³⁷ In a related editorial, one of the study’s authors, Robert Jackson, called on the EPA to reopen its aborted investigation into drinking water contamination in heavily fracked areas of Texas. Jackson also emphasized that methane migration through unseen cracks in the rock surrounding the wellbore “raises the interesting possibility that a drilling company could follow procedures — cementing and casing below the local aquifer — and still create a potential pathway for gas to migrate into drinking water.”²³⁸
- November 26, 2014 – A critical review of biocides in fracking fluid by a Colorado State team found that the fate of these chemicals underground is not known and their toxicity not well understood. While many biocides are short-lived, some may transform into more toxic or persistent compounds. Among the most common chemical components of fracking fluid, biocides are used to inhibit the growth of deep-life microorganisms, including sulfate-reducing bacteria that contribute to corrosion of well casings and can form biofilms that prevent the upward flow of natural gas. Oxidizing biocides that are chlorine- or bromine-based can react with other fracking chemicals and may produce toxic halogenated byproducts. The authors noted biocides pose a unique risk for drinking water when fracking liquid waste is treated for discharge to surface water via sewage treatment plants. Sub-lethal concentrations may contribute to adaptation of surviving microorganisms and, hence, antibiotic resistance of pathogens. They cited particular concern over surface spills and well integrity issues associated with casing or cement failure.²³⁹
- November 3, 2014 – The West Virginia Department of Environmental Protection confirmed that three private drinking water wells were contaminated when Antero Resources mistakenly drilled into one of its own gas wells. Benzene, a human carcinogen, and toluene, a reproductive toxicant, were detected in the drinking water at

²³⁶ Hopey, D. (2015, January 15). Study: high levels of pollutants from drilling waste found in Pa. rivers. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/latest-oil-and-gas/2015/01/14/Study-High-levels-of-pollutants-from-drilling-waste-found-in-Pennsylvania-rivers-shale/stories/201501140143>

²³⁷ Darrah, T. H., Vengosh, A., Jackson, R. B., Warner, N. R., & Poreda, R. J. (2014). Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales. *Proceedings of the National Academy of Sciences*, 111 (39), 14076-14081. doi: 10.1073/pnas.1322107111

²³⁸ Jackson, R. (2014, December 1). Reopen Barnett Shale water probe. *The Texas Tribune*. Retrieved from <http://tribtalk.org/2014/12/01/reopen-barnett-shale-water-probe/>

²³⁹ Kahrilas, G. A., Blotvogel, J., Stewart, P. S., & Borch, T. (2015). Biocides in hydraulic fracturing fluids: a critical review of their usage, mobility, degradation, and toxicity. *Environmental Science & Technology*, 49,16-32. doi: 10.1021/es503724k

concentrations four times the legal maximum limit. Additionally, a nearby abandoned gas well, a drinking water well, and an actively producing gas well were all pressurized as a result of the mishap and began exhibiting “artesian flow.”²⁴⁰

- October 22, 2014 – A follow-up to the August 2014 Environmental Integrity Project report describes an even greater potential public health threat from a loophole in the Safe Drinking Water Act, wherein companies are allowed to inject other petroleum products (beyond diesel) without a permit, and many of these non-diesel drilling fluids contain even higher concentrations of the same toxins found in diesel. The authors recommend that “EPA should revisit its guidance and broaden the categories of diesel products that require Safe Drinking Water Act permits before they can be injected into oil and gas wells.”²⁴¹
- October 20, 2014 – While developing a technique to fingerprint and trace accidental releases of hydraulic fracturing fluids, researchers showed that liquid waste from shale gas fracking operations is chemically different than waste flowing out of conventional wells. The researchers hypothesized that the hydraulic fracturing process itself liberates elements from clay minerals in the shale formations, including boron and lithium, which then enter the liquid waste.²⁴²
- October 15, 2014 – Four thousand gallons of liquid fracking waste dumped into Waynesburg sewer system was discovered by sewage treatment plant workers in Greene County, Pennsylvania. The Department of Environmental Protection surmised that “someone removed a manhole cover in a remote location and dumped the fluid.” The treatment plant discharges into a creek that feeds the Monongahela River, which provides drinking water to more than 800,000 people.²⁴³
- October 6, 2014 – A state investigation that found no fracking-related water contamination in a drinking water well in Pennsylvania’s Washington County was invalidated by testimony presented to the state Environmental Hearing Board. Not all contaminants that were present in the water were reported, and the investigation relied on obsolete testing methods. More sophisticated testing revealed the presence of several chemical contaminants in the well water. The well is located 2,800 feet down gradient

²⁴⁰ Board, G. (2014, November 3). September drilling accident contaminated water in Doddridge County. *West Virginia Public Broadcasting*. Retrieved from <http://wvpublic.org/post/dep-september-drilling-accident-contaminated-water-doddridge-county>

²⁴¹ Schaeffer, E., & Bernhardt, C. (2014, October 22). Fracking’s toxic loophole. The Environmental Integrity Project. Retrieved from <http://environmentalintegrity.org/wp-content/uploads/FRACKINGS-TOXIC-LOOPHOLE.pdf>

²⁴² Warner, N. R., Darrah, T. H., Jackson, R. B., Millot, R., Kloppmann, W., & Vengosh, A. (2014). New tracers identify hydraulic fracturing fluids and accidental releases from oil and gas operations. *Environ. Sci. Technol.*, *48*(21), 12552–12560. doi: 10.1021/es5032135

²⁴³ Hopey, D. (2014, October 15). Waynesburg officials investigate dumping of fracking wastewater. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/news/environment/2014/10/15/Waynesburg-investigates-dumping-of-fracking-wastewater/stories/201410150056>

from a drilling site and fracking waste pit where multiple spills and leaks more than four years earlier had contaminated two springs.²⁴⁴

- September 23, 2014 – In a two-part audit of records, the GAO found that the EPA is failing to protect U.S. drinking water sources from fracking-related activities such as waste disposal via injection wells. Nationwide, 172,000 injection wells accept fracking waste; some are known to have contaminated drinking water. And yet, both short-term and long-term monitoring is lax, and record-keeping varies widely from state to state. The EPA neither mandates nor recommends a fixed list of chemicals for monitoring on the grounds that “injection fluids can vary widely in composition and contain different naturally occurring chemicals and fluids used in oil and gas production depending on the source of the injection fluid.”²⁴⁵ Disposal of oil and gas waste via injection wells is, in fact, subject to regulation under the Safe Drinking Water Act, but, in practice, no one knows exactly what the waste contains, and regulations are deficient. In the United States, at least two billion gallons of fluids are injected into the ground *each day* to enable oil and gas extraction via fracking or to dispose of liquid waste from fracking operations.^{246, 247}
- September 18, 2014 – Range Resources was fined a record \$4.5 million by the Pennsylvania Department of Environmental Protection for contaminating groundwater. The culprits were six leaking pits in Washington County that each held millions of gallons of fracking wastewater.²⁴⁸
- September 12, 2014 – A Pennsylvania State ecosystems scientist, together with USGS scientists, reviewed the current knowledge of the effects of fracking and its associated operations on terrestrial and aquatic ecosystems in 20 shale plays in the U.S. Findings of species and habitats at highest risk include (in addition to land-based examples) vernal pond inhabitants and stream biota. The research builds on previous reviews identifying “three main potential stressors to surface waters: changes in water quantity (hydrology), sedimentation, and water quality.” Researchers determined that there are no published data specifically on the effects of fracking on forest-dwelling amphibians, but “many species breed in vernal ponds which are negatively affected by changes in water quantity and quality and direct disturbance. Many amphibians are also highly sensitive to road salts.” Given that the U.S. EPA recently found 55 percent of all rivers and streams to be

²⁴⁴ Hopey, D. (2014, October 6). Testimony: obsolete tests tainted shale analysis. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/companies-powersource/2014/10/06/Testimony-Obsolete-tests-tainted-shale-analysis/stories/201410060075>

²⁴⁵ U.S. Government Accountability Office. (2014, September 23). Drinking water: characterization of injected fluids associated with oil and gas production. GAO-14-657R. Retrieved from <http://www.gao.gov/products/GAO-14-857R>.

²⁴⁶ Sadasivam N. (2014, July 29). Report criticizes EPA oversight of injection wells, *ProPublica*. Retrieved from <http://www.propublica.org/article/report-criticizes-epa-oversight-of-injection-wells>

²⁴⁷ U.S. Government Accountability Office. (June 27, 2014). EPA program to protect underground sources from injection of fluids associated with oil and gas production needs improvement. GAO-14-555. Retrieved from <http://www.gao.gov/products/GAO-14-555>

²⁴⁸ Hopey, D. (2014, September 18). Range resources to pay \$4.15M penalty. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/local/2014/09/18/DEP-orders-Range-Resources-to-pay-4-million-fine/stories/201409180293>

in poor condition, these researchers warned, “Large-scale development of shale resources might increase these percentages.” They expressed concern for the native range of brook trout by the cumulative effects of shale development, especially in Pennsylvania.²⁴⁹

- September 9, 2014 – A research team from Stanford and Duke Universities discovered that fracking wastewater processed by sewage treatment plants contributes to the formation of carcinogenic chemical byproducts. These raise public health risks when downstream surface water is used for drinking. Even when fracking wastewater was diluted by a factor of 10,000, the bromides and iodides in the waste reacted with organic matter to create highly toxic halogenated compounds—at troublingly high concentrations. These toxic compounds are not filterable by municipal wastewater treatment plants. Halogenated disinfection byproducts in drinking water are linked to both colon and bladder cancers.²⁵⁰
- August 29, 2014 – A review of Pennsylvania Department of Environmental Protection files on fracking-related damage to drinking water—which are kept on paper and stored in regional offices—revealed that 243 private water supplies in 22 counties had been contaminated or had lost flow and dried up as a result of nearby drilling and fracking operations in the past seven years. Pollutants included methane, metals, and salts as well as carbon-based compounds (ethylene glycol and 2-butoxyethanol) that are known to be constituents of fracking fluid. As reported by the *Pittsburgh Post-Gazette*, this tally—which came as a response to multiple lawsuits and open-records requests by media sources—was the first time the agency “explicitly linked a drilling operation to the presence of industrial chemicals in drinking water.”^{251, 252}
- August 13, 2014 – Over the last decade, drilling companies have repeatedly claimed they are no longer using diesel fuel in fracking, although a 2011 investigation by U.S. House Democrats concluded otherwise. The Environmental Integrity Project examined disclosure data submitted to FracFocus and identified at least 351 wells in 12 states that have been fracked over the last four years with one or more of the five prohibited products identified as diesel. EIP researchers also discovered numerous fracking fluids

²⁴⁹ Brittingham, M. C., Maloney, K. O., Farag, A. M., Harper, D. D., & Bowen, Z. H. (2014). Ecological risks of shale oil and gas development to wildlife, aquatic resources and their habitats. *Environmental Science & Technology*, 48(19), 11034–11047. doi: dx.doi.org/10.1021/es5020482

²⁵⁰ Parker, K. M., Zeng, T., Harkness, J., Vengosh, A., & Mitch, W. A. 2014. Enhanced formation of disinfection byproducts in shale gas wastewater-impacted drinking water supplies. *Environmental Science & Technology*, 48(19), 11161–11169. doi: 10.1021/es5028184

²⁵¹ Pennsylvania Department of Environmental Protection. (2014 August 29). Water supply determination letters. Retrieved from

http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf

²⁵² Legere, L. (2014, September 9). DEP releases updated details on water contamination near drilling sites: some 240 private supplies damaged by drilling in the past 7 years. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/policy-powersource/2014/09/09/DEP-releases-details-on-water-contamination/stories/201409090010>

with high diesel content for sale online, including over a dozen products sold by Halliburton and advertised as additives, friction reducers, emulsifiers, etc.²⁵³

- August 13, 2014 – An international team of researchers found high levels of carbon-based compounds in liquid fracking waste. These impurities can react with chlorine and bromine to create toxic byproducts. This study suggests that chemical treatment of liquid fracking waste will magnify its toxic potency, as will reusing and recycling it.²⁵⁴ The European Commission subsequently published a summary of these findings.²⁵⁵
- August 13, 2014 – A team from Lawrence Berkeley National Laboratory reported that scientific efforts to understand the hazards of fracking continue to be hampered by industry secrecy. A comprehensive examination of the chemical formulations of fracking fluid—whose precise ingredients are protected as proprietary business information—revealed that no publicly available toxicity or physical chemical information was available for one-third of all the fracking chemicals surveyed. Another ten percent of chemicals, including biocides and corrosion inhibitors, were known to be toxic to mammals.^{256, 257}
- August 12, 2014 – A Stanford University research team working in the Pavillion gas basin in Wyoming documented that fracking in shallow layers of bedrock, including those that serve as drinking water aquifers, is not uncommon. This finding overturns the industry claim that oil and gas deposits targeted by fracking operations are located at much greater depths than underground drinking water sources and are isolated from them by hundreds of feet of impermeable rock. Because it is exempt from provisions of the Safe Drinking Water Act, fracking in drinking water aquifers is not prohibited by law.²⁵⁸
- August 3, 2014 – An investigation by the *Pittsburgh Post-Gazette* found that half of all fracking-related spills that resulted in violations and fines were not discovered by the gas companies themselves, even though Pennsylvania state law requires them to pro-actively seek and report such incidents. The newspaper’s analysis of hundreds of thousands of

²⁵³ Greene, M. (2014, August 13). Fracking beyond the law: Despite industry denials, investigation reveals continued use of diesel in hydraulic fracturing. The Environmental Integrity Project. Retrieved from <http://environmentalintegrity.org/wp-content/uploads/Fracking-Beyond-the-Law.pdf>

²⁵⁴ Maguire-Boyle, S. J., & Barron, A. R. (2014). Organic compounds in produced waters from shale gas wells. *Environ. Sci.: Processes Impacts*, 16, 2237-2248. doi: 10.1039/C4EM00376D

²⁵⁵ European Commission. (2015, February 19). Chemical composition of fracking wastewater. *Science for Environment Policy*, 404. Retrieved from http://ec.europa.eu/environment/integration/research/newsalert/pdf/chemical_composition_of_fracking_wastewater_404na4_en.pdf

²⁵⁶ Stringfellow, W. T., Domen, J. K., Carmarillo, M. K., Sandelin, W. L., Tinnacher, R., Jordan, P., . . . Birkholzer, J. (August 13, 2014). Characterizing compounds used in hydraulic fracturing: a necessary step for understanding environmental impacts. Presentation before the American Chemical Society conference, San Francisco. Abstract retrieved from http://abstracts.acs.org/chem/248nm/program/view.php?obj_id=262051&terms=

²⁵⁷ Robinson, P. (2014, August 19). Fracking fluid survey shows missing information. *Scientific American*. Retrieved from <http://www.scientificamerican.com/article/fracking-fluid-survey-shows-missing-information/>

²⁵⁸ Banerjee, N. (2014, August 12). Oil companies fracking into drinking water sources, new research finds. *Los Angeles Times*. Retrieved from <http://www.latimes.com/nation/la-na-fracking-groundwater-pavillion-20140811-story.html#page=1>

state and company documents showed that self-regulation in the gas fields is a failure. One-third of all spills were discovered by state inspectors, while one-sixth were found by residents. Likely, much contamination is entirely undetected and unreported.²⁵⁹

- July 21, 2014 – An investigation by the *Columbus Dispatch* showed that Halliburton delayed disclosure to federal and state EPA agencies of the full list of chemicals that spilled into a creek following a fire on one of its well pad in Monroe County, Ohio. Although the creek is an important supply of drinking water for downstream communities and the spill precipitated a mass die-off of fish and other aquatic wildlife, five full days passed before EPA officials were provided a full inventory of chemicals used at Halliburton’s operation. As a result, the public was denied knowledge of potential chemical exposures.²⁶⁰
- July 17, 2014 – A team of environmental scientists, biologists, and engineers, from institutions including the University of Michigan and McGill University, assessed the current state of understanding of the impact fracking and its associated activities have on the ecological health of surface waters. Though various approaches such as geographic information systems and site monitoring provide insights into potential risks to aquatic ecosystems, the authors concluded that inadequate data currently exist. They identified possible outcomes such as, “erosion and sedimentation, increased risk to aquatic ecosystems from chemical spills or runoff, habitat fragmentation, loss of stream riparian zones, altered biogeochemical cycling, and reduction of available surface and hyporheic water volumes because of withdrawal-induced lowering of local groundwater levels.”²⁶¹
- July 7, 2014 – California Department of Gas, Oil, and Geothermal Resources ordered seven energy companies to stop injecting liquid fracking waste into aquifers. The ongoing drought that has compelled farmers to supplement irrigation with water drawn from groundwater sources prompted state officials to look at the status of aquifers previously considered too deep for use or too poor in quality. They discovered that at least seven injection wells were very likely pumping liquid fracking waste into protected groundwater supplies rather than aquifers that had been sacrificed for the purpose of waste disposal. Across the United States, more than 1000 aquifers are exempt from any type of pollution protection at all, and many of these are in California, according to a related *ProPublica* investigation.²⁶²

²⁵⁹ Hamill, S. D. (2014, August 3). Drillers did not report half of spills that led to fines. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/news/state/2014/08/03/Drillers-did-not-report-half-of-spills-that-led-to-fines/stories/201408020142>

²⁶⁰ Arenschiold, L. (2014, July 21). Halliburton delayed releasing details on fracking chemicals after Monroe County spill. *The Columbus Dispatch*. Retrieved from <http://www.dispatch.com/content/stories/local/2014/07/21/details-on-chemicals-trickle-in-after-spill.html>

²⁶¹ Burton Jr., G. A., Basu, N., Ellis, B. R., Kapo, K. E., Entekin, S. & Nadelhoffer, K. (2014). Hydraulic “fracking”: are surface water impacts an ecological concern? *Environmental Toxicology and Chemistry*, 33(8), 1679-1689.

²⁶² Lustgarten, A. (2014, July 18). California halts injects of fracking waste, warning it may be contaminating aquifers. *ProPublica*. Retrieved from <http://www.propublica.org/article/ca-halts-injection-fracking-waste-warning-may-be-contaminating-aquifers>

- June 25, 2014 – A study by Cornell University researchers found that fracking fluid and fracking wastewater mobilized previously deposited chemical contaminants in soil particles in ways that could potentially exacerbate the impacts of fracking fluid spills or leaks. The research team concluded that, by interfering with the ability of soil to bond to and sequester pollutants such as heavy metals, fracking fluids may release from soils an additional repository of contaminants that could migrate into groundwater.²⁶³
- June 23, 2014 – Building on earlier findings that water samples collected from sites with confirmed fracking spills in Garfield County, Colorado exhibited moderate to high levels of estrogen and androgen-disrupting activity, a University of Missouri team extended their investigation to other types of hormonal effects. As reported at a joint meeting of the International Society of Endocrinology and the Endocrine Society, their research documented that commonly used fracking chemicals can also block the receptors for thyroid hormone, progesterone, and glucocorticoids (a family of hormones involved in both fertility and immune functioning). Of 24 fracking chemicals tested, all 24 interfered with the activity of one or more important hormone receptors. There is no known safe level of exposure to hormone-disrupting chemicals.²⁶⁴
- May 11, 2014 – According to the GAO, the federal government is failing to inspect thousands of oil and gas wells located on public land, including those that pose special risks of water contamination or other environmental damage. An investigation by the Associated Press found that the Bureau of Land Management “had failed to conduct inspections on more than 2,100 of the 3,702 wells that it had specified as ‘high priority’ and drilled from 2009 through 2012. The agency considers a well ‘high priority’ based on a greater need to protect against possible water contamination and other environmental safety issues.”²⁶⁵
- March 25, 2014 – An industry-funded study of oil and gas well integrity found that more than six percent of wells in a major shale exploration region in Pennsylvania showed evidence of leaking and conceded that this number is likely an underestimate. Researchers concluded that the percentage of wells with some form of well barrier or integrity failure is highly variable and could be as high as 75 percent. A separate analysis in the same study found 85 examples of cement or casing failures in Pennsylvania wells monitored between 2008 and 2011.²⁶⁶

²⁶³ Sang, W., Stoof, C., Zhang, W., Morales, V., Gao, B., Kay, R., . . . Steenhuis, T. (2014). Effect of hydrofracking fluid on colloid transport in the unsaturated zone. *Environmental Science & Technology*, 48(14), 8266–8274. Retrieved from <http://pubs.acs.org/doi/abs/10.1021/es501441e>

²⁶⁴ The Endocrine Society (2014, June 23). Hormone-disrupting activity of fracking chemicals worse than initially found. *Science Daily*. Retrieved from http://www.sciencedaily.com/releases/2014/06/140623103939.htm?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+sciencedaily%2Ftop_news%2Ftop_health+%28ScienceDaily%3A+Top+Health+News%29

²⁶⁵ Yen, H. (2014, May 11). Fed govt failed to inspect higher risk oil wells. *Associated Press*. Retrieved from <http://bigstory.ap.org/article/fed-govt-failed-inspect-higher-risk-oil-wells>

²⁶⁶ Davies, R. J., Almond, S., Ward, R. S., Jackson, R. B., Adams, C., Worrall, F., . . . Whitehead, M. A. (2014). Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation. *Marine and Petroleum Geology*, 56, 239-254. doi: 10.1016/j.marpetgeo.2014.03.001

- March 7, 2014 – In a comprehensive evaluation, Duke University scientists and colleagues reviewed the state of knowledge on possible effects of shale gas and hydraulic fracturing on water resources in the United States and concluded, “Analysis of published data (through January 2014) reveals evidence for stray gas contamination, surface water impacts in areas of intensive shale gas development, and the accumulation of radium isotopes in some disposal and spill sites.”²⁶⁷
- February 19, 2014 – A Pennsylvania court found a gas corporation guilty of contaminating a woman’s drinking water well in Bradford County. Methane levels after fracking were 1,300-2,000 times higher than baseline, according to the court brief. Iron levels and turbidity had also increased. The brief stated, “In short, Jacqueline Place lived for ten months deprived totally of the use of her well, and even after its ‘restoration,’ has been burdened with a water supply with chronic contamination, requiring constant vigilance and ongoing monitoring.”²⁶⁸
- January 16, 2014 – Data from the Colorado Oil and Gas Conservation Commission showed that fracking-related chemical spills in Colorado exceed an average rate of one spill per day. Of the 495 chemical spills that occurred in that state over a one-year period of time, nearly a quarter impacted ground or surface water. Sixty-three of the spills spread within 1,500 feet of pigs, sheep, and cows; 225 spread within 1,500 feet of buildings.²⁶⁹
- January 10, 2014 – Duke University water tests revealed ongoing water contamination in Parker County, Texas, providing evidence that the EPA had prematurely ended its prior investigation into the water contamination.²⁷⁰ A letter sent to the EPA from more than 200 environmental organizations called on the agency to re-open its investigation.²⁷¹
- January 5, 2014 – An Associated Press investigation into drinking water contamination from fracking in four states—Pennsylvania, Ohio, West Virginia, and Texas—found many cases of confirmed water contamination and hundreds more complaints. The Associated Press noted that their analysis “casts doubt on industry view that it rarely

²⁶⁷ Vengosh, A., Jackson, R. B., Warner, N., Darrah, T. H., & Kondash, A. (2014). A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States [Abstract]. *Environmental Science & Technology*. doi: 10.1021/es405118y

²⁶⁸ Gibbons, B. (2014, February 19). Woman wins case against Chesapeake Jaqueline Place of Terry Township to receive compensation for well contamination. *TheDailyReview.com*. Retrieved from <http://thedailyreview.com/news/woman-wins-case-against-chesapeake-jaqueline-place-of-terry-township-to-receive-compensation-for-well-contamination-1.1636832>

²⁶⁹ Tomasic, J. (2014, January 16). Colorado drilling data: More than a spill a day. *The Colorado Independent*. Retrieved from <http://www.coloradoindependent.com/145629/colorado-drilling-data-more-than-a-spill-a-day>

²⁷⁰ Drajem, M. (2014, January 9). Duke fracking tests reveal dangers driller's data missed. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2014-01-10/epa-s-reliance-on-driller-data-for-water-irks-homeowners.html>

²⁷¹ Drajem, M. (2014, January 27). EPA needs fracking review: 'Gasland' maker, environmentalists. *Bloomberg*. Retrieved from <http://go.bloomberg.com/political-capital/2014-01-27/epa-needs-fracking-review-gasland-producer-environmentalists-say/>.

happens.”²⁷²

- December 24, 2013 – A report from the EPA Inspector General concluded that evidence of fracking-related water contamination in Parker County, Texas was sound and faulted the EPA for prematurely ending its investigation there, relying on faulty water testing data from the gas industry in doing so, and failure to intervene when affected residents’ drinking water remained unsafe.²⁷³ As reported by *Business Insider*, “The EPA Screwed Up When It Dropped This Fracking Investigation.”²⁷⁴
- December 16, 2013 – Lead by Susan Nagel of the University of Missouri School of Medicine, researchers documented endocrine-disrupting properties in chemicals commonly used as ingredients of fracking fluid and found similar endocrine-disrupting activity in groundwater and surface water samples collected near drilling and fracking sites in Garfield County, Colorado. Endocrine disruptors are chemicals that interfere with the activity of hormones in the body and, at very low concentrations, can raise the risk of reproductive, metabolic, and neurological disorders, especially when exposures occur in early life.^{275, 276, 277}
- December 7, 2013 – Reporting on the second gas leak at a single gas well in one month, the Fort Worth *Star-Telegram* uncovered another inherent risk of fracking for groundwater contamination: Silica sand, which is used as an ingredient in fracking fluid for its ability to prop open the shale fractures, can damage steel pipes as it flows back up the well along with the gas. According to Dan Hill, head of the petroleum engineering department at Texas A&M University, new wells are the most susceptible to sand erosion because “the amount of sand and gas rushing through valves and flow lines is at its greatest when a well first goes into production.”²⁷⁸
- November 28, 2013 – An Associated Press investigation uncovered nearly 300 oil pipeline spills in North Dakota in the previous ten months, all with no public notification. These were among some 750 “oil field incidents” that had occurred in the state over the same time period, also without public notification. Until the AP inquiry, industry and state officials had kept quiet about one particular “massive spill” that had been

²⁷² Begos, K. (2014, January 05). 4 states confirm water pollution from drilling. *USA Today*. Retrieved from <http://www.usatoday.com/story/money/business/2014/01/05/some-states-confirm-water-pollution-from-drilling/4328859/>

²⁷³ Banerjee, N. (2013, December 24). EPA report on fracking in Texas raises new concerns. *Los Angeles Times*. Retrieved from <http://www.latimes.com/nation/la-na-epa-fracking-20131225,0,6042944.story#ixzz2oVB9FXVY>

²⁷⁴ Miedema, D. (2013, December 25). The EPA screwed up when it dropped this fracking investigation. *Business Insider*. Retrieved from <http://www.businessinsider.com/epa-criticized-for-dropping-fracking-investigation-2013-12>

²⁷⁵ Kassotis, C. D., Tillitt, D. E., Davis, J. W., Hormann, A. M., & Nagel, S. C. (2013). Estrogen and androgen receptor activities of hydraulic fracturing chemicals and surface and ground water in a drilling-dense region. *Endocrinology*. doi: 10.1210/en.2013-1697

²⁷⁶ Banerjee, N. (2013, December 16). Hormone-disrupting chemicals found in water at fracking sites. *Los Angeles Times*. Retrieved from <http://articles.latimes.com/2013/dec/16/science/la-sci-fracking-health-20131217>

²⁷⁷ Endocrine Society. (2013, December 16). Fracking chemicals disrupt hormone function. *ScienceDaily*. Retrieved from www.sciencedaily.com/releases/2013/12/131216140428.htm

²⁷⁸ Hirst, C., & Fuquay, J. (2013, December 7). Second leak reported at east Fort Worth gas well site. *Star-Telegram*. Retrieved from <http://www.star-telegram.com/2013/12/07/5399740/second-leak-reported-at-east-fort.html?rh=1>

accidentally discovered by a wheat farmer. Even small spills can contaminate water sources permanently and take cropland out of production.²⁷⁹

- November 26, 2013 – A USGS report found serious impacts of fracking on watersheds and water quality throughout the Appalachian Basin, as well as issues with radiation and seismic events. As noted in the report, the knowledge of how extraction affects water resources has not kept pace with the technology.^{280, 281} Meanwhile, clean fresh water is becoming an increasingly scant resource. A report prepared for the U.S. State Department forecasts a serious freshwater shortage by 2030, with global demand exceeding supply by 40 percent.²⁸²
- November 22, 2013 – A USGS study of pollution from oil production in North Dakota, where horizontal drilling and hydraulic fracturing are heavily used, identified two potential plumes of groundwater contamination covering 12 square miles. The cause was traced to a casing failure in a wastewater disposal well. Drilling companies had incorrectly assumed that, once injected underground, the wastewater would remain contained. According to *EnergyWire*, the development of the Bakken oil formation is “leaving behind an imprint on the land as distinct as the ones left by the receding ice sheets of the ice age.”²⁸³
- September 10, 2013 – Pennsylvania Attorney General Kathleen Kane filed criminal charges against Exxon Mobil Corporation’s subsidiary, XTO Energy Corporation, for a spill of 50,000 gallons of toxic drilling wastewater in 2010 that contaminated a spring and a tributary of the Susquehanna River. In July, XTO settled civil charges for the incident without admitting liability by agreeing to pay a \$100,000 fine and improve its wastewater management.²⁸⁴
- September 10, 2013 – Out of concern for risks posed to drinking water in the nation’s capital, George Hawkins, General Manager of DC Water, Washington, DC’s local water provider, called for a prohibition on horizontal drilling and hydraulic fracturing in the

²⁷⁹ MacPherson, J. (2013, October 28). Nearly 300 pipeline spills in North Dakota have gone unreported to the public since January 2012. *Huffington Post*. Retrieved from http://www.huffingtonpost.com/2013/10/28/pipeline-spills-north-dakota_n_4170133.html?ncid=edlinkusaolp00000003

²⁸⁰ Kappel, W. M., Williams, J. H., & Szabo, Z. (2013). Water resources and shale gas/oil production in the Appalachian Basin - Critical issues and evolving developments. *U.S. Geological Survey*. Retrieved from <http://pubs.usgs.gov/of/2013/1137/pdf/ofr2013-1137.pdf>

²⁸¹ Mall, A. (2013, November 26). New USGS analysis: Threats to water, wildlife, and health from oil and gas development in the Appalachian basin [Web log post]. Retrieved from http://switchboard.nrdc.org/blogs/amall/new_usgs_analysis.html

²⁸² National Intelligence Council. (2012, February 2). *Global Water Security: Intelligence Community Assessment*, (ICA 2012-08). Retrieved from http://www.dni.gov/files/documents/Special%20Report_ICA%20Global%20Water%20Security.pdf

²⁸³ Vaidyanathan, G. (2013, November 22). Bakken shale: As oil production sets in, pollution starts to migrate -- scientists. *E&E Publishing, LLC*. Retrieved from <http://www.eenews.net/stories/1059990892>

²⁸⁴ Maykuth, A. (2013, September 13). Shale criminal charges stun drilling industry. *Philly.com*. Retrieved from http://articles.philly.com/2013-09-13/news/42012429_1_xto-energy-inc-criminal-charges-attorney-general

George Washington National Forest until the process can be proven safe.²⁸⁵ The Potomac River is the source of the District's water supply and has its headwaters in the George Washington National Forest, which sits atop the Marcellus Shale. The general managers of Fairfax Water, provider of drinking water for Fairfax County, Virginia, and the U.S. Army Corps of Engineers have called for a similar prohibition.²⁸⁶

- September 3, 2013 – The North Dakota Department of Mineral Resources voiced concern about an increasing number of fracking well blowouts (23 incidents in the past year) that result in spills and public safety threats.²⁸⁷
- August 28, 2013 – A joint USGS and U.S. Fish and Wildlife Service study documented a causal link between a fracking wastewater spill and the widespread death of fish in the Acorn Fork, a creek in Kentucky.²⁸⁸
- July 25, 2013 – A University of Texas at Arlington study of drinking water found elevated levels of arsenic and other heavy metals in some samples from private drinking water wells located within five kilometers of active natural gas wells in the Barnett Shale.²⁸⁹
- July 3, 2013 – *ProPublica* reported that the EPA was wrong to have halted its investigation of water contamination in Wyoming, Texas and Pennsylvania—where high levels of benzene, methane, arsenic, oil, methane, copper, vanadium, and other chemicals associated with fracking operations have been documented.²⁹⁰ Although numerous organizations and health professionals around the country have since called on the agency to resume its investigation, no action has been taken.
- June 6, 2013 – Reviewing hundreds of regulatory and legal filings, *Bloomberg News* reported that drillers have offered out-of-court cash settlements and property buyouts to homeowners who claim that fracking ruined their water. These agreements typically come with gag orders and sealed records. This strategy, the investigation noted, allows the industry to continue claiming that no cases of water contamination due to fracking have ever been confirmed, impedes public health research, and shields data from

²⁸⁵ Letter from George Hawkins, General Manager, DC Water, to U.S. Secretary of Agriculture, Thomas Vilsack, (Sept. 10, 2013), <http://www.washingtoncitypaper.com/blogs/housingcomplex/2013/09/20/dc-water-chief-urges-agriculture-secretary-not-to-allow-fracking-near-d-c/>

²⁸⁶ Wiener, A. (2013, September 20). DC Water Chief urges Agriculture Secretary not to allow fracking near D.C. *Washington City Paper*. Retrieved from <http://www.washingtoncitypaper.com/blogs/housingcomplex/2013/09/20/dc-water-chief-urges-agriculture-secretary-not-to-allow-fracking-near-d-c/>

²⁸⁷ Sun Staff. (2013, September 3). More blowouts a concern for N.D. *The Jamestown Sun*. Retrieved from <http://www.jamestownsun.com/content/more-blowouts-concern-nd>

²⁸⁸ Papoulias, D., & MacKenzie, T. (2013, August 28). Hydraulic fracturing fluids likely harmed threatened Kentucky fish species. *USGS Newsroom*. Retrieved from <http://www.usgs.gov/newsroom/article.asp?ID=3677>

²⁸⁹ Fontenot, B. E., Hunt, L. R., Hildenbrand, Z. L., Carlton Jr., D. D., Oka, H., Walton, J. L., . . . Schug, K. A. (2013). An evaluation of water quality in private drinking water wells near natural gas extraction sites in the Barnett Shale formation. *Environmental Science & Technology*, 47(17), 10032-10040. doi: 10.1021/es4011724

²⁹⁰ Lustgarten, A. (2013, July 3). EPA's abandoned Wyoming fracking study one retreat of many. *ProPublica*. Retrieved from <http://www.propublica.org/article/epas-abandoned-wyoming-fracking-study-one-retreat-of-many>

regulators, policy makers, and the new media.²⁹¹ The EPA also long ago noted how non-disclosure agreements between oil and gas operators and landowners challenge scientific progress and keep examples of drilling harm secret from the public. In a 1987 report, the EPA wrote, “In some cases, even the records of well-publicized damage incidents are almost entirely unavailable for review. In addition to concealing the nature and size of any settlement entered into between the parties, impoundment curtails access to scientific and administrative documentation of the incident.”²⁹²

- June 3, 2013 – A study by Duke University researchers linked fracking with elevated levels of methane, ethane, and propane in nearby groundwater.²⁹³ Published in *Proceedings of the National Academy of Sciences*, the study included results from 141 northeastern Pennsylvania water wells. Methane levels were, on average, six times higher in drinking water wells closer to drilling sites when compared with those farther away, while ethane was 23 times higher.²⁹⁴
- May 19, 2013 – In Pennsylvania, the *Scranton Times-Tribune* released details of an investigation that revealed at least 161 cases of water contamination from fracking between 2008 and the fall of 2012, according to state Department of Environmental Protection records.²⁹⁵
- April 2013 – Researchers analyzing publicly available Colorado data found 77 surface spills impacting groundwater in Weld County alone. Samples of these spills often exceeded drinking water maximum contaminant levels (MCLs) for benzene, toluene, ethylbenzene and xylene; for benzene, a known carcinogen, 90 percent of the samples exceeded the legal limit.²⁹⁶
- March 4, 2013 – Researchers at the University of Pittsburgh Graduate School of Public Health analyzed samples of gas drilling wastewater discharged to surface water through

²⁹¹ Efstathiou, J., Jr., & Drajem, M. (2013, June 5). Drillers silence fracking claims with sealed settlements. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2013-06-06/drillers-silence-fracking-claims-with-sealed-settlements.html>

²⁹² Environmental Protection Agency. (1987). *Report to Congress: Management of wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy* (Rep.). 137-138. Washington, D.C.: U.S. Environmental Protection Agency.

²⁹³ Jackson, R. B., Vengosh, A., Darrah, T. H., Warner, N. R., Down, A., Poreda, R. J., . . . Karr, J. D. (2013). Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *Proceedings of the National Academy of Sciences*, 110(28), 11250-11255. doi: 10.1073/pnas.1221635110

²⁹⁴ CBS/AP. (2013, June 25). Methane found in Pa. drinking water near fracked wells. *CBS News*. Retrieved from <http://www.cbsnews.com/news/methane-found-in-pa-drinking-water-near-fracked-wells/>

²⁹⁵ Legere, L. (2013, May 19). Sunday Times review of DEP drilling records reveals water damage, murky testing methods. *The Times-Tribune*. Retrieved from <http://thetimes-tribune.com/news/sunday-times-review-of-dep-drilling-records-reveals-water-damage-murky-testing-methods-1.1491547>

²⁹⁶ Gross, S. A., Avens, H. J., Banducci, A. M., Sahmel, J., Panko, J. M., & Tvermoes, B. E. (2013). Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations. *Journal of the Air & Waste Management Association*, 63(4), 424-432. doi: 10.1080/10962247.2012.759166

wastewater treatment plants. Barium, strontium, bromides, chlorides, and benzene all exceeded levels known to cause human health impacts.²⁹⁷

- December 9, 2012 – State data in Colorado showed more than 350 instances of groundwater contamination resulting from more than 2,000 spills from oil and gas operations over the past five years. Further, as the *Denver Post* reported, “Contamination of groundwater—along with air emissions, truck traffic and changed landscapes—has spurred public concerns about drilling along Colorado’s Front Range.”²⁹⁸
- May 4, 2012 – A report for the Canadian Government, released under the Access to Information Act, reviewed the process, the regulatory framework globally, and the potential health hazards related to shale gas extraction. Additionally, the report evaluated mechanisms for potential impacts and summarized the data knowledge and data gaps. Regarding water contamination, the report determined, “Although quantitative data are lacking, the qualitative data available indicate that potential contamination of water related to the shale gas industry may present hazard to the public health, especially for local population.” Regarding air contamination: “air emissions related to the shale gas industry present health hazards since the air pollutants originating from the vehicles and engines fuelled by diesel are toxic to the respiratory and cardiovascular systems and can cause premature mortality, volatile organic compounds have been associated to neurotoxicity and some of these compounds (e.g. benzene) as well as NORMs are known or possible human carcinogens.” The report concluded, “Any step of shale gas exploration/exploitation may represent a potential source of drinking water and air contamination; Hydraulic fracturing and wastewater disposal were identified as the main potential sources of risk.”²⁹⁹
- May 2012 – A report by researchers at Natural Resources Defense Council and Carnegie Mellon University found that the options available for dealing with fracking wastewater are inadequate to protect public health and the environment, resulting in increasing quantities of toxic wastewater as an ongoing problem without a good solution.³⁰⁰
- January 11, 2012 – The USGS reported that the Marcellus Shale is already highly fractured and that numerous fissures naturally occurring within the formation could

²⁹⁷ Ferrar, K. J., Michanowicz, D. R., Christen, C. L., Mulcahy, N., Malone, S. L., & Sharma, R. K. (2013). Assessment of effluent contaminants from three facilities discharging Marcellus shale wastewater to surface waters in Pennsylvania. *Environmental Science & Technology*, 47(7), 3472-3481. doi: 10.1021/es301411q

²⁹⁸ Finley, B. (2012, December 9). Drilling spills reaching Colorado groundwater; state mulls test rules. *The Denver Post*. Retrieved from http://www.denverpost.com/environment/ci_22154751/drilling-spills-reaching-colorado-groundwater-state-mulls-test#ixzz2EihHU2fg

²⁹⁹ Louis, S. (2012, May 4). Potential health hazards from shale gas exploration and exploitation—Drinking water and ambient air. Presented to Health Canada by SANEXEN Environmental Services; 0/Ref.: RA11-410. Document released under the (Canadian) Access to Information Act.

³⁰⁰ Hammer, R., & VanBriesen, J. (2012, May). *In fracking’s wake: New rules are needed to protect our health and environment from contaminated wastewater* (Rep.). Natural Resources Defense Council. Retrieved from <http://www.nrdc.org/energy/files/fracking-wastewater-fullreport.pdf>

potentially provide pathways for contaminants to migrate vertically into water supplies.³⁰¹

- October 25, 2011 – After receiving new information from two companies, members of Congress updated their findings to show that “between 2005 and 2009, oil and gas service companies injected 32.7 million gallons of diesel fuel or hydraulic fracturing fluids containing diesel fuel in wells in 20 states.”³⁰²
- October 17, 2011 – Thomas P. Jacobus, General Manager of the U.S. Army Corps of Engineers’ Washington Aqueduct, called for a prohibition on horizontal hydraulic fracturing in the George Washington National Forest because of concern that fracking poses risks to drinking water. The Washington Aqueduct—which provides drinking water to Washington, DC, Arlington County, Virginia, and Falls Church, Virginia—is supplied by the Potomac River, which has its headwaters in the George Washington National Forest that sits atop the Marcellus Shale. Jacobus said, “Enough study on the technique [hydraulic fracturing] has been published to give us great cause for concern about the potential for degradation of the quality of our raw water supply....”³⁰³
- October 11, 2011 – Charles M. Murray, General Manager of Fairfax Water, called for a prohibition on horizontal hydraulic fracturing in the George Washington National Forest. “Natural gas development activities have the potential to impact the quantity and quality of Fairfax Water’s source water,” Murray wrote. “Downstream water users and consumers will bear the economic burden if drinking water sources are contaminated or the quality of our source water supply is degraded.”³⁰⁴ Fairfax Water provides drinking water for Fairfax County in Virginia.
- September 7, 2011 – In its draft Supplemental Generic Environmental Impact Statement (SGEIS), the New York State Department of Environmental Conservation (NYS DEC) acknowledged that “there is questionable available capacity”³⁰⁵ for New York’s public sewage treatment plants to accept drilling wastewater, yet the agency said that it would

³⁰¹ U.S. Geological Survey, New York Water Science Center. (2012, January 11). *Comments on the revised draft supplemental generic environmental impact statement*. (Rep.). Retrieved from http://www.ewg.org/sites/default/files/report/ReviseddraftSGEIS_USGScomments_Version3_0.pdf

³⁰² Waxman, H. A., Markey, E. J., & DeGette, D. (2011, October 25). *Committee on Energy & Commerce* (U.S.A., Congress, Committee on Energy & Commerce). Retrieved from <http://democrats.energycommerce.house.gov/index.php?q=news/rep-waxman-markey-and-degette-report-updated-hydraulic-fracturing-statistics-to-epa>

³⁰³ Jacobus, T. P. (2012, April 25). Draft environmental impact statement for the George Washington National Forest [Letter written October 17, 2011 to K. Landgraf]. Retrieved, from http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5366331.pdf

³⁰⁴ Murray, C. M. (n.d.). Draft environmental impact statement for the George Washington National Forest [Letter written October 11, 2013 to K. Landgraf]. Retrieved from <http://www.svnva.org/wp-content/uploads/fairfax-wash-aqueduct-gwnf-comments.pdf>

³⁰⁵ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (6-62, Rep.).

allow those facilities to accept such waste if the plants meet permitting conditions.³⁰⁶ The NYS DEC proposed underground injection as one alternative to sewage treatment procession of fracking waste. Although it is a common method of disposal for fracking wastewater,³⁰⁷ the last significant government study of pollution risks from oil and gas wastewater injection wells occurred in 1989 and found multiple cases of costly groundwater contamination.³⁰⁸ In subsequent years, studies have continued to link underground injection of drilling wastewater to pollution as well as earthquakes.³⁰⁹

- September 2011 – A team led by Theo Colburn of the Endocrine Disruptor Exchange found that 25 percent of chemicals known to be used in fracking fluids are implicated in cancer, 37 percent could disrupt the endocrine system, and 40-50 percent could cause nervous, immune and cardiovascular system problems. The research team also found that more than 75 percent could affect the skin, eyes, and respiratory system, resulting in various problems such as skin and eye irritation or flu-like symptoms.³¹⁰
- August 4, 2011 – As reported by the *New York Times*, the EPA had alerted Congress in 1987 about a case of water contamination caused by fracking. Its report documented that a shale gas well hydraulically fractured at a depth of more than 4,200 feet contaminated a water supply only 400 feet from the surface.^{311, 312, 313}
- May 17, 2011 – The state of Pennsylvania fined Chesapeake Energy Corporation \$900,000 for an incident in which improper cementing and casing in one of the company's gas wells allowed methane to migrate underground and contaminate 16 private drinking water wells in Bradford County.³¹⁴

³⁰⁶ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (6-57 through 6-63, Rep.).

³⁰⁷ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (6-64, Rep.).

³⁰⁸ United States Government Accountability Office. (1989, July 5). Drinking water: Safeguards are not preventing contamination from injected oil and gas wastes. Retrieved from <http://www.gao.gov/products/RCED-89-97>

³⁰⁹ Fountain, H. (2012, January 1). Disposal halted at well after new quake in Ohio. *The New York Times*. Retrieved from <http://www.nytimes.com/2012/01/02/science/earth/youngstown-injection-well-stays-shut-after-earthquake.html>

³¹⁰ Colborn, T., Kwiatkowski, C., Schultz, K., & Bachran, M. (2011). Natural gas operations from a public health perspective. *Human and Ecological Risk Assessment: An International Journal*, 17(5), 1039-1056. doi: 10.1080/10807039.2011.605662

³¹¹ Urbina, I. (2011, August 4). A tainted water well, and concern there may be more. Retrieved from <http://www.nytimes.com/2011/08/04/us/04natgas.html>

³¹² U.S. Environmental Protection Agency. (1987). *Report to Congress: Management of wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy* (Rep.). 4-22, 4-23. Retrieved from <http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=20012D4P.PDF>

³¹³ Horwitt, D. (2011, August 3). Cracks in the facade. *Environmental Working Group*. Retrieved from <http://www.ewg.org/research/cracks-façade>

³¹⁴ Levy, M. (2011, May 18). DEP fines Chesapeake \$1 million. *Pressconnects.com*. Retrieved from <http://www.pressconnects.com/viewart/20110517/NEWS01/105170345/DEP-fines-Chesapeake-1-million>

- May 17, 2011 – A Duke University study documented “systematic evidence for methane contamination of drinking water associated with shale gas extraction.”³¹⁵ The study showed that methane levels were 17 times higher in water wells near drilling sites than in water wells in areas without active drilling.³¹⁶
- April 22, 2011 – Describing one of many blowouts, the Associated Press reported on a shale gas well in Canton, Pennsylvania that spewed thousands of gallons of chemical-laced water on farmland and into a stream for two consecutive days before being brought under control.³¹⁷
- April 18, 2011 – As part of a year-long investigation into hydraulic fracturing and its potential impact on water quality, U.S. Representatives Henry Waxman (D-Calif.), Edward Markey (D-Mass.) and Diana DeGette (D-Colo.) released the second of two reports issued in 2011. Their analysis of hydraulic fracturing fluids used by the 14 leading oil and natural gas service companies between 2005 and 2009 found, among other things, that the companies used more than 650 different products that contained chemicals that are known or possible human carcinogens, regulated under the Safe Drinking Water Act, or listed as hazardous air pollutants under the Clean Air Act. The report also showed that “between 2005 and 2009, the companies used 94 million gallons of 279 products that contained at least one chemical or component that the manufacturers deemed proprietary or a trade secret ... in most cases the companies stated that they did not have access to proprietary information about products they purchased ‘off the shelf’ from chemical suppliers. In these cases, the companies are injecting fluids containing chemicals that they themselves cannot identify.”³¹⁸ These findings were reported in the *New York Times*.³¹⁹
- January 2011 – A team of scientists led by a University of Central Arkansas researcher called attention to the threat posed to surface waters by rapidly expanding shale gas development, noting a lack of data collection accompanying the rush to drill. “Gas wells are often close to surface waters that could be impacted by elevated sediment runoff from

³¹⁵ Osborn, S. G., Vengosh, A., Warner, N. R., & Jackson, R. B. (2011). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proceedings of the National Academy of Sciences*, 108, 8172-8176. doi: 10.1073/pnas.1100682108

³¹⁶ Duke University. (2011). Methane levels 17 times higher in water wells near hydrofracking sites, study finds. *ScienceDaily*. Retrieved from <http://www.sciencedaily.com/releases/2011/05/110509151234.htm>

³¹⁷ The Associated Press. (2011, April 22). Crews stop flow of drilling fluid from Pennsylvania well. *Syracuse.com*. Retrieved from http://www.syracuse.com/news/index.ssf/2011/04/crews_stop_flow_of_drilling_fl.html

³¹⁸ Waxman, H. A., Markey, E. J., & DeGette, D. (2011, April 18). Committee on Energy & Commerce (U.S.A., Congress, Committee on Energy & Commerce). Retrieved from <http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic-Fracturing-Chemicals-2011-4-18.pdf>

³¹⁹ Urbina, I. (2011, April 17). Chemicals were injected into wells, report says. *The New York Times*. Retrieved from <http://www.nytimes.com/2011/04/17/science/earth/17gas.html>

pipelines and roads, alteration of stream flow as a result of water extraction, and contamination from introduced chemicals or the resulting wastewater.”³²⁰

- January 31, 2011 – As part of a year-long investigation into hydraulic fracturing and its potential impact on water quality, U.S. Representatives Henry Waxman (D-Calif.), Edward Markey (D-Mass.) and Diana DeGette (D-Colo.) reported that “between 2005 and 2009, oil and gas service companies injected 32.2 million gallons of diesel fuel or hydraulic fracturing fluids containing diesel fuel in wells in 19 states.” Furthermore, revealing apparent widespread violation of the Safe Drinking Water Act, the investigation found that no oil and gas service companies had sought—and no state or federal regulators had issued—permits for the use of diesel fuel in hydraulic fracturing.³²¹
- April 29, 2010 – In 2010, the Colorado Oil and Gas Conservation Commission fined Occidental Petroleum Corporation (OXY) USA a record \$390,000 for an incident of pollution, discovered in 2008, when its drilling wastes leaked through an unlined pit, contaminated two springs with benzene, and polluted other nearby water sources. In addition, the regulators separately fined OXY USA \$257,400 for a nearby case of pollution, also discovered in 2008, in which a torn liner in a pit caused drilling waste fluids to leak out and contaminate two springs with benzene.³²²
- June 5, 2009 – A leaking pipe carrying fracking waste in Washington County, Pennsylvania, polluted a tributary of Cross Creek Lake, killing fish, salamanders, crayfish, and aquatic insect life in approximately three-quarters of a mile of the stream.³²³
- April 26, 2009 – Officials in three states linked water contamination and methane leaks to gas drilling. Incidents included a case in Ohio where a house exploded after gas seeped into its water well and multiple cases of exploding drinking water wells in Dimock, Pennsylvania.³²⁴

³²⁰ Entrekin, S., Evans-White, M., Johnson, B., & Hagenbuch, E. (2011). Rapid expansion of natural gas development poses a threat to surface waters. *Frontiers in Ecology and the Environment*, 9(9), 503-511. doi: 10.1890/110053

³²¹ Waxman, H. A., Markey, E. J., & DeGette, D. (2011, January 31). *Committee on Energy & Commerce* (U.S.A., Congress, Committee on Energy & Commerce). Retrieved from <http://democrats.energycommerce.house.gov/index.php?q=news/waxman-markey-and-degette-investigation-finds-continued-use-of-diesel-in-hydraulic-fracturing-f>

³²² Webb, D. (2010, April 29). Record fine, second one against Oxy approved. *Grand Junction Sentinel*. Retrieved from <http://www.gjsentinel.com/news/articles/record-fine-second-one-against-oxy-approved>

³²³ Pittsburgh Post-Gazette. (2009, June 5). Waste from Marcellus shale drilling in Cross Creek Park kills fish. *Pittsburgh Post-Gazette*. Retrieved, from <http://www.post-gazette.com/washington/2009/06/05/Waste-from-Marcellus-shale-drilling-in-Cross-Creek-Park-kills-fish/stories/200906050136>

³²⁴ Lustgarten, A. (2009, April 26). Officials in three states pin water woes on gas drilling. *ProPublica*. Retrieved from <http://www.propublica.org/article/officials-in-three-states-pin-water-woes-on-gas-drilling-426>

- November 13, 2008 – *ProPublica* reported more than 1,000 cases of drilling-related contamination documented by courts and state and local governments in Colorado, New Mexico, Alabama, Ohio, and Pennsylvania.³²⁵
- December 15, 2007 – In Bainbridge, Ohio, a gas well that was improperly cemented and subsequently fractured by Ohio Valley Energy Systems Corporation allowed natural gas to migrate outside of the well, causing a home to explode. In addition, 23 nearby water wells were contaminated, two of which were located more than 2,300 feet from the drilling site.^{326, 327, 328}

Inherent engineering problems that worsen with time

Studies show that many oil and gas wells leak, allowing for the migration of natural gas and potentially other substances into groundwater and/or the atmosphere. According to Schlumberger, one of the world's largest companies specializing in fracking, about five percent of wells leak immediately, 50 percent leak after 15 years, and 60 percent leak after 30 years. Recent research suggests that the act of fracking itself creates pathways for leaks. The problem of leaking wells, identified by industry, has no known solution. Data from Pennsylvania's Department of Environmental Protection (DEP) agree, showing over nine percent of shale gas wells drilled in the state's northeastern counties leaking within the first five years. Leaks pose serious risks, including potential loss of life or property from explosions and migration of gas and other harmful chemicals into drinking water supplies. Methane leaking into aquifers, can under some conditions, be transformed by bacteria into hydrogen sulfide and other poisonous byproducts. Microbes from deep shale formations can likewise generate sulfides contributing, over time, to corrosion of pipes and casings.

Leaks also allow methane to escape into the atmosphere, where it acts as a more powerful greenhouse gas than carbon dioxide. There is no evidence to suggest that the problem of cement and well casing impairment is abating. Indeed, analysis of more than 75,000 compliance reports for more than 41,000 wells in Pennsylvania found that newer wells have higher leakage rates than older ones and that unconventional shale gas wells leak more than conventional wells drilled within the same time period. Industry has no solution for rectifying the chronic problem of well casing/cement failures and resulting leakage.

³²⁵ Lustgarten, A. (2008, November 13). Buried secrets: Is natural gas drilling endangering U.S. water supplies? *ProPublica*. Retrieved from <http://www.propublica.org/article/buried-secrets-is-natural-gas-drilling-endangering-us-water-supplies-1113>

³²⁶ Ohio Department of Natural Resources Division of Mineral Resources Management. (2008, September 1). *Report on the investigation of the natural gas invasion of aquifers in Bainbridge Township of Geauga County, Ohio*. (Rep.). Retrieved from <http://www.ohiodnr.com/mineral/bainbridge/tabid/20484/default.aspx>

³²⁷ Bair, E. S., Freeman, D. C., & Senko, J. M. (2010, June). *Expert panel technical report, subsurface gas invasion Bainbridge Township, Geauga County, Ohio* (Rep.). Retrieved from <http://oilandgas.ohiodnr.gov/portals/oilgas/pdf/bainbridge/DMRM%200%20Title%20Page,%20Preface,%20Acknowledgements.pdf>

³²⁸ Ohio Department of Natural Resources, Order Number 2009-17 (Apr. 14, 2009) (see attachments A, B).

- November 23, 2017 – An investigative journalist from *The Tyee* in Vancouver obtained a copy of a 2013 report from British Columbia’s Oil and Gas Commission warning about hundreds of uncontrolled methane leaks from shale gas wells located in the northern Rocky Mountain range near Fort Nelson. The commission’s report, never shared with the public or with elected officials, remained an internal document until it was uncovered by the newspaper. Cornell University engineer Anthony Ingraffea, quoted in the story, said the report’s findings served as another confirmation that wells leak badly and inevitably over time. “What do they expect from underground operations such as these, total obedience to design intent? Why are operators and regulators around the world seemingly surprised when things go wrong underground, and in so many ways, and so often?” Ingraffea said.^{329, 330}
- July 5, 2017 – A team of researchers led by microbiologists from Ohio State University investigated bacteria from hydraulically fractured shale by sampling fracking wastewater from a well drilled in the Utica shale. The dominant microorganism was a bacterium that generates sulfides, which can contribute to corrosion of well casings. “The impact of microbial metabolism within these environments is poorly understood. . . . These findings emphasize the potential detrimental effects that could arise from thiosulfate-reducing microorganisms in hydraulically fractured shales, which are undetected by current industry-wide corrosion diagnostics.”³³¹
- July 9, 2015 – As part of a larger examination of the potential health and environmental impacts of fracking in California, the California Council on Science and Technology (CCST) documented cases of well failures triggered by underground movements that caused well casings to shear. Sheared well casings can allow gas and fluids from the fracking zone to migrate to overlying aquifers. The CCST team identified several mechanisms by which casing shears can occur in California as oil wells age: surface subsidence, heaving, reservoir compaction, and earthquakes. Prolonged drought can also damage the integrity of well casings: as groundwater levels fall, landforms can sink and contribute to casing shear.³³²
- June 30, 2015 – According to the New York State Department of Environmental Conservation (NYS DEC) Findings Statement, “there is a risk that well integrity can fail, especially over time, and questions have arisen about whether high-volume hydraulic fracturing can cause seismic changes which could potentially result in fracturing fluid migration through abandoned wells or existing fissures and faults. Thus, high-volume

³²⁹ Nikiforuk, A. (2017, November 23). Despite what politicians say, hundreds of BC gas wells leak methane. *The Tyee*. Retrieved from <https://thetyee.ca/News/2017/11/23/Hundreds-of-BC-Gas-Wells-Leak-Meth/>

³³⁰ BC Oil and Gas Commission. (2013, December). *Gas migration preliminary investigation report*. Retrieved from <https://www.bcogc.ca/node/14620/download>

³³¹ Booker, A. E., Borton, M. A., Daly, R. A., Welch, S. A., Nicora C. D., Hoyt, D. W., . . . Wilkins, M. J. (2017). Sulfide generation by dominant Halanaerobium microorganisms in hydraulically fractured shales. *mSphere*, 2(4), e00257-17. doi: 10.1128/mSphereDirect.00257-17

³³² Stringfellow, W. T., Cooley H., Varadharajan, C., Heberger, M., Reagan, M. T., Domen, J.K., Sandelin, W. . . . Houseworth, J. E. (2015, July 9). Volume II, Chapter 2: Impacts of well stimulation on water resources. In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from <http://ccst.us/publications/2015/vol-II-chapter-2.pdf>

hydraulic fracturing could result in significant adverse impacts to water resources from well construction and fracturing fluid migration.³³³

- June 4, 2015 – As part of a draft assessment of fracking’s impact on drinking water, the U.S. EPA examined cases of water contamination across the United States and concluded that “construction issues, sustained casing pressure, and the presence of natural faults and fractures can work together to create pathways for fluids to migrate toward drinking water resources.” Fracking older wells poses additional risks, the draft study notes, because aging itself “can contribute to casing degradation, which can be accelerated by exposure to corrosive chemicals, such as hydrogen sulfide, carbonic acid, and brines” and because many older wells were never designed to withstand the high pressures and stress of fracking operations. The EPA estimates that 6 percent of the 23,000 U.S. oil and gas wells (= 1,380 wells) first fracked in 2009 or 2010 were drilled more than ten years earlier.³³⁴
- December 2, 2014 – Problems with structural integrity have been documented in a well at the only hydraulically fractured site in the United Kingdom. Email messages obtained under freedom of information laws reveal that problems with wellbore integrity emerged in April of 2014 and attempts were made to remediate the problem, although nothing was reported at that time to regulators. The drilling company, Cuadrilla Resources, continues to deny that any problems exist with the well, emphasizing that “no leak of fluids” occurred and that “the issue” was resolved during the abandonment process. Cuadrilla had previously been reprimanded for failing to disclose a more minor deformation in the well casing. The well was abandoned at the end of last year, following two earthquakes in 2011, which scientists determined to have been caused by fracking at the site.³³⁵
- August 11, 2014 – Researchers affiliated with multiple universities and with the Los Alamos National Laboratory summarized recent field observations of wellbore-integrity failure, concluding that, because at least some well failures are not identified, reported barrier failure rates of 1-10 percent of wells and reported rates of groundwater contamination of 0.01-0.1 percent of wells constitute a “lower bound” for possible environmental problems. Citing hydraulic fracturing, as well as temperature and pressure changes, as operations that can induce pathways for leaks, the authors point out that few studies have considered the very-long-term fate (“>50 years”) of wellbore systems. They

³³³ New York State Department of Environmental Conservation. (2015, June 30). *Final supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program: Regulatory program for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus Shale and other low-permeability gas reservoirs, findings statement*. Retrieved from

http://www.dec.ny.gov/docs/materials_minerals_pdf/findingstatehvhf62015.pdf

³³⁴ U.S. Environmental Protection Agency (2015, June 30). *Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources*, executive summary (draft). Retrieved from http://www2.epa.gov/sites/production/files/2015-06/documents/hf_es_erd_jun2015.pdf

³³⁵ Bryant, B. (2014, December 2). The only fracked site in the United Kingdom suffered structural failure. *Vice News*. Retrieved from <https://news.vice.com/article/the-only-fracking-site-in-the-united-kingdom-suffered-structural-failure>

include “whether unconventional resource development alters the frequency of well integrity failures” as a critical topic for future research.³³⁶

- July 30, 2014 – Based on records obtained from Pennsylvania’s Department of Environmental Protection (PA-DEP), Scranton’s *Times-Tribune* reported that five natural gas wells in Bradford County have leaked methane for years because of persistent casing and cement problems. In the most recent violation, a PA-DEP inspector found combustible gas flowing through vents connected to the cement between layers of pipe. The agency issued a notice of violation for each well, saying combustible gas outside the well’s surface casing violates state regulations. Each of the wells has four layers of steel casing, but nothing prevents leaking (stray) methane from flowing into the atmosphere. No evidence of water contamination has yet been seen. None of the wells have produced any gas for sale.³³⁷
- June 30, 2014 – A study published in *Proceedings of the National Academy of Sciences* by a Cornell University research team projected that over 40 percent of shale gas wells in Northeastern Pennsylvania will leak methane into groundwater or the atmosphere over time. Analyzing more than 75,000 state inspections of more than 41,000 oil and gas wells in Pennsylvania since 2000, the researchers identified high occurrences of casing and cement impairments inside and outside the wells. A comparative analysis showed that newer, unconventional (horizontally fracked) shale gas wells were leaking at six times the rate of conventional (vertical) wells drilled over the same time period. The leak rate for unconventional wells drilled after 2009 was at least six percent, and rising with time. In the state’s northeastern counties between 2000 and 2012, over nine percent of shale gas wells drilled leaked within the first five years.³³⁸ The study also discovered that over 8,000 oil and gas wells drilled since 2000 had not received a facility-level inspection. This study helps explain the results of earlier studies that documented elevated levels of methane in drinking water aquifers located near drilling and fracking operations in Pennsylvania and points to compromised structural integrity of well casings and cement as a possible mechanism.
- May 22, 2014 – In a 69-page report, University of Waterloo researchers warned that natural gas seeping from 500,000 wellbores in Canada represents “a threat to environment and public safety” due to groundwater contamination, greenhouse gas emissions, and explosion risks wherever methane collects in unvented buildings and spaces. The report found that 10 percent of all active and suspended gas wells in British Columbia now leak methane. Additionally, the report found that some hydraulically fractured shale gas wells in that province have become “super methane emitters” that

³³⁶ Jackson R. B., Vengosh, A., Carey, J. W., Davies, R. J., Darrah, T. H., O’Sullivan, F., & Pétron, G. (2014). The environmental costs and benefits of fracking. *Annual Review of Environment and Resources*, 39, 327–62. doi: 10.1146/annurev-environ-031113-144051

³³⁷ Gibbons, B. (2014, July 30). Five gas wells leaked methane for years. *Times-Tribune*. Retrieved from <http://thetimes-tribune.com/news/five-gas-wells-leaked-methane-for-years-1.1727537>

³³⁸ Ingraffea, A., Wells, M., Santoro, R., & Shonkoff, S. (2014). Assessment and risk analysis of casing and cement impairment in oil and gas wells in Pennsylvania, 2000–2012. *Proceedings of the National Academy of Sciences*. Retrieved from <http://www.pnas.org/content/early/2014/06/25/1323422111.abstract>

spew as much as 2,000 kilograms of methane a year.^{339, 340}

- May 1, 2014 – Following a comprehensive review of evidence, the Council of Canadian Academies identified inherent problems with well integrity as one of its top concerns about unconventional drilling and fracking. According to one expert panel, “the greatest threat to groundwater is gas leakage from wells from which even existing best practices cannot assure long-term prevention.”³⁴¹ Regarding their concerns related to well integrity and cement issues, the panel wrote:

Two issues of particular concern to panel members are water resources, especially groundwater, and GHG emissions. Both related to well integrity.... Natural gas leakage from improperly formed, damaged, or deteriorated cement seals is a long-recognized yet unresolved problem Leaky wells due to improperly placed cement seals, damage from repeated fracturing treatments, or cement deterioration over time, have the potential to create pathways for contamination of groundwater resources and to increase GHG emissions.

They further explain:

Cement may crack, shrink, or become deformed over time, thereby reducing the tightness of the seal around the well and allowing the fluids and gases ... to escape into the annulus between casing and rock and thus to the surface.... The challenge of ensuring a tight cement seal [will] be greater for shale gas wells that are subjected to repeated pulses of high pressure during the hydraulic fracturing process than for conventional gas wells. This pressure stresses the casing and therefore the cement that isolates the well from surrounding formations repeatedly.

- January 8, 2013 – According to state inspections of all 6,000 wells drilled in Pennsylvania’s Marcellus Shale before 2013, six to ten percent of them leaked natural gas, with the rate of leakage increasing over time. The rate was six percent in 2010 (97 well failures out of 1,609 wells drilled); 7.1 percent in 2011 (140 well failures out of 1,972 wells drilled); and 8.9 percent in 2012 (120 well failures out of 1,346 wells drilled).³⁴² These data include wells that were cited for leakage violations, and wells that were noted to be leaking by inspectors but which had not been given violations. The NYS DEC forecasts that 50,000 wells could be drilled over the life of the Marcellus Shale

³³⁹ Dusseault, M. B., Jackson, R. E., & MacDonal, D. (2014, May 22). *Towards a road map for mitigating the rates and occurrences of long-term wellbore leakage*. Geofirma. Retrieved from http://geofirma.com/wp-content/uploads/2015/05/lwp-final-report_compressed.pdf

³⁴⁰ Nikiforuk, A. (2014, June 5). Canada’s 500,000 leaky energy wells: ‘Threat to public’ *The Tyee*. Retrieved from <http://www.thetyee.ca/News/2014/06/05/Canada-Leaky-Energy-Wells/>

³⁴¹ Council of Canadian Academies. (2014, May 1). *Environmental Impacts of Shale Gas Extraction in Canada: the Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction*. Retrieved from <http://bit.ly/1nNicuf>

³⁴² Ingraffea, A. R. (2013). Some scientific failings within high volume hydraulic fracturing proposed regulations. Retrieved from http://www.psehealthyenergy.org/data/NYS_DEC_Proposed_REGS_comments_Ingraffea_Jan_2013.pdf

play. If they fail at the same rate as wells in Pennsylvania, 4,000 wells would fail and leak in New York almost immediately.³⁴³

- March 2009 – A study published by the Society of Petroleum Engineers of more than 315,000 oil, gas, and injection wells in Alberta, Canada, found that 4.5 percent of the wells had unintended gas flow to the surface. In one designated area, officials required testing for gas migration outside the well casings in addition to routine testing for gas leaks within the rings of steel casings (annuli). Within this special testing zone, 15.5 percent of wells (3,205 of 20,725) leaked gas, and the incidence of gas leaks was four times percent higher in horizontal or deviated wells than in vertical wells.³⁴⁴
- Autumn 2003 – Schlumberger, one of the world’s largest companies specializing in hydraulic fracturing and other oilfield services, reported in its in-house publication, *Oilfield Review*, that more than 40 percent of approximately 15,500 wells in the outer continental shelf area in the Gulf of Mexico were leaking gas. These included actively producing wells, in addition to shut-in and temporarily abandoned wells. In many cases, the gas leaked through the spaces (annuli) between layers of steel casing that drilling companies had injected with cement precisely to prevent such gas leaks. Leakage rates increased dramatically with age: about five percent of the wells leaked immediately; 50 percent were leaking after 15 years; and 60 percent were leaking after about 30 years.³⁴⁵ Gas leaks pose serious risks including loss of life from explosions and migration of gas and associated contaminants into drinking water supplies. Leaks also allow the venting of raw methane into the atmosphere where it acts as a powerful greenhouse gas.
- November 2000 – Maurice Dusseault, a specialist in rock mechanics at the University of Waterloo in Ontario, and two co-authors presented a paper published by the Society of Petroleum Engineers, in which they reported that oil and natural gas wells routinely leak gas through cracks in their cement casings, likely caused by cement shrinkage over time and exacerbated by upward pressure from natural gas. According to their paper, in Alberta, it is common for wells to leak natural gas into aquifers. “Because of the nature of the mechanism, the problem is unlikely to attenuate,” they wrote, “and the concentration of the gases in the shallow aquifers will increase with time.”³⁴⁶

³⁴³New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (2-1, Rep.).

³⁴⁴ Watson, T. L., & Bachu, S. (2009). Evaluation of the potential for gas and CO₂ leakage along wellbores, Society of Petroleum Engineers. *SPE Drilling & Completion*, 24, 115-126. doi: 10.21.18/106817-PA

³⁴⁵ Brufatto, C. (2003). From mud to cement - Building gas wells. *Oilfield Review*, 15(3). Retrieved from http://www.slb.com/resources/publications/industry_articles/oilfield_review/2003/or2003aut06_building_gas_wells.aspx

³⁴⁶ Dusseault, M. B., Gray, M. N., & Nawrocki, P. A. (2000). Why oil wells leak: Cement behavior and long-term consequences. *Society of Petroleum Engineers*. Retrieved from <http://www.hydrorelief.org/frackdata/references/65704543-Casing-Leaks.pdf>

Radioactive releases

High levels of radiation documented in fracking wastewater from many shale formations raise special concerns in terms of impacts to groundwater and surface water. Measurements of radium in fracking wastewater in New York and Pennsylvania, from the particularly radioactive Marcellus Shale, have been as high as 3,600 times the regulatory limit for drinking water, as established by the U.S. Environmental Protection Agency (EPA). One study found toxic levels of radiation in a Pennsylvania waterway even after fracking wastewater was disposed of through an industrial wastewater treatment plant. The disposal of radioactive drill cuttings is an additional concern. A recent study found high levels of radon in buildings located in heavily drilled areas of Pennsylvania, with levels of radon rising since the start of the fracking boom. Unsafe levels of radon and its decay products in natural gas produced from the Marcellus Shale may also contaminate pipelines and compressor stations, as well as pose risks to end-users when allowed to travel into homes. There is no federal oversight and, in some cases, a total lack of state regulations for handling radioactive oil and gas waste. Increasing evidence documents illegal, haphazard dumping of radioactive fracking waste, along with its disposal in municipal landfills not engineered to contain radioactivity. North Dakota alone generates 70 tons per day of radioactive drilling and fracking waste.

- September 22, 2017 – State health regulators confirmed that unknown quantities of radioactive waste from drilling and fracking operations have been illegally buried in Colorado landfills not permitted to accept it.³⁴⁷
- November 23, 2016 – University of Iowa researchers evaluated radioactive materials—uranium, thorium, radium, lead, and polonium isotopes—from drill cutting samples extracted from a single well drilled in northern Pennsylvania. They found complex patterns of vertical stratification. For example, the deep drill cuttings had significantly more uranium (U) than the cuttings removed from shallow portions of the well. Noting that virtually all drill cutting waste from the Marcellus Shale is deposited in landfills, the authors examined the stability of the various radioactive materials by simulating different conditions of landfill leaching. The results suggested some environmental mobility of radionuclides in drill cuttings. In particular, as acidity increased, radionuclide leaching increased, with ²³⁸U and ²³⁴U being the most leachable radionuclides. The authors concluded, “Although previous studies have suggested that [radioactive materials] in drill cuttings pose a minimal health risk to the general public when deposited in landfills, our results indicate that Marcellus Shale drill cuttings warrant further radiochemical investigation.”³⁴⁸
- April 27, 2016 – Duke University researchers who studied oil and gas wastewater

³⁴⁷ Finley, B. (2017, September 22). Colorado landfills are illegally burying low-level radioactive waste from oil and gas industry, Denver Post learns. *Denver Post*. Retrieved from <https://www.denverpost.com/2017/09/22/colorado-landfills-illegally-burying-radioactive-waste-oil-gas/>

³⁴⁸ Eitheim, E. S., May, D., Forbes, T. Z., & Nelson, A. W. (2016). Disequilibrium of naturally occurring radioactive materials (NORM) in drill cuttings from a horizontal drilling operation. *Environmental Science & Technology Letters* 3, 425-29. doi: 10.1021/acs.estlett.6b00439

(“brine”) spills reported that “the water contamination from brine spills is remarkably persistent in the environment, resulting in elevated levels of salts and trace elements that can be preserved in spill sites for at least months to years” In addition, radioactivity was elevated in soil and sediment sampled at spill sites, indicating that radium had accumulated in the soils of spill-affected areas.³⁴⁹ The bigger the spill, the higher the soil radioactivity level. Study author Avner Vengosh told *InsideClimate News*, “We found even if you take away the spill water . . . you still left behind the legacy of radioactivity in the soils,” where it can linger for thousands of years.³⁵⁰

- March 10, 2016 – Louisville’s *Courier-Journal* reported on illegal dumping of radioactive oil and gas drilling wastes in two Kentucky landfills. Landfill operators in Greenup and Estill counties were issued violation notices for failing to “accurately characterize the waste for what it was, allowing what’s considered an illegal release of a hazardous material into the environment.” The illegal dumping at the Greenup County landfill alone consisted of 369 tons of radioactive drilling waste.³⁵¹
- February 26, 2016 – Radioactive oil and gas waste from fracking operations in Ohio, Pennsylvania, and West Virginia was illegally sent to Estill County, Kentucky’s Blue Ridge Landfill. The radioactive level of the material that was buried “was at least 340 times more than the amount that is allowed to be buried at a solid waste landfill,” according to WKYT in Lexington. WKYT reported that Estill County leaders would “fight ‘tooth and toenail’ to get the bottom of how low-level radioactive waste ended up in a county landfill,” and do its own testing at the landfill and nearby schools.³⁵²
- November 23, 2015 – Absence of federal oversight and, in some cases, a total lack of state regulations for handling radioactive oil and gas waste was the topic of a report in *High Country News*, which detailed the regulatory situation in six Western states: Colorado, Idaho, Montana, North Dakota, South Dakota, and Wyoming. North Dakota alone generates an estimated 70 tons a day of radioactive oil and gas waste. “Because the waste is often too radioactive to be disposed of in landfills, it sometimes gets dumped illegally.” Proposed new rules in North Dakota would raise the radioactivity limit for the waste.³⁵³

³⁴⁹ Lauer, N. E., Harkness, J. S., & Vengosh, A. (2016). Brine spills associated with unconventional oil development in North Dakota. *Environmental Science & Technology*, 50(10), 5389–5397. doi: 10.1021/acs.est.5b06349

³⁵⁰ Hirji, Z. (2016, April 29). Persistent water and soil contamination found at N.D. wastewater spills. *InsideClimate News*. Retrieved from <http://insideclimatenews.org/news/29042016/north-dakota-wastewater-spill-water-soil-contamination-radium-selenium-bakken-oil>

³⁵¹ Bruggers, J. (2016, March 10). State begins crackdown on radioactive waste. *Courier-Journal*. Retrieved from <http://www.courier-journal.com/story/tech/science/environment/2016/03/08/state-orders-end-hauling-radioactive-waste/81496490/>

³⁵² WKYT. (2016, February, 26). Estill County leaders to fight 'tooth and toenail' over radioactive waste in landfill. WKYT. Retrieved from <http://www.wkyt.com/content/news/Estill-Co-leaders-to-fight-tooth-and-toenail-over-radioactive-waste-in-landfill-370308981.html>

³⁵³ Peterson, J. (2015, November 23). States lack rules for radioactive drilling waste disposal. *High Country News*. Retrieved from <http://www.hcn.org/articles/states-lack-rules-for-handling-radioactive-drilling-waste>

- July 8, 2015 – Radium-226 is the dominant radioactive material in flowback water from hydraulically fractured wells in the Marcellus Shale. A Pittsburgh team of researchers studied its fate in three wastewater storage pits in southwestern Pennsylvania over a 2.5-year period of time. They found that radium-226 concentrations increased when flowback water was being reused for additional fracking operations. Also, radium-226 tended to accumulate in the bottom sludge. This sludge could be classified as radioactive solid waste because it exceeded the radium-226 limit for landfill disposal. A risk assessment showed that potential radiation dose equivalent levels around the three fracking waste pits were within the regulatory limit for the general public.³⁵⁴
- April 9, 2015 – A Johns Hopkins Bloomberg School of Public Health study found that levels of radon in Pennsylvania homes—a region with some of the highest indoor radon concentrations in the US—have been rising since 2004, around the time the fracking industry arrived in the state.³⁵⁵ Radon exposure is the second leading cause of lung cancer worldwide, after cigarette smoking.³⁵⁶ Researchers found that buildings in counties where the most fracking has taken place in the past decade have had significantly higher radon readings compared with those in low-fracking areas, a difference that did not exist before 2004. Use of well water was associated with 21 percent higher indoor radon concentrations than in buildings using public water sources. This study, the first to define and evaluate the predictors of indoor radon concentrations in Pennsylvania, concluded that radon’s presence was related to geology, water sources, weather, and natural gas drilling.³⁵⁷
- April 2, 2015 – A team of toxicologists, geochemists, and radiation scientists led by the University of Iowa analyzed the contribution of various naturally occurring radioactive materials (NORM) to the total radioactivity of fracking waste fluids, finding evidence of long-lived, environmentally persistent radioactive decay products.³⁵⁸ “NORM is emerging as a contaminant of concern in hydraulic fracturing/unconventional drilling wastes, yet the extent of the hazard is currently unknown.” The study determined that previous testing and study methods likely underestimate radioactivity by focusing only on radium. The researchers developed a new method to accurately predict the concentrations of uranium, thorium, and radium and their alpha-emitting progeny, polonium and lead, in fracking wastewater. They found that, under certain conditions,

³⁵⁴ Zhang, T., Hammock, R. W., & Vidic, R. D. (2015). Fate of radium in Marcellus Shale flowback water impoundments and assessment of associated health risks. *Environmental Science & Technology* 49, 9347-54. doi: 10.1021/acs.est.5b01393

³⁵⁵ Casey, J. A., Ogburn, E. L., Rasmussen, S. G., Irving, J. K., Pollak, J., Locke, P. A., & Schwartz, B. S. (2015). Predictors of indoor radon concentrations in Pennsylvania, 1989-2013. *Environmental Health Perspectives*. Advance online publication. doi: 10.1289/ehp.

³⁵⁶ National Cancer Institute (2011, December 6). Radon and cancer fact sheet. Retrieved from <http://www.cancer.gov/about-cancer/causes-prevention/risk/substances/radon/radon-fact-sheet>

³⁵⁷ Hurdle, J. & Phillips, S. (2015, April 9). New study raises possible link between gas drilling and radon levels. *StateImpact Pennsylvania*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2015/04/09/new-study-raises-possible-link-between-gas-drilling-and-radon-levels/>

³⁵⁸ Nelson, A. W., Eitrheim, E. S., Knight, A. W., May, D., Mehrhoff, M. A., Shannon, R., . . . Schultz, M.K. (2015). Understanding the radioactive in growth and decay of naturally occurring radioactive materials in the environment: An analysis of produced fluids from the Marcellus Shale. *Environmental Health Perspectives*, 123(7). doi: 10.1289/ehp.1408855

radioactivity increased over time, due to ingrowth of alpha-emitting radioactive progeny of long-lived parent radionuclides such as radium. The authors warned that these decay products may potentially contaminate recreational, agricultural, and residential areas, and that a more detailed understanding is needed of how radionuclides accumulate in higher organisms. In an accompanying article in *Environmental Health Perspectives*, James Burch, a University of South Carolina epidemiologist who was not involved in the study, said that fracking activities and wastewater disposal, which often take place in close proximity to where people live and work, raise risks for human exposure. “The technology is vastly outpacing what we know about the health effects.”³⁵⁹

- May 8, 2014 – A group of leading medical experts and the American Lung Association of the Northeast detailed research and growing concerns about potential health impacts of radon and radium associated with natural gas production and the Marcellus Shale, in particular. High levels of radiation in the Marcellus Shale could pose health threats if high concentrations of radon and its decay products travel with natural gas, a problem compounded by the short distance Marcellus gas could travel in pipelines to people’s homes.³⁶⁰
- March 24, 2014 – A team led by toxicology researchers at the University of Iowa identified high levels of radioactivity in fracking wastewater as a significant concern and noted that the testing methods used and recommended by state regulators in the Marcellus Shale region can dramatically underestimate the amount of radioactivity—specifically radium—in fracking wastewater.³⁶¹ Results obtained using EPA-recommended protocols can be obscured by the presence of other contaminant mixtures. Regarding the use of EPA protocols with fracking wastewater or other highly saline solutions, Duke University geochemist Avner Vengosh noted, “People have to know that this EPA method is not updated.”³⁶²
- February 2014 – The Marcellus Shale is known to have high uranium and radium content. According to Mark Engle, USGS geochemist, the concentration of radium-226 can exceed 10,000 picoCuries/Liter (pCi/L) in the shale. Radium-226 has a half-life of 1,600 years. Radium and other naturally occurring radioactive materials (NORM) can be released from shale rock during drilling and fracking and can emerge with flowback and produced waters. It can thus enter the ambient environment and become concentrated in the sludge that results from treatment of flowback water, and in river sediment around water treatment facilities. It can also be found in landfills in which sludge and sediment

³⁵⁹ Konkel, L. (2015). What's NORMal for fracking? Estimating total radioactivity for produced fluids. *Environmental Health Perspectives*, 123(7). Retrieved from <http://ehp.niehs.nih.gov/123-a186/>

³⁶⁰ Campbell, J. (2014, May 8). Fracking critics keep pushing for state-backed health study. *Politics on the Hudson*. Retrieved from <http://polhudson.lohudblogs.com/2014/05/08/fracking-critics-keep-pushing-state-backed-health-study/>

³⁶¹ Nelson, A. W., May, D., Knight, A. W., Eitheim, E. S., Mehrhoff, M., Shannon, R., . . . Schultz, M. K. (2014). Matrix complications in the determination of radium levels in hydraulic fracturing flowback water from Marcellus shale. *Environmental Science & Technology*, 1(3), 204-208. doi: 10.1021/ez5000379

³⁶² Kelly, S. (2014, March 24). Research shows some test methods miss 99 percent of radium in fracking waste. *Desmogblog.com*. Retrieved from <http://www.desmogblog.com/2014/03/23/some-testing-methods-can-miss-99-percent-radium-fracking-waste-new-research-reports>

have been disposed. Some radium can be found in drinking water. Geochemist Avner Vengosh warned, “Once you have a release of fracking fluid into the environment, you end up with a radioactive legacy.”³⁶³

- October 2, 2013 – A peer-reviewed study of the impacts of drilling wastewater treated and discharged into a creek by a wastewater facility in western Pennsylvania documented radium levels approximately 200 times greater in sediment samples near the discharge location than in sediment samples collected upstream of the plant or elsewhere in western Pennsylvania. “The absolute levels that we found are much higher than what you allow in the U.S. for any place to dump radioactive material,” one of the authors told *Bloomberg News*. The pollution occurred despite the fact that the treatment plant removed a substantial amount of the radium from the drilling wastewater before discharging it. The researchers wrote that the accumulation of radium in sludge removed from the wastewater “could pose significant exposure risks if not properly managed.”^{364, 365}
- February 2013 – In an analysis of fracking sludge samples from Pennsylvania, researchers “... confirmed the presence of alpha, beta, and gamma radiation in the soil and water in reserve pits located on agricultural land.” Total beta radiation exceeded regulatory guideline values by more than 800 percent, and elevated levels of some of the radioactive constituents remained in a vacated pit that had been drained and leveled. It is imperative, the research team concluded, “that we obtain better knowledge of the quantity of radioactive material and the specific radioisotopes being brought to the earth’s surface from these mining processes.”³⁶⁶
- July 26, 2012 – Responding to concern about radon in natural gas produced from the Marcellus Shale, the USGS analyzed ten samples of gas collected near the wellheads of three Pennsylvania gas wells. The agency found radon levels ranging from 1-79 picocuries per liter, with an average of 36 and a median of 32. (The highest radon activity reported here would decay to 19.8 pCi/L in approximately a week; by comparison, the EPA’s threshold for indoor air remediation is 4 pCi/L.) Asserting they knew of no previous published measurements of radon in natural gas from the Appalachian Basin, which contains the Marcellus Shale, agency scientists concluded that the number of

³⁶³ Brown V. J. (Feb 2014). Radionuclides in fracking wastewater. *Environmental Health Perspectives* 122(2), A50-A55. doi: 10.1289/ehp.122-A50

³⁶⁴ Warner, N. R., Christie, C. A., Jackson, R. B., & Vengosh, A. (2013). Impacts of shale gas wastewater disposal on water quality in Western Pennsylvania. *Environmental Science & Technology*, 47(20), 11849-11857. doi: 10.1021/es402165b

³⁶⁵ Efstathiou, J., Jr. (2013, October 2). Radiation in Pennsylvania creek seen as legacy of fracking. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2013-10-02/radiation-in-pennsylvania-creek-seen-as-legacy-of-frackin.html>

³⁶⁶ Rich, A. L., & Crosby, E. C. (2013). Analysis of reserve pit sludge from unconventional natural gas hydraulic fracturing and drilling operations for the presence of technologically enhanced naturally occurring radioactive material (TENORM). *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, 23(1), 117-135. doi: 10.2190/NS.23.1.h

samples “is too small to ... yield statistically valid results” and urged “collection and interpretation of additional data.”³⁶⁷

- January 11, 2012 – In its review of the New York State Department of Environmental Conservation’s (NYS DEC) Supplemental Generic Environmental Impact Statement (SGEIS) on high volume fracturing, the EPA expressed concerns about the diffusion of responsibility for the ultimate disposal of radioactive wastes generated by treatment or pretreatment of drilling wastewater. The EPA also raised concerns about the lack of analysis of radon and other radiation exposure. “Who is responsible for addressing the potential health and safety issues and associated monitoring related to external radiation and the inhalation of radon and its decay products?” the EPA asked. “Such potential concerns need to be addressed.”³⁶⁸
- September 7, 2011 – The USGS reported that radium levels in wastewater from oil and gas wells in New York and Pennsylvania, including those in the Marcellus Shale, “have a distinctly higher median ... than reported for other formations in the Appalachian Basin, and range to higher values than reported in other basins.” The median level of radium found in Marcellus Shale wastewater in New York, 5,490 pCi/L, is almost 1,100 times the maximum contaminant level for drinking water, which is five pCi/L. In other words, if a million gallons of Marcellus Shale wastewater contaminated with the median level of radium found in New York were to spill into a waterway, 1.1 billion gallons of water would be required to dilute the radium to the maximum legal level.³⁶⁹ (The EPA’s health-based goal for radium in drinking water is zero.) Over time, radium naturally decays into radioactive radon gas. Thus, higher radium levels also suggest that higher levels of radon may also be present in natural gas produced from the Marcellus Shale.
- February 27, 2011 – The *New York Times* reported on the threat to New York’s drinking water from Pennsylvania drilling waste due to the presence of chemical contaminants, including high levels of radioactivity. The investigation found that sewage treatment plants were neither testing for nor capable of removing that radioactivity, which was subsequently discharged into waterways that supply drinking water, and that, in some cases, wastewater contained radium levels that were hundreds of times higher than the drinking water standard. Drillers sent some of this waste to New York State for disposal even though, as the article noted, EPA scientists had warned the state about this very problem in a December 2009 letter that advised against sewage treatment plants

³⁶⁷ Rowan, E. L., & Kraemer, T. F. (2012). *Radon - 222 content of natural gas samples from upper and middle Devonian sandstone and shale reservoirs in Pennsylvania: Preliminary data*. United States Geological Survey. (Rep.). Retrieved from <http://pubs.usgs.gov/of/2012/1159/ofr2012-1159.pdf>

³⁶⁸ Environmental Protection Agency. (2012, January 11). *EPA comments on revised draft NYSDEC revised dSGEIS for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* [Press release]. Retrieved from <http://www.epa.gov/region2/newsevents/pdf/EPA%20R2%20Comments%20Revised%20dSGEIS%20Enclosure.pdf>

³⁶⁹ Rowan, E. L., Engle, M. A., Kirby, C. S., & Kraemer, T. F. (2011, September 7). *Radium content of oil- and gas-field produced waters in the northern Appalachian basin (USA): Summary and discussion of data*. (Rep United States Geological Survey. Retrieved from <http://pubs.usgs.gov/sir/2011/5135/>
<http://water.epa.gov/drink/contaminants/basicinformation/radionuclides.cfm>

accepting drilling waste with radium levels 12 or more times as high as the drinking water standard.³⁷⁰

- 2008-2009 – The New York State DEC found that wastewater from 11 of 13 vertical wells drilled in New York’s Marcellus Shale in 2008 and 2009 contained radium levels ranging from 400 times to nearly 3,400 times EPA’s safe level limit for radium in drinking water. These figures later informed the 2011 study of radium in drilling wastewater conducted by the USGS.³⁷¹

Occupational health and safety hazards

Drilling and fracking jobs are among the most dangerous jobs in the nation with a fatality rate that is four to seven times the national average. Irregularities in reporting practices mean that counts of on-the-job fatalities among oil and gas workers are likely underestimates. Contract workers are especially at risk; the majority of those killed by fatal falls in oil and gas extraction from 2003–2013 worked for contractors. Occupational hazards include head injuries, traffic accidents, blunt trauma, burns, inhalation of hydrocarbon vapors, toxic chemical exposures, heat exhaustion, dehydration, and sleep deprivation. An investigation of occupational exposures found high levels of benzene in the urine of well-pad workers, especially those in close proximity to flowback fluid coming up from wells following fracturing activities. Exposure to silica dust, which is definitively linked to silicosis and lung cancer, was singled out by the National Institute for Occupational Safety and Health as a particular threat to workers in fracking operations where silica sand is used. At the same time, research shows that many gas field workers, despite these serious occupational hazards, are uninsured or underinsured and lack access to basic medical care.

- December 6, 2017 – Two occupational fatalities and numerous injuries resulted from explosions and fires along oil and gas pipelines in Colorado in the time since two men were killed at home from such a blast in April 2016, according to a *Denver Post* investigation. One contract worker was killed and two others were injured in May while they “were changing ‘dump lines’ and ‘one or more tanks exploded,’ according to a report filed in [Colorado Oil and Gas Conservation Commission’s] database.” Another worker died of his burn injuries from a flash fire in November that broke out during work on a pipeline. “The COGCC did not receive a report on this incident... because the pipeline was a ‘gathering line’ outside the agency’s regulatory purview.” The

³⁷⁰ Urbina, I. (2011, February 26). Regulation lax as gas wells’ tainted water hits rivers. *The New York Times*. Retrieved from http://www.nytimes.com/2011/02/27/us/27gas.html?pagewanted=all&_r=0

³⁷¹ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (5-133, 5-141, 7-60, Appendix 12, Appendix 13, Rep.).

investigation documented additional gaps in regulatory oversight and responses to deaths and injuries.³⁷²

- October 1, 2017 – An investigation by the *Toronto Star*, the *National Observer*, *Global News*, and four Canadian journalism schools reported on hydrogen sulphide (H₂S)-related health threats and incidents (including one occupational death) in Saskatchewan, and government and industry failure to prevent, warn, and respond to this threat. The more than 50 reporters involved “examined thousands of industry and government documents, analyzed terabytes of data and delved into dozens of freedom-of-information requests,” documenting, for example, the existence of government data describing H₂S “hotspots” across the province, that were never released to the public despite agency deliberations. In addition, reporters wrote,

Ministry and industry met four times between 2012 and 2014 to plot strategy, including emergency planning zones, a public communications document, a code of practice and a licensing regime for high-risk, single-well batteries. Those plans were never adopted, a ministry statement confirms.

An industry salesman was killed in 2014 while taking samples. A valve broke and the concentration of H₂S in the spewed fluids, according to the company, “was estimated at 40,000 parts per million, more than enough to bring near-instant death.” The investigation found that four months after the death, “a secret ministry report listed 161 facilities ‘that may be in violation of (the ministry’s) sour gas emission control.’”³⁷³

- May 30, 2017 – In a “rare, but not unprecedented” case, the U.S. Environmental Protection Agency (EPA) opened an investigation of air emissions from two North Dakota oil well sites where worker deaths occurred in 2012 and 2014. The EPA requested information from both companies to determine Clean Air Act compliance on the day of the deaths. According to the *E&E News* report, it was not clear whether the agency was “looking at civil or criminal sanctions.” Both workers, who were “flow testers,” “assigned to regularly measure tank levels by hand,” were found dead near tank hatches.³⁷⁴ [No further information could be located on this investigation.]
- April 28, 2017 – Fatality rates for oil and gas extraction workers associated with falls increased two percent per year during 2003–2013, according to the Centers for Disease Control and Prevention’s *Morbidity and Mortality Weekly Report*. These 63 fatal falls represented 15 percent of the fatal events among this group in the time period. The majority of those who were killed by falls worked for drilling contractors. In the vast

³⁷² Finley, B. (2017, December 6). A dozen fires and explosions at Colorado oil and gas facilities in 8 months since fatal blast in Firestone. *Denver Post*. Retrieved from <http://www.denverpost.com/2017/12/06/colorado-oil-gas-explosions-since-firestone-explosion/>

³⁷³ Cribb, R., Sonntag, P., Elliot, P. W., & McSheffrey, E. (2017, October 1). That rotten stench in the air? It’s the smell of deadly gas and secrecy. *Thestar.com*. Retrieved from <https://www.thestar.com/news/canada/2017/10/01/that-rotten-stench-in-the-air-its-the-smell-of-deadly-gas-and-secrecy.html>

³⁷⁴ Soraghan, M. (2017, May 30). EPA investigating emissions in tank deaths. *E&E News*. Retrieved from <https://www.eenews.net/stories/1060055258>

majority of cases, “fall protection was required by regulation, but it was not used, was used improperly, or the equipment failed.” Authors noted several limitations of their report, such as the lack of information on self-employed workers and lack of detail in some fatality reports.³⁷⁵

- April 26, 2017 – The 2017 edition of the AFL-CIO report, *Death on the Job: The Toll of Neglect*, which reported on the year 2015, showed that, although the number of deaths in the oil and gas extraction industries decreased compared to 2014 (89 compared to 144), employment in oil and gas extraction also decreased from 613,783 in 2014 to 533,184 in 2015. The deaths in the oil and gas extraction industries “accounted for 74% of the fatal work injuries in the mining sector.” Referring to the challenges of getting a firm handle on statistics in this industry, the report stated that, “[f]atality rate data for the oil and gas industry are limited, but available data during the past seven years show fatality rates in oil and gas extraction that are four to seven times the national fatality rate.” Further, “[n]ot surprisingly, states with large amounts of oil and gas activity also have high job fatality rates.” Citing the continuing problem of assigning cause of death in the case of possible inhalation of toxic fumes, the report stated, “[w]hile some deaths are appropriately classified as inhalation deaths, others can be labeled as cardiac arrhythmia or respiratory failure, without further investigation as to whether the health event was induced by acute chemical exposure.” As in previous years, the report expressed concerns about the regulatory gaps in controlling a range of potentially fatal hazards in the industry.³⁷⁶
- February 1, 2017 – University of Tennessee Civil and Environmental Engineering faculty investigated the occupational inhalation risks from the emissions of chemical storage tanks in 60,644 fracking wells. They also analyzed the combined occupational inhalation risks caused by open flowback pits and the storage tanks. They used AERMOD, the air pollution dispersion modeling system developed by the American Meteorological Society and EPA, and inhalation risk assessment to determine potential acute non-cancer, chronic non-cancer, acute cancer, and chronic cancer risks. Their results showed the percentage of wells presenting these risks were 12.41, 0.11, 7.53, and 5.80, respectively. They also found that the storage tanks presented the majority of the cancer risks, and the non-cancer risks were associated primarily to the open pits. The known human carcinogen formaldehyde was “the dominant contributor” to both acute (4,267 wells) and chronic (3,470 wells) cancer risk. Authors also reported that volatile organic compound (VOC) emissions from nearby wells and other on-site sources means that the data used in their study “were lower than reported concentrations from field measurements where higher occupational inhalation risks for exposure may be expected.”³⁷⁷

³⁷⁵ Mason, K. L., Retzer, K. D., Hill, R., & Lincoln, J. M. (2017). Occupational fatalities resulting from falls in the oil and gas extraction industry, United States, 2005–2014. *MMWR*, 66(16), 417–421. doi: <http://dx.doi.org/10.15585/mmwr.mm6616a2>

³⁷⁶ AFL-CIO. (2016). *Death on the job: The toll of neglect*. Retrieved from <https://aflcio.org/reports/death-job-toll-neglect-2017>

³⁷⁷ Chen, H., & Carter, K. E. (2017). Modeling potential occupational inhalation exposures and associated risks of toxic organics from chemical storage tanks used in hydraulic fracturing using AERMOD. *Environmental Pollution*, 224, 300–309. doi: 10.1016/j.envpol.2017.02.008

- January 19, 2017 – A group of Canadian physicians published a report documenting ten intentional intoxications from the ingestion of fracking fluid. Each individual survived, which the authors attribute to “[r]apid case finding and diligent contact tracing.” Their report, published in the *American Journal of Kidney Diseases*, focused on this appropriate response and treatment, but also described the “outbreak” challenge from a public health perspective and emphasized the need for prevention education and “requiring secure storage of these products.” Though the professions or workplaces of the patients are not described, presumably they were oil and gas industry workers with easy access to fracking fluid.³⁷⁸
- September 25, 2016 – A four-chapter investigative series by the *Denver Post* explored in detail Colorado’s 12-year record of an oil and gas worker dying, on average, every three months. The piece documented the obstacles present in even clarifying the occupational mortalities owing to the differing reporting practices of the Bureau of Labor Statistics, OSHA, and state officials. “Regulation is so disjointed that no one can even agree on the number of workers killed on the job.” Investigating the details of the deaths through any available records, the *Post* described a “regulatory vacuum,” as well as “little consequence” to the industry when deaths (or worksite violations) occur. Worker death circumstances examined in the piece included electrocutions, falls and collapsed structures, crushings by equipment, explosions, and a drowning in frack sand. The *Post* also identified five lawsuits over 15 years “in which workers alleged that they were punished for reporting injuries or safety hazards.”³⁷⁹
- April 27, 2016 – According to the 2016 edition of the AFL-CIO report, *Death on the Job: The Toll of Neglect*, the fatality rate for workers in the oil and gas extraction industries is nearly five times the national average, and the states with prominent oil and gas industries are among the most dangerous states to work. In addition, the report emphasized, the industry has been exempted from some critical Occupational Safety and Health Administration (OSHA) standards, including that for carcinogenic benzene. The report also emphasized the danger of silica dust exposure in hydraulic fracturing-related work and the significant delays in controlling workers’ exposures in these operations. “Oil and gas extraction is subject to OSHA general industry and construction regulations, none of which are designed to address the particular safety and hazards in the oil and gas industry. . . . The escalating fatalities and injuries in the oil and gas extraction industry demand intensive and comprehensive intervention,” the report stated.³⁸⁰
- April 21, 2016 – According to an updated report from the Bureau of Labor Statistics, fatal work injuries in oil and gas extraction industries in 2014 reached a new high of

³⁷⁸ Collister, D., Duff, G., Palatnick, W., Komenda, P., Tangri, N., & Hingwala, J. (2017). A methanol intoxication outbreak from recreational ingestion of fracking fluid. *American Journal of Kidney Diseases*, 69(5), 696-700. doi: 10.1053/j.ajkd.2016.10.029

³⁷⁹ Sangosti, R.J. (2016, September 25). Drilling through danger. *Denver Post*. Retrieved from <http://extras.denverpost.com/oil-gas-deaths/index.html>

³⁸⁰ AFL-CIO. (2016). Death on the job: The toll of neglect. Retrieved from <http://www.aflcio.org/Issues/Job-Safety/Death-on-the-Job-Report>

144.³⁸¹ The final 2015 data are scheduled for release on December 16, 2016.

- February 29, 2016 – *Inside Energy*'s report on high rates of hydrocarbon vapor poisoning among oilfield workers noted that an outdated reliance on manual measurements rather than automated monitoring contributes to ongoing toxic exposures of workers. Under federal oil and gas regulations, oil companies are effectively required to send workers “up on oil and gas tanks to manually measure crude oil, putting them at risk.” The report explained that the Bureau of Land Management (BLM) allows just one kind of automated measurement. The method is expensive and uncommonly used: “there are only 1,500 in use, compared to more than 83,000 oil tanks on federal land. By being so inflexible, BLM’s outdated rules make it very hard to use safer oil measuring devices while making manual oil tank measurement—which endangers workers—the most viable option for companies.”³⁸²
- February 19, 2016 – The fatal injuries of a backhoe operator who struck and hit an unmarked, high-pressure gas line in July 2015 prompted an investigation by *StateImpact* in Pennsylvania. The news group noted that “there are no local, state or federal rules on how deep the lines should be buried underground, or even if they’re buried at all. There are no standards for building and maintaining the lines. They don’t have to be marked. And the operator of the line doesn’t have to participate in PA One Call [a statewide communications system for preventing damage to underground facilities], which led to the fatality in Armstrong County.”³⁸³
- January 15, 2016 – In a publication in Centers for Disease Control’s *Mortality & Morbidity Weekly Report*, researchers urged local and state epidemiologists and medical examiners to not overlook hydrocarbon exposure as an underlying cause of death in gas and oil field workers. “Health and safety professionals need to recognize and act on nonfatal warning signs and symptoms, such as dizziness, confusion, immobility and collapse in oil and gas workers who might have been exposed to high concentrations of [hydrocarbon gas vapors] and to [oxygen]-deficient atmospheres.” Only three of nine deaths that occurred between 2010 and 2015 in the oil and gas fields west of Appalachia were ruled by coroners to have resulted from exposure to gas vapors, although all nine had opened hatches of storage tanks and were exposed to hydrocarbon vapors and oxygen-deficient air.³⁸⁴ The *Pittsburgh Post-Gazette* quoted emeritus professor at the University of Pittsburgh Bernard Goldstein saying, “Occupational health experts also

³⁸¹ U.S. Bureau of Labor Statistics. (2016, April 21). Revisions to the 2014 Census of Fatal Occupational Injuries (CFOI). Retrieved from http://www.bls.gov/iif/foi/foi_revised14.htm

³⁸² Guerin, E. (2016, February 29). “Senseless exposures”: How money and federal rules endanger oilfield workers. *Inside Energy*. Retrieved from <http://insideenergy.org/2016/02/29/senseless-exposures-how-money-and-federal-rules-endanger-oilfield-workers/>

³⁸³ Phillips, S. (2016, February 19). Worker dies in pipeline accident, PUC steps up calls for reform. *StateImpact*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2016/02/19/worker-dies-in-pipeline-accident-puc-steps-up-calls-for-reform/>

³⁸⁴ Harrison, R. J., Retzer, K., Kosnett, M. J., Hodgson, M., Jordan, T., Ridl, S., & Kiefer, M. (2016). Sudden deaths among oil and gas extraction workers resulting from oxygen deficiency and inhalation of hydrocarbon gases and vapors — United States, January 2010–March 2015. *Morbidity and Mortality Weekly Report*, 65(1), 6-9. Retrieved from <http://www.cdc.gov/mmwr/volumes/65/wr/mm6501a2.htm>

suspect that some deaths involving fires, falls, crashes and mishandling of equipment have resulted from faulty judgement or ‘wooziness’ associated with hydrocarbon vapor exposure ... [b]ut that underlying factor rarely shows up in fatality reports.”³⁸⁵

- December 14, 2015 – As reported in the *Guardian*, the suicide rate in the Canadian province of Alberta spiked by 30 percent spike in the first half of 2015, possibly linked to the boom-and-bust cycle of the fracking industry. At the time of reporting, 40,000 jobs had been lost in Alberta since the drop in oil prices in late 2014. Mental health professionals interviewed for the report included Edmonton social worker Leonard McEwan, who specializes in clinical crises intervention and whose patients include those directly or indirectly employed in the oil fields, noticed a sharp increase in suicides after the recent plunge in oil prices. As revealed in the investigative report, three in every four Alberta suicides are male and the vast majority are under 55. Gladys Blackmore, executive director of a mental health program that targets those employed in the industry, believes that young, male workers “living high-risk lifestyles, often in work camps, where they ‘fly-in/fly-out’ for up to 24 days at a time” are particularly vulnerable.³⁸⁶
- November 7, 2015 – The *Denver Post* reported on a “new federal database that was developed to more precisely capture the deadly nature of oil and gas extraction.” For Colorado, the national Fatalities in Oil and Gas Extraction (FOG) database contained two additional oil and gas worker deaths for 2014 than did the Bureau of Labor Statistics. “‘We knew from the Bureau of Labor Statistics data about the basics of what’s killing workers,’ said Kyla Retzer, an epidemiologist who led the effort to compile the FOG report. ‘We just wanted to be more in-depth in finding out what were the types of operations and equipment were involved in these deaths.’”³⁸⁷
- November 4, 2015 – San Antonio’s *Express-News* Editorial Board called for specific actions to address Texas’s status “a national leader in oil field deaths.” The Board wrote that federal fines are too low and unchanged since 1991 and that there is no Level 1 trauma center south of San Antonio near the region’s oil- and gas-producing counties.³⁸⁸

³⁸⁵ Litvak, A. (2016, January 25). Vapors linked to oxygen depletion present hazard for oil, gas workers. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/policy-powersource/2016/01/25/Vapors-linked-to-oxygen-depletion-present-hazard-for-oil-gas-workers/stories/201601220095>

³⁸⁶ Mouallem, O. (2015, December 14). The boom, the bust, the darkness: suicide rate soars in wake of Canada's oil crisis. *The Guardian*. Retrieved from https://www.theguardian.com/world/2015/dec/14/canada-oil-production-crisis-suicide-alberta?CMP=share_btn_fb

³⁸⁷ Whaley, M. (2015, November 7). Colorado oil deaths greater in 2014 than previously calculated. *Denver Post*. Retrieved from <http://www.denverpost.com/2015/11/07/colorado-oil-deaths-greater-in-2014-than-previously-calculated/>

³⁸⁸ *Express-News* Editorial Board. (2015, November 4). Take care of the state’s oil, gas workers. *MySanAntonio.Com*. Retrieved from <http://www.mysanantonio.com/opinion/editorials/article/Take-care-of-the-state-s-oil-gas-workers-6611077.php>

- September 17, 2015 – The Bureau of Labor Statistics reported that the number of fatal work injuries in oil and gas extraction industries rose 27 percent between 2013 and 2014.³⁸⁹
- September 15, 2015 – E&E Publishing’s *EnergyWire* reported on the potentially deadly risk of exposure to vapors from oil and gas field storage tanks, including deaths that were officially attributed to cardiac arrest, though inhalation of toxic gases and lack of oxygen played a role, as demonstrated in subsequent litigation. The reporter gave detail on the circumstances of several of the deaths, including that of a long-haul trucker who had heart disease and was diabetic, and whose death was classified as natural. “But he didn’t suffer a heart attack that day, or a diabetic episode. Medical experts said he likely wouldn’t have died outside the toxic atmosphere on the catwalk.” A Denver cardiologist testified that “there was no other reason for him to have died that day.”³⁹⁰ (NIOSH has subsequently targeted outreach to medical examiners to improve their recognition of this hazard and potential cause of death; see above.)
- September 5, 2015 – In partnership with Rocky Mountain PBS I-News, *The Durango Herald* reported on the oil and gas industry’s varied practices in their handling of silica sand with regard to worker protection. In 2012 the National Institute for Occupational Safety and Health issued an alert concerning workers at fracking sites being exposed to silica dust at levels that exceeded occupational exposure limits. Industry has resisted updates to the standards. The *Herald* report addressed technological and work practice controls to reduce exposure on the part of some companies. Still, authors wrote, silicosis “can hide for a decade before causing symptoms. No one knows how many oil and gas workers may have already been exposed.”³⁹¹
- June 29, 2015 – An investigation by the Center for Public Integrity (CPI) found that lung-damaging silica is not sufficiently regulated to prevent silicosis (which is incurable and has no effective treatment) or lung cancer in the workplace. Rules governing occupational exposure to silica dust are far outdated, and advocacy efforts to tighten them are four decades old. At particular risk, say the authors, are workers in oil and gas fields where silica sand is used in fracking operations. Citing research by NIOSH, the CPI team noted that nearly 80 percent of the air samples on the well pads were above the recommended exposure limit for silica dust.³⁹²

³⁸⁹ U.S. Department of Labor, Bureau of Labor Statistics (2015, September 17). National census of fatal occupational injuries in 2014 (preliminary results). USDL-15-1789. Retrieved from <http://www.bls.gov/news.release/pdf/foi.pdf>

³⁹⁰ Soraghan, B. (2015, September 14). SAFETY: How shale oil can kill. *E&E Publishing, LLC*. Retrieved from <http://www.eenews.net/stories/1060024589>

³⁹¹ Boiko-Weyrauch, A. (2015, September 5). Oil, gas industry responding to threat of worker lung disease. *Durango Herald*. Retrieved from <http://www.durangoherald.com/article/20150905/NEWS02/150909741/Oil-gas-industry-responding-to-threat-of-worker-lung-disease->

³⁹² Morris, J., Hopkins, J. S., & Jameel, M. (2015, June 30). Unequal risk: Slow-motion tragedy for American workers. *The Center for Public Integrity*. Retrieved from <http://www.publicintegrity.org/2015/06/29/17518/slow-motion-tragedy-american-workers>

- June 15, 2015 – *EnergyWire* examined issues surrounding exposure to crystalline silica from frack sand mining, which is a health concern to those living near mines and to those working in the industry. Families living near industrial sand mining reported that their health has been compromised by sand mine development and are concerned that companies are not properly monitoring their extraction sites. The article noted that the Occupational Safety & Health Administration (OSHA) is working on a new exposure rule for workers that OSHA estimates would save nearly 700 lives and prevent 1,600 new cases of silicosis annually. The oil and gas industry is fighting the rule because of the cost associated with complying with a more stringent permissible exposure limit. Crispin Pierce, public health researcher at the University of Wisconsin in Eau Claire, is in the midst of a three-pronged research project to look at the industry’s air effects. Among other findings, his project’s air monitors around sand plants have found consistently finding higher readings than the Wisconsin Department of Natural Resources’ reported regional values.³⁹³
- June 15, 2015 – In an update, NIOSH noted that silicosis death rates are rising again, reversing an earlier, decade-long decline. In the list of job tasks with known high silica exposures, the update named hydraulic fracturing of gas and oil wells. These results are particularly concerning in light of earlier research showing significant under-detection of silicosis among deceased workers with known exposure to silica dust.³⁹⁴
- June 13, 2015 – Reporting on North Dakota’s fracking boom, the Center for Investigative Reporting found that the major oil companies have largely written the rules governing their own accountability for accidents. Deeply entrenched corporate practices and weak federal oversight, according to the report, have led to high injury and death rates and a shift of assigned responsibility to others. Using data from U.S. and Canadian regulators, the journalists verified 74 on-the-job deaths among workers in Bakken Shale drilling and fracking operations since 2006. The actual number of deaths is likely higher than currently reported because federal regulators do not have a systematic way to record oil- and gas-related deaths, and OSHA does not include certain fatalities, including those of independent contractors. The report concluded that there was too little oversight from OSHA, that laws to protect workers were outdated, and that there was a culture of self-regulation by the industry.³⁹⁵
- May 29, 2015 – The Centers for Disease Control and Prevention published statistics on work-related fatalities during the fracking boom. The occupational fatality rate among U.S. oil and gas industry extraction workers between 2003 and 2013 remained an average of seven times higher than among U.S. workers in general (25.1 versus 3.7 deaths per 100,000 workers per year). Within this 11-year period, the industry doubled the size of its

³⁹³ King, P. (2015, June 15). Frac sand towns question whether rules protect them against silica pollution. *EnergyWire*. Retrieved from <http://www.eenews.net/stories/1060020192>

³⁹⁴ Mazurek, J. M. & Weissman, D. (2015, June 15). Silicosis update. *NIOSH Science Blog*. Retrieved from <http://blogs.cdc.gov/niosh-science-blog/2015/06/15/silicosis-update/>

³⁹⁵ Gollan, J. (2015, June 13). In North Dakota’s Bakken oil boom there will be blood. *Reveal; Center for Investigative Reporting*. Retrieved from <https://www.revealnews.org/article/in-north-dakotas-bakken-oil-boom-there-will-be-blood/>

workforce and increased drilling rigs by 71 percent. The number of occupational deaths increased 27.6 percent, with a total of 1,189 deaths, but it did not increase as much as the number of workers, resulting in an overall decrease in the fatality rate of 36.3 percent. Transportation accidents and contact with objects and equipment were the most frequent fatal events. Evidence suggests that the increased use of automated technologies on drilling rigs may be contributing to the decline in death rates.³⁹⁶

- April 22, 2015 – The AFL-CIO published data for job injuries, illnesses and deaths in a national and state-by-state profile of worker safety and health in the United States, presenting comparisons by state and industry. For the third year in a row, North Dakota had the highest on-the-job fatality rate in the nation: 14.9 deaths per 100,000 workers, a rate that is more than four times the national average, and which has more than doubled since 2007. The fatality rate in the mining and oil and gas extraction sector in North Dakota was 84.7 per 100,000, which is nearly seven times the national fatality rate of 12.4 per 100,000 in this industry.^{397, 398}
- April 10, 2015 – In a study that was inclusive of fracking-based extraction but not specific to it, NIOSH researchers updated their investigation into the sudden deaths of nine oil and gas extraction workers found near hatches where hydrocarbons were stored. All nine victims died between 2010 and 2014 and were unobserved or working alone at the time of their deaths. The first report attributed the fatalities to “inhalation of volatile petroleum hydrocarbons.”³⁹⁹ The update noted that when workers open hatches on production tanks, a plume of hydrocarbon gases and vapors can be rapidly released due to high internal pressure. Exposure to high concentrations of these low-molecular-weight hydrocarbons creates asphyxiation and explosive hazards and can have narcotic effects, resulting in disorientation, dizziness, and light-headedness. The authors cited reports of other sudden deaths following butane and propane inhalation, exposure to which can induce irregular heartbeat, insufficient oxygen supply, and respiratory depression.⁴⁰⁰ As reported by the *Denver Post*, most of the death certificates listed natural causes or heart failure as the cause likely because medical examiners can easily miss signs of toxic inhalation during a routine autopsy. The nomadic nature of the industry presents obstacles to proper training in tank handling techniques.⁴⁰¹ NIOSH issued

³⁹⁶ Mason, K. L., Retzer, K. D., Hill, R., & Lincoln, J. M. (2015, May 29). Occupational fatalities during the oil and gas boom—United States, 2003-2013. *Morbidity and Mortality Weekly Report*, 64, 551-554. Retrieved from <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6420a4.htm>

³⁹⁷ AFL-CIO Safety and Health Department, (2015, April 22). Death on the job: The toll of neglect. Retrieved from <http://www.aflcio.org/Issues/Job-Safety/Death-on-the-Job-Report>

³⁹⁸ Kasperkevic, J. (2015, April 29). About 150 US workers are killed on the job every day – report. *Guardian*. Retrieved from <http://www.theguardian.com/us-news/2015/apr/29/north-dakota-deadliest-state-workers-third-year-running>

³⁹⁹ NIOSH. (2015, March 15). Suspected inhalation fatalities involving workers during manual tank gauging, sampling, and fluid transfer operations on oil and gas well sites, 2010-2014. *CDC Workplace Safety & Health Topics*. Retrieved from http://www.cdc.gov/niosh/topics/fog/data.html#_ftn1

⁴⁰⁰ King, B., Esswein, E., Retzer, K., Snawder, J., Ridl, S., Breitenstein, M. Alexander-Scott, M., & Hill, R. (2015, April 10). *NIOSH Science Blog*, Centers for Disease Control. Retrieved from <http://blogs.cdc.gov/niosh-science-blog/2015/04/10/flowback-3/>

⁴⁰¹ Whaley, M. (2015, May 18). Toxic vapors suspected in deaths of three Colorado oil and gas workers. *Denver Post*. Retrieved from http://www.denverpost.com/news/ci_28136543/colorado-oil-and-gas-workers-fell-victim-little

recommendations for worker protections, including respiratory protection training and engineering controls for remote gauging and venting.⁴⁰²

- February 15, 2015 – Burn injuries among North Dakota workers surged to more than 3,100 over the past five years as the area has become the epicenter of a massive drilling and fracking boom, as reported by the *Star Tribune*. Despite the flammability of Bakken crude oil and the danger of oil rig work, North Dakota has no burn centers, and burn victims must be transported out of state, typically to the Minneapolis-St. Paul area some 600 miles away. The article also covered the severe, debilitating, costly, and sometimes fatal aspects of these occupational injuries.⁴⁰³
- February 13, 2015 – NIOSH reported that while silicosis death rates declined between 2001 and 2010, silicosis deaths were still occurring among young persons aged 15 to 44 years old, indicating extremely high exposures to respirable silica dust. Among emerging new settings that put workers at risk for silicosis, the authors named oil and gas extraction industry workers.⁴⁰⁴
- January 14, 2015 – The *Charleston Gazette-Mail* reported that, due to an increase in workplace deaths that has accompanied the boom in natural gas drilling and production from the Marcellus Shale fields in Northern West Virginia, the Governor there has called for a study aimed at reversing that trend. “Between 2009 and 2013, as the industry boomed in the Marcellus region, 15 natural gas workers died on the job in West Virginia, according to the federal data. During the previous five-year period, from 2004 to 2008, three workers died in West Virginia’s oil and gas industry, according to the [U.S. Bureau of Labor Statistics].”⁴⁰⁵
- January 12, 2015 – Oil and gas production employs less than one percent of the U.S. workforce, but in the past five years it has had more than ten percent of all workplace fatalities from fires and explosions. A review by *EnergyWire* of federal labor statistics last year found the industry had more deaths from fires and explosions than any other private industry. The only “industry” with more fire and explosion fatalities than oil and gas was firefighting, the report stated. These statistics are inclusive of deaths related to fracking operations but are not specific to them.⁴⁰⁶

⁴⁰² Associated Press. (2015, May 18). 9 oil well deaths lead to warning about inhaling chemicals. *Times-Call*. Retrieved from http://www.timescall.com/news/nationworldnews/ci_28138297/9-oil-well-deaths-lead-warning-about-inhaling

⁴⁰³ Rao, M. (2015, February 15). Twin Cities hospitals are front line in treating Bakken burn victims. *StarTribune.com*. Retrieved from <http://www.startribune.com/lifestyle/health/291967611.html?page=all&prepage=1&c=y#continue>

⁴⁰⁴ Bang, K. M., Mazurek, J. M., Wood, J. M., White, G. E., Hendricks, S. A., & Weston, A. (2015), Silicosis mortality trends and new exposures to respirable crystalline silica – United States, 2001-2010. *Morbidity and Mortality Weekly Report*, 64(05), 117-120. Retrieved from <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6405a1.htm>

⁴⁰⁵ Ward, K. (2015, January 14). Tomblin calls for study of increased deaths from gas-drilling boom. *Charleston Gazette*. Retrieved from <http://www.wvgazette.com/article/20150114/GZ01/150119573/1419>

⁴⁰⁶ Soraghan, M. (2015, January 12). At least 16 drilling industry workers died in fires, explosions last year. *EnergyWire*. Retrieved from <http://www.eenews.net/stories/1060011452>

- December 26, 2014 – A report in the *Houston Chronicle* illustrated the difficulties oil and gas workers encounter when injured on the job. In one case a worker fell from a rig, injuring his head. Supervisors did not record the accident. After he became too ill to work, he was shifted to other jobs and soon after, sent home. His daughter filed a Worker’s Compensation claim, which was denied for “late reporting, no knowledge of injury by employer and no medical reports.” The article noted that oilfield injuries are generally undercounted nationally. These include injuries related to drilling and fracking operations as well as those linked to other techniques of extraction.⁴⁰⁷
- December 4, 2014 – Benzene, a naturally occurring component of crude oil and natural gas, is a known carcinogen, with no known threshold of safety. Although the American Petroleum Institute in 1948 stated that “the only absolutely safe concentration ... is zero,” the organization since then undertook an intensive campaign to combat strict exposure limits. An investigation by the Center for Public Integrity found that, “[f]or decades, the petrochemical industry spent millions on science seeking to minimize the dangers of benzene. ... Taken together, the documents—put in context by interviews with dozens of lawyers, scientists, academics, regulators and industry representatives—depict a ‘research strategy’ built on dubious motives, close corporate oversight and painstaking public relations.”⁴⁰⁸
- December, 2014 – In a report intended to inform employers and workers about the known hazards that result from hydraulic fracturing and flowback operations, OSHA noted that there is no publicly available worker injury, illness, or fatality data specific for fracking or flowback operations. At the same time, more workers are exposed to fracking- and flowback-related hazards due to the huge increase in the numbers of these operations over the past ten years. “In light of this, OSHA has determined that additional information concerning hydraulic fracturing and flowback operations hazards should be provided to educate and protect workers.”⁴⁰⁹
- November 11, 2014 – University of Wisconsin toxicologist Crispin Pierce documented super-fine dust drifting from facilities that process silica sand for fracking operations. Pierce and his team detected silica dust in ambient air near frac sand operations at levels that exceed EPA air quality standards by a factor of four. Occupational exposure to respirable crystalline silica is linked in adult workers to silicosis, lung cancer, and pulmonary tuberculosis. Health threats to the general public from frac sand-related air pollution have not yet been studied directly. One of the first investigations of silica dust

⁴⁰⁷ Olsen, L. (2014, December 16). Many oilfield injuries go unreported. *Houston Chronicle*. Retrieved from <http://www.houstonchronicle.com/news/houston-texas/houston/article/Many-oilfield-injuries-go-unreported-5980350.php>

⁴⁰⁸ Lombardi, K. (2014, December 4). Benzene and worker cancers: ‘An American tragedy.’ The Center for Public Integrity. Retrieved from <http://www.publicintegrity.org/2014/12/04/16320/benzene-and-worker-cancers-american-tragedy>

⁴⁰⁹ U.S. Department of Labor, Occupational Safety and Health Administration. (2014). Hydraulic fracturing and flowback hazards other than respirable silica. OSHA 3763-12 2014.

levels in the community environment, the Wisconsin study will appear next year in the *National Journal of Environmental Health*.⁴¹⁰

- November 11, 2014 – A high-pressure water line ruptured, killing one worker and seriously injuring two others during the hydraulic fracturing of an oil well in Weld County, Colorado.⁴¹¹
- October 6, 2014 – Toxicologist Peter Thorne, chair of University of Iowa’s Department of Occupational and Environmental Health, warned the Winneshiek County Board of Supervisors about potential community impacts and cancer risks of silica exposure from sand used for fracking operations. Thorne’s ongoing investigation, which involves air sampling, risk assessments, and inhalation toxicology studies, focuses on the public health hazards of mining, processing, and storing sand. His team has documented spikes in silica particulate matter related to the transport of the silica sand by rail. The study aims to determine if mining poses an “unacceptable exposure” to the public and quantify the level of risk. For silica-exposed workers, NIOSH continues to identify needed health protections. Thorne noted, “Workers handling materials should be using respirators, but most are not.”⁴¹²
- September 25, 2014 – The Civil Society Institute's Boston Action Research, in cooperation with Environmental Working Group and Midwest Environmental Advocates, issued a report on the hazards of silica mining. The report noted that frac sand mining is expanding rapidly in the United States and poses a little-understood threat to public health, the environment, and local economies. Given the pace of the drilling and fracking boom, silica extraction could spread to a dozen other states with untapped or largely untapped sand deposits, including Illinois, Maine, Massachusetts, Michigan, Missouri, New York, North Carolina, South Carolina, Pennsylvania, Tennessee, Vermont, and Virginia. The *International Business Times* published a summary of the findings.^{413, 414}
- August 29, 2014 – In a peer-reviewed study, NIOSH partnered with oil and gas operators and service companies to evaluate worker exposures to, and internal uptake of, volatile organic chemicals at six sites in Colorado and Wyoming where wells were being

⁴¹⁰ Kremer, R. (2014, November 11). High levels of super-fine dust are detected around Wisconsin frac sand mines. *Wisconsin Public Radio*. Retrieved from [http://www.wpr.org/high-levels-super-fine-dust-are-detected-around-wisconsin-frac-sand-](http://www.wpr.org/high-levels-super-fine-dust-are-detected-around-wisconsin-frac-sand-mines?utm_content=buffer8947f&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer)

[mines?utm_content=buffer8947f&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer](http://www.wpr.org/high-levels-super-fine-dust-are-detected-around-wisconsin-frac-sand-mines?utm_content=buffer8947f&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer)

⁴¹¹ Paul, J. (2014, November 11). Brighton man ID'd as victim in fatal Weld County fracking blast. *The Denver Post*. Retrieved from http://www.denverpost.com/news/ci_26937782/brighton-man-idd-victim-fatal-weld-county-fracking?source=pkg

⁴¹² Strandberg, S. (2014, October 6). U of I researcher informs supervisors about frac-sand impact. *Decorah Newspapers*. Retrieved from <http://www.decorahnewspapers.com/Content/Home/Home/Article/U-of-I-researcher-informs-supervisors-about-frac-sand-impact/-/2/-2/35735>

⁴¹³ Chapman, E., Hopkins, L., Jasset, A., Sheldon, S., & Smith, G. (2014, September 25). Communities at risk: Frac sand mining in the Upper Midwest—A report by Boston Action Research (a project of Civil Society Institute). Retrieved from <http://216.30.191.148/fracsandmining/> and www.bit.ly/fracsandmining

⁴¹⁴ Gallucci, M. (2014, September 25). US oil & gas fracking boom could drive silica sand mining operations in 12 more states, environmental groups say. *International Business Times*. Retrieved from <http://www.ibtimes.com/us-oil-gas-fracking-boom-could-drive-silica-sand-mining-operations-12-more-states-1695246>

prepared for production. The study found benzene in the urine of well pad workers. Benzene is “naturally present in flowback fluids and the time spent working around flowback and production tanks ... appears to be the primary risk factor for inhalation exposures.” In some cases, airborne concentrations of benzene exceeded the NIOSH Recommended Exposure Limit concentrations and, in a few instances, the American Conference of Governmental Industrial Hygienists’ Threshold Limit Value, “when workers performed work tasks near a point source for benzene emissions.”⁴¹⁵

- July 29, 2014 – As part of an investigation into the health impacts of drilling and fracking on animal health, veterinarian Michelle Bamberger and Cornell biochemist Robert Oswald, published an interview with a twenty-year oil and gas industry worker about his experiences and worker safety. His account included injuries, 16-hour workdays, fatigue, exposure to chemicals, and inadequate health and safety training. “No one out there tells you about stuff that has latency. That is the last thing they are going to do is tell you that something that you are handling will take you out in 20 years or 10 years or cause you some kind of ailment, or you can potentially drag this home to your family.”⁴¹⁶
- July 14, 2014 – As part of an analysis of safety and research needs associated with drilling and fracking, researchers at the Colorado School of Public Health and the College of Health Sciences at the University of Wyoming documented high injury and on-the-job mortality rates among gas and oilfield workers. The occupational fatality rate was 2.5 times higher than that of the construction industry and seven times higher than that of general industry. By contrast, injury rates were lower than the construction industry, suggesting that injuries are underreported. Researchers documented crystalline silica levels above occupational health standards and identified the existence of other hazards, including particulate matter, benzene, noise, and radiation. The team called for exposure assessments for both chemical hazards and physical hazards that lead to occupational illness (noise, radioactivity); screening and surveillance systems to assess incidence and prevalence of occupational illness; industry/academic collaboration to conduct occupational epidemiologic studies; and assessment of the effectiveness of industry interventions to reduce exposures.⁴¹⁷
- July 2014 – The British labor journal *Hazards* identified health concerns in the drilling and fracking industry: increased rate of death on the job, toxic releases, silica exposure, and exposure to hydrocarbons and endocrine disruptors. The union that organizes the construction, rig, and transport workers, on which fracking would rely, agreed at its July 2014 national conference to lobby for a moratorium on fracking because “[d]elegates want union members to be made aware of the dangers of fracking and be advised not to

⁴¹⁵ Esswein, E., Snawder, J., King, B., Breitenstein, M., Alexander-Scott, M., & Kiefer, M. (2014). Evaluation of some potential chemical risks during flowback operations in unconventional oil and gas extraction: Preliminary results. *Journal of Occupational and Environmental Hygiene*, 11, D174-0184.

⁴¹⁶ Bamberger, M., & Oswald, R. (2014). The shale gas revolution from the viewpoint of a former industry insider. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*. Early Online View. doi: 10.2190/NS.EOV.1

⁴¹⁷ Witter, R. Z., Tenney, L., Clark, S., & Newman, L. S. (2014). Occupational exposures in the oil and gas extraction industry: State of the science and research recommendations. *American Journal of Industrial Medicine*, 57(7), 847-856. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1002/ajim.22316/full>

work on fracking sites.”⁴¹⁸

- June 29, 2014, and August 31, 2014 – An initial report and follow-up analysis in *The Columbus Dispatch* examined fire hazards at well pads. In one notable case, malfunctioning hydraulic tubing allowed a well pad fire in Monroe County, Ohio to spread rapidly, prompting evacuations. Local firefighters had neither the correct equipment nor did they know the chemicals they were trying to extinguish. One firefighter was treated for smoke inhalation.^{419, 420}
- May 19, 2014 – Underscoring the dangerous nature of chemicals used in fracking operations, NIOSH reported that at least four gasfield workers have died since 2010 from acute chemical exposures during flowback operations and warned that flowback operations can “result in elevated concentrations of volatile hydrocarbons in the work environment that could be acute exposure hazards.” The agency further noted that such volatile hydrocarbons “can affect the eyes, breathing, and the nervous system and at high concentrations may also affect the heart causing abnormal rhythms.”^{421, 422}
- May 16, 2013 – A NIOSH study revealed that worker exposure to crystalline silica dust from sand used in fracking operations exceeded “relevant occupational health criteria” at all eleven tested sites, and the magnitude of some exposures exceeded NIOSH limits by a factor of 10 or more. “[P]ersonal respiratory protection alone is not sufficient to adequately protect against workplace exposures.” Inhalation of crystalline silica can cause incurable silicosis, lung cancer, chronic obstructive pulmonary disease, kidney disease and autoimmune diseases.⁴²³ Although community exposures distant from mines are possible, there are no federal or state standards for silica in ambient air.⁴²⁴
- May 8, 2014 – A report by the AFL-CIO found that the fracking boom has made North Dakota the most dangerous state for U.S. workers—with a fatality rate five times higher than the national average—and that North Dakota’s fatality rate has doubled since 2007. The AFL-CIO called North Dakota “an exceptionally dangerous and deadly place to

⁴¹⁸ O’Neill, R. (editor). (July 2014). Chemicals, dust and deaths and the new rush for oil and gas.

Hazards Magazine. Special Online Report. Retrieved from <http://www.hazards.org/oil/fracking.htm#top>

⁴¹⁹ Richards, J. S. (2014, June 29). Glitch sparks smoky fire at gas well. *Columbus Dispatch*. Retrieved from <http://www.dispatch.com/content/stories/local/2014/06/29/glitchsparks-smoky-fire-at-gas-well.html>

⁴²⁰ Arenschiold, L. (2014, August 31). Fracking fire points out failings. *Columbus Dispatch* Retrieved from <http://www.dispatch.com/content/stories/local/2014/06/29/glitchsparks-smoky-fire-at-gas-well.html>

⁴²¹ Snawder, J., Esswein, E., King, B., Breitenstein, M., Alexander-Scott, M., Retzer, K., . . . Hill, R. (2014, May 19). Reports of worker fatalities during flowback operations [Web log post]. *NIOSH Science Blog*. Retrieved from <http://blogs.cdc.gov/niosh-science-blog/2014/05/19/flowback/>

⁴²² Iafolla, R. (2014, May 20). Four fatalities linked to used fracking fluid exposure during 'flowback,' NIOSH reports. *Bloomberg BNA*. Retrieved from <http://www.bna.com/four-fatalities-linked-n17179890610/>

⁴²³ Esswein, E. J., Breitenstein, M., Snawder, J., Kiefer, M., & Sieber, W. K. (2013). Occupational exposures to respirable crystalline silica during hydraulic fracturing. *Journal of Occupational and Environmental Hygiene*, 10(7), 347-356. doi: 10.1080/15459624.2013.788352

⁴²⁴ University of Iowa Environmental Health Sciences Research Center. (2012). Exposure assessment and outreach to engage the public on health risks from frac sand mining. Retrieved from <http://cph.uiowa.edu/ehsrc/fracsand.html>

work.” U.S. Secretary of Labor Thomas E. Perez called the rising rate of workplace deaths suffered in the oil and gas sector “unacceptable.”⁴²⁵

- April 24, 2014 – A University of Texas San Antonio report commissioned by the Methodist Healthcare Ministries found that many oil and gas field workers in the Eagle Ford Shale are uninsured or underinsured and that “the most noticeable health impacts so far are work-related illnesses and injuries: heat exhaustion, dehydration, sleep deprivation, exposure to oil and gas spills and accidents.” The study also noted that oil and gas production has put strain on healthcare facilities.⁴²⁶
- April 10, 2014 – West Virginia University researcher Michael McCawley reported that some of the nation’s highest rates of silicosis are in heavily drilled areas within the Northern Panhandle of West Virginia and southwestern Pennsylvania. A disease that hardens the lungs through inflammation and development of scar tissue, silicosis is entirely attributable to exposure to silica dust, a known occupational hazard at drilling and fracking operations. Two years earlier, OSHA and NIOSH issued a joint “Hazard Alert” to warn fracking workers of the health hazards of exposure to silica dust, including silicosis.⁴²⁷
- February 25, 2014 – A year-long investigation by the *Houston Chronicle* found that fracking jobs are deadly, with high fatality rates and high rates of serious injury. Within just one year in Texas, 65 oil and gas workers died, 79 lost limbs, 82 were crushed, 92 suffered burns and 675 broke bones. From 2007 to 2012, at least 664 U.S. workers were killed in oil and gas fields.^{428, 429}
- December 27, 2013 – National Public Radio (NPR) reported spiking rates of fatalities related to oil and gas drilling operations, which had increased more than 100 percent since 2009. NPR noted that in the previous year, 138 workers were killed on the job, making the fatality rate among oil and gas workers nearly eight times higher than the average rate of 3.2 deaths for every 100,000 workers across all industries.⁴³⁰

⁴²⁵ Picchi, A. (2014, May 8). The most dangerous U.S. state for workers. *CBS News*. Retrieved from <http://www.cbsnews.com/news/the-most-dangerous-us-state-for-workers/>

⁴²⁶ Ghahremani, Y. (2014, April 24). Fractured Healthcare: Pumping Resources Back into the Eagle For Shale Communities/Executive Summary: Methodist Healthcare Ministries and Center for Community and Business Research at the University of Texas San Antonio. Retrieved from <http://www.joomag.com/en/newsstand/fractured-healthcare-pumping-resources-back-into-the-eagle-ford-shale-communities-apr-2014/0368470001398347080>

⁴²⁷ Hicks, I. (2014, April 10). Gas workers risk silica exposure. *The Intelligencer, Wheeling News-Register*. Retrieved from <http://www.news-register.net/page/content.detail/id/598589/Gas-Workers-at-Risk-Of-Silica-Ex---.html>

⁴²⁸ Olsen, L. (2014, February 22). Houston Chronicle exclusive: Drilling boom, deadly legacy. Retrieved from <http://www.houstonchronicle.com/news/special-reports/article/Houston-Chronicle-exclusive-Drilling-boom-5259311.php#0>

⁴²⁹ Hsieh, S. (2014, February 25). Why are so many workers dying in oil fields? Retrieved from <http://www.thenation.com/blog/178523/why-are-so-many-workers-dying-oil-fields>

⁴³⁰ Schneider, A., & Geewax, M. (2013, December 27). On-the-job deaths spiking as oil drilling quickly expands. Retrieved from <http://www.npr.org/2013/12/27/250807226/on-the-job-deaths-spiking-as-oil-drilling-quickly-expands>

- October 30, 2012 – In a policy statement, the American Public Health Association (APHA) asserted that, high volume horizontal hydraulic fracturing (HVHF) “poses potential risks to public health and the environment, including groundwater and surface water contamination, climate change, air pollution, and worker health.” The statement also noted that the public health perspective has been inadequately represented in policy processes related to HVHF.⁴³¹ The policy statement added:

[H]ydraulic fracturing workers are potentially exposed to inhalation health hazards from dust containing silica. There may also be impacts on workers and communities affected by the vastly increased production and transport of sand for HVHF. Inhalation of fine dusts of respirable crystalline silica can cause silicosis. Crystalline silica has also been determined to be an occupational lung carcinogen.

- 2005 – A researcher at Stanford University examined hazards associated with oil and gas extraction from exposure to radiation and determined that inhalation of high levels of radon gas is a serious concern to workers and those living nearby. Because the boiling point of radon lies between those of propane and ethane, gaseous radon (²²²Rn) will concentrate in ethane and propane fractions. “Elevated Rn activity concentration values have been measured at several processing plant sites.... It is well known that the radiological impact of the oil and gas-extracting and processing industry is not negligible.”⁴³²
- May 9, 2003 – A New York Medical College study re-evaluated the chest X-rays of patients with exposure to silica who died from various respiratory problems and found that more than eight percent had undiagnosed silicosis. The study suggested that occupational lung disease may be undercounted in high-risk occupations. The authors of this study said that improved OSHA standards, with ongoing exposure monitoring and medical surveillance, would significantly improve the recognition of cases and justify more stringent preventive measures to reduce exposure. They further noted that practitioners need skills in taking an occupational exposure history. Although ten years have passed since this study was published, both recommendations have yet to be implemented.⁴³³

Public health effects, measured directly

By several measures, evidence for fracking-related health problems is emerging across the United States and Canada. Studies of birth outcomes in regions of intensive unconventional oil and gas extraction continue to point to reproductive risks, including low birth weight and

⁴³¹ American Public Health Association. (2012, October 30). The environmental and occupational health impacts of high-volume hydraulic fracturing of unconventional gas reserves. Retrieved from <http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1439>

⁴³² Steinhäusler, F. (2005). Radiological impact on man and the environment from the oil and gas industry: Risk assessment for the critical group. *Nato Science Series: IV: Earth and Environmental Sciences*. doi: 10.1007/1-4020-2378-2_19. http://rd.springer.com/chapter/10.1007/1-4020-2378-2_19

⁴³³ Goodwin, S. S., Stanbury, M., Wang, M.-L., Silbergeld, E., & Parker, J. E. (2003). Previously undetected silicosis in New Jersey decedents. *American Journal of Industrial Medicine*, 44, 304-11. doi: 10.1002/ajim.10260

preterm births. In Pennsylvania, as the number of gas wells increase in a community, so do rates of hospitalization, and community members experience sleep disturbance, headache, throat irritation, stress/anxiety, cough, shortness of breath, sinus, fatigue, wheezing, and nausea. Drilling and fracking operations are also correlated with increased rates of asthma, elevated motor vehicle fatalities, ambulance runs and emergency room visits, and gonorrhea incidence. Benzene levels in ambient air surrounding drilling and fracking operations are sufficient to elevate risks for future cancers in both workers and nearby residents, according to studies. Animal studies show numerous threats to fertility and reproductive success from exposure to various concentrations of oil and gas chemicals, including at levels representative of those found in drinking water. Two dozen chemicals commonly used in fracking operations are endocrine disruptors that can variously disrupt organ systems, lower sperm counts, and cause reproductive harm at levels to which people can be realistically exposed.

- December 13, 2017 – A team of health economists analyzed fracking’s health impacts on infants. They examined birth certificates for all 1.1 million infants born in Pennsylvania between 2004 and 2013 and combined these data with maps showing when and where gas wells were drilled in the state. Their results indicated that the introduction of fracking “reduces health among infants born to mothers living within 3 km (1.9 miles) of a well site during pregnancy.” For mothers living within one kilometer (.6 miles), they found a 25 percent increase in the probability of low birth weight, “significant declines” in average birth weight, as well as declines in other measures of infant health. They also observed reductions in infant health when mothers lived within one to three kilometers of a fracking site; these were about one-third to one-half of the declines of those mothers living closer.⁴³⁴ The researchers estimated that “about 29,000 out of the nearly 4 million U.S. births (0.7 percent) annually occur within 1 kilometer of a fracking site and 95,500 are born within 3 kilometers.” “For policymakers weighing the costs and benefits of fracking before deciding whether to allow it in their communities, this study provides a clear cost: an increase in the probability of poorer health for babies born near these sites.”⁴³⁵
- November 6, 2017 – As part of a pilot project, a team of Montreal-based public health researchers evaluated exposure of pregnant mothers to volatile organic compounds (VOCs) in an area of intensive fracking in northeastern British Columbia. At least 28,000 unconventional natural gas wells had been drilled to date in the Peace River Valley. Analyzing the urine of 29 pregnant women, researchers found high concentrations of muconic acid, which is a degradation product of benzene, a widely studied developmental toxicant and an air contaminant in the vicinity of gas wells. The median concentration of this chemical was approximately 3.5 times higher in the study group than in the general Canadian population. In five of the 29 women, the concentration of muconic acid exceeded an exposure index by the American Conference of Governmental Industrial Hygienists that was designed for workplace settings. (No guidelines for the public exist.)

⁴³⁴ Currie, J., Greenstone, M., & Meckel, K. (2017). Hydraulic fracturing and infant health: New evidence from Pennsylvania. *Science Advances*, 3(12), e1603021. doi: 10.1126/sciadv.1603021

⁴³⁵ Currie, J., Greenstone, M., & Meckel, K. (2017). Hydraulic fracturing and infant health: New evidence from Pennsylvania (Research Summary). *Energy Policy Institute at the University of Chicago*. Retrieved from https://epic.uchicago.edu/sites/default/files/EPIC_121017_FrackingResearchSummary_Final.121317.pdf

By design, this small pilot study sets the groundwork for more extensive biomonitoring and environmental analysis.⁴³⁶

- September 19, 2017 – University of Texas Health Science Center researchers conducted a case-control study nested within their larger cohort of women with single births (see below) in the 24-county Barnett Shale between November 30, 2010 and November 29, 2012. Its specific purpose was to consider timing of unconventional gas development activity “during potentially sensitive windows of exposure,” as well as “potential differences in risk by UGD drilling phase,” with regard to preterm births. Results suggest a link between maternal residential proximity to UGD-activity and preterm births, which were similar by drilling phase and “slightly stronger in the first two trimesters of pregnancy.”⁴³⁷
- September 14, 2017 – Researchers reviewed health assessments taken between February 2012 and October 2015 of adults in Pennsylvania communities with intense unconventional natural gas development (UNGD). The most frequently reported symptoms were sleep disturbance, headache, throat irritation, stress/anxiety, cough, shortness of breath, sinus problems, fatigue, wheezing, nausea, each occurring in over 20 percent of the sample. Over 43 percent of the sample reported sleep disturbance. To meet the inclusion criteria, as developed and implemented by a physician and nurse practitioner, the symptoms were reviewed to ensure no plausible cause relating to “past medical and surgical history, concurrent medical conditions, family and social history, and environmental exposures unrelated to UNGD. For example, if the social history indicated a ½ pack/day smoking history, the symptom of ‘difficulty breathing’ was not included.” Independently, the timing of the exposure for each symptom that met the inclusion criteria was determined, using the beginning drilling date for each unconventional natural gas well within one kilometer (.6 miles) of the patient’s residence; records were excluded if it was not possible to verify at least one gas well within this distance.⁴³⁸
- August 21, 2017 – Using county-level data from 2003 to 2013, researchers found that, all together, counties in the Marcellus Shale region that experienced a boom in hydraulic fracturing showed a 20 percent increase in the incidence rate of gonorrhea.⁴³⁹
- July 21, 2017 – A University of Texas Health Science Center School of Public Health team assessed the links between the residential proximity of pregnant mothers to

⁴³⁶ Caron-Beaudoin, É, Valter, N., Chevrier, J., Ayotte, P., Frohlich, K., & Verner, M.-A. (2017). Gestational exposure to volatile organic compounds (VOCs) in Northeastern British Columbia, Canada: A pilot study. *Environment International*, 110, 131-138. doi: 10.1016/j.envint.2017.10.022

⁴³⁷ Marshall, A. K., Symanski, E., & Whitworth, K. W. (2017). The association between unconventional gas development and preterm birth: Evaluating drilling phases and critical windows of susceptibility [Abstract]. *Annals of Epidemiology*, 27(8), 530.

⁴³⁸ Weinberger, B., Greiner, L. H., Walleigh, L., & Brown, D. (2017). Health symptoms in residents living near shale gas activity: A retrospective record review from the Environmental Health Project. *Preventive Medicine Reports*, 8, 112-115. doi: 10.1016/j.pmedr.2017.09.002

⁴³⁹ Komarek, T., & Cseh, A. (2017). Fracking and public health: Evidence from gonorrhea incidence in the Marcellus Shale region. *Journal of Public Health Policy*, 38(4), 464-481. doi: 10.1057/s41271-017-0089-5

unconventional natural gas development activity and various newborn health problems: preterm birth, small-for-gestational age (SGA), fetal death, and low birth weight. They found evidence of a “moderate positive association” between residential proximity to UGD-activity and increased odds of preterm birth, and a “suggestive association” with fetal death. Nearly 159,000 births and fetal deaths from November 30, 2010 to November 29, 2012 in the 24-county Barnett Shale area were considered.⁴⁴⁰

- February 15, 2017 – A study from the University of Colorado School of Public Health and Anschutz Medical Campus showed that children and young adults between the ages of 5 and 24 with acute lymphocytic leukemia (ALL) were 4.3 times more likely to live in area dense with active oil and gas wells. The researchers did not find such a link with ALL cases in 0-4 year olds, or with incidence of non-Hodgkin lymphoma. The study focused on rural areas and towns in 57 Colorado counties and did not include cities of more than 50,000 people. Authors wrote, “Because oil and gas development has potential to expose a large population to known hematologic carcinogens, such as benzene, further study is clearly needed to substantiate both our positive and negative findings.”⁴⁴¹
- August 25, 2016 – Researchers found that Pennsylvanians residing near intensive unconventional gas well activity were significantly more likely to experience chronic rhino sinusitis (at least three months of nasal and sinus symptoms), migraine headaches, and higher levels of fatigue than residents who do not live near such activity.⁴⁴² Data were gathered from nearly 8,000 patients of Geisinger Health System from 40 counties in north and central Pennsylvania, and matched with the proximity of respondents to all phases of gas drilling activity and intensity, using information from the Pennsylvania Departments of Environmental Protection (PA DEP) and Conservation and Natural Resources, as well as satellite imagery. According to lead author Aaron W. Tustin, MD, MPH, resident physician in the Department of Environmental Health Sciences at the Johns Hopkins Bloomberg School of Public Health, “[t]hese three health conditions can have debilitating impacts on people’s lives... In addition, they cost the health care system a lot of money.”⁴⁴³
- July 18, 2016 – Living near fracking operations significantly increases asthma attacks, according to a Johns Hopkins University study of 35,000 medical records of people with

⁴⁴⁰ Whitworth, K. W., Marshall, A. K., & Symanski, E. (2017). Maternal residential proximity to unconventional gas development and perinatal outcomes among a diverse urban population in Texas. *PLOS ONE*, *12*(7), e0180966. doi: 10.1371/journal.pone.0180966

⁴⁴¹ McKenzie, L. M., Allshouse, W. B., Byers, T. E., Bedrick, E. J., Serdar, B., & Adgate, J. L. (2017). Childhood hematologic cancer and residential proximity to oil and gas development. *PLOS ONE*, *12*(2), e0170423. doi: 10.1371/journal.pone.0170423

⁴⁴² Tustin, A. W., Hirsch, A. G., Rasmussen, S. G., Casey, J. A., Bandeen-Roche, K., & Schwartz, B. S. (2017). Associations between unconventional natural gas development and nasal and sinus, migraine headache, and fatigue symptoms in Pennsylvania. *Environmental Health Perspectives*, *125*, 189-197. doi: 10.1289/EHP281

⁴⁴³ Phillips, S. (25 August, 2016). New study links gas drilling to migraines, fatigue and chronic sinus symptoms. *State Impact Pennsylvania*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2016/08/25/new-study-points-to-association-between-gas-drilling-to-migraines-fatigue-and-chronic-sinus-symptoms/>

asthma in north and central Pennsylvania, from 2005 to 2012.⁴⁴⁴ The data show that those who live near a higher number of, or larger, active gas wells were 1.5 to 4 times more likely to suffer from asthma attacks compared to those who live farther away, with the closest group having the highest risk. There was increased risk in all three types of exacerbations defined: mild (new oral corticosteroid medication order), moderate (emergency department encounter), or severe (hospitalization). In addition, researchers identified increased risk during all four phases of well development: pad preparation, drilling, stimulation (fracking), and production. The study was praised for its “rigorous research methods,” by a scientist not part of the team.⁴⁴⁵

- July 5, 2016 – Researchers from five universities and the U.S. Geological Survey (USGS) identified a link between exposure to fracking and drilling chemicals and adverse reproductive and developmental outcomes in laboratory mice. The study used 23 oil and gas chemicals in four different concentrations, representing concentrations found in drinking water and groundwater, to higher concentrations found in oil and gas industry wastewater. Offspring of pregnant laboratory mice consuming these mixtures were compared to those that did not. Results suggested “numerous potential threats to fertility and reproductive success . . . including altered pituitary hormone levels, reproductive organ weights, and disrupted ovarian follicle development.” Researchers observed these negative outcomes even in the offspring exposed to the lowest dose of chemicals. Building on previous research showing reduced sperm counts in male offspring, they also reported on “tentative mechanistic information for the observed adverse health effects.”⁴⁴⁶
- February 9, 2016 – An exploratory study of hospitalization rates for three study areas in Queensland, Australia showed rates for specific types of hospital admissions increased more quickly in a coal seam gas study area than in other study areas (a coal mining area and a rural/agricultural area). Coal seam gas is the methane trapped in pores and fractures in underground coal deposits; its exploitation is a form of unconventional natural gas development. A portion of coal seam gas extraction uses fracking. This preliminary study found the strongest link between increased hospitalization rates over time in a coal seam gas area to be for the category of ‘Blood/immune’ diseases.⁴⁴⁷
- October 14, 2015 – Using an animal model, an interdisciplinary research team measured the endocrine-disrupting activities of 24 chemicals used and/or produced by oil and gas

⁴⁴⁴ Rasmussen, S. G., Ogburn, E. L., McCormack, M., Casey, J. A., Bandeen-Roche, K. Mercer, D. G., & Schwartz, B. S. (2016). Association between unconventional natural gas development in the Marcellus Shale and asthma exacerbations. *JAMA Internal Medicine*. Advance online publication. doi: 10.1001/jamainternmed.2016.2436

⁴⁴⁵ Song, L., & Kusnetz, N. (2016, July 18). Increased asthma attacks tied to exposure to natural gas production. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/18072016/asthma-study-marcellus-shale-pennsylvania-natural-gas-fracking>

⁴⁴⁶ Kassotis, C. D., Bromfield, J. J., Klemp, K. C., Meng, C-X., Wolfe, A., Zoeller, R. T., . . . Nagel, S. C. (2016). Adverse reproductive and developmental health outcomes following prenatal exposure to a hydraulic fracturing chemical mixture in female C57Bl/6 Mice. *Endocrinology*, *157*(9), 3469–3481. doi: 10.1210/en.2016-1242

⁴⁴⁷ Werner, A. K., Watt, K., Cameron, C. M., Vink, S., Page, A., & Jagals, P. (2016). All-age hospitalization rates in coal seam gas areas in Queensland, Australia, 1995–2011. *BMC Public Health*, *16* (125). doi: 10.1186/s12889-016-2787-5

operations, finding that 23 of them “can activate or inhibit the estrogen, androgen, glucocorticoid, progesterone, and/or thyroid receptors, and mixtures of these chemicals can behave synergistically, additively, or antagonistically.” Further, the researchers tested prenatal exposures to the chemicals and found effects on multiple organs, including adverse reproductive effects on the matured offspring.⁴⁴⁸ This study is the first to demonstrate that endocrine-disrupting chemicals, which are commonly used in fracking operations, can harm the reproductive health of mice, at levels of exposure that are realistic for humans. The study’s senior author told *ScienceDaily*, “In addition to reduced sperm counts, the male mice exposed to the mixture of chemicals had elevated levels of testosterone in their blood and larger testicles. These findings may have implications for the fertility of men living in regions with dense oil and/or natural gas production.”⁴⁴⁹

- October 8, 2015 – Pregnant women who live near active fracking operations in Pennsylvania were at a 40 percent increased risk of giving birth prematurely and at a 30 percent increased risk for having obstetrician-labeled high-risk pregnancies, according to a study by Johns Hopkins Bloomberg School of Public Health and other researchers. High-risk pregnancies were those that included hypertension, high pre-pregnancy body mass index, and asthma. The study used data from the Geisinger Health System on 9,384 pregnant women and their 10,496 newborns between January 2009 and January 2013; Geisinger covers 40 counties in north and central Pennsylvania. Researchers developed an index for proximity to fracking wells based on distance from the women’s homes, stage of drilling and depth of wells dug, and the amount of gas that was produced at those wells during the pregnancies. The highest-activity quartile had the highest rates of premature births and high-risk pregnancies.^{450, 451}
- July 22, 2015 – Using a mammal model, New York University School of Medicine scientists, together with other U.S. and Chinese researchers, demonstrated cancerous changes linked to exposure to wastewater from Marcellus fracking operations. Their study also documented elevated levels of barium and strontium in exposed animal cells. The wastewater studied originated in Pennsylvania and was stored for a time to allow radioactivity and levels of short-lived VOCs to decline. The results suggest that “even aged flow back water could pose substantial health threats to exposed humans.”⁴⁵²
- July 15, 2015 – A study by University of Pennsylvania and Columbia University

⁴⁴⁸ Kassotis, C.D., Klemp, K.C., Vu, D.C., Lin, C.-H., Meng, C.-X., Besch-Williford, C.L., . . . Nagel, S.C. (2015). Endocrine-disrupting activity of hydraulic fracturing chemicals and adverse health outcomes after prenatal exposure in male mice. *Endocrinology* 156(12), 4458–4473. doi: 10.1210/en.2015-1375

⁴⁴⁹ Endocrine Society. (2015, October 14). Fracking chemicals tied to reduced sperm count in mice. *ScienceDaily*. Retrieved from www.sciencedaily.com/releases/2015/10/151014134533.htm

⁴⁵⁰ Casey, J. A., Savitz, D. A., Rasmussen, S. G., Ogburn, E. L., Pollak, J., Mercer, D. G., & Schwartz, B. S. (2016). Unconventional natural gas development and birth outcomes in Pennsylvania, USA. *Epidemiology* 27(2), 163–172. doi: 10.1097/EDE.0000000000000387

⁴⁵¹ Johns Hopkins Bloomberg School of Public Health. (2015, October 8). Study: fracking industry wells associated with premature birth. Retrieved from <http://www.jhsph.edu/news/news-releases/2015/study-fracking-industry-wells-associated-with-premature-birth.html>

⁴⁵² Yao, Y., Chen, T., Shen, S. S., Niu, Y., DesMarais, T. L., Linn, R., . . . Costa, M. (2015). Malignant human cell transformation of Marcellus Shale gas drilling flow back water. *Toxicology and Applied Pharmacology*, 288, 121-130. doi: 10.1016/j.taap.2015.07.011

researchers found that drilling and fracking activity was associated with increased rates of hospitalization in Pennsylvania. During a period of dramatic increase in drilling and fracking activity between 2007 and 2011, inpatient prevalence rates surged for people living near shale gas wells. Cardiology inpatient prevalence rates were significantly associated with number of wells per zip code and their density, while neurology inpatient prevalence rates were significantly associated with density of wells. Hospitalizations for cancer, skin conditions, and urological problems also rose significantly. During the same time period, no such increase in health problems was observed in a control Pennsylvania county without any drilling and fracking activity. In communities with the most wells, the rate of cardiology hospitalizations was 27 percent higher than in control communities with no fracking. “While the clinical significance of the association remains to be shown, [fracking] has just begun in Pennsylvania, and thus observing a significant association over this short time is striking.... Our study also supports the concept that health care utilization should be factored into the value (costs and benefits) of hydraulic fracturing over time.”⁴⁵³ In a related *Newsweek* story, lead researcher Reynold Panettieri, Jr. said, “At this point, we suspect that residents are exposed to many toxicants, noise and social stressors due to hydraulic fracturing near their homes and this may add to the increased number of hospitalizations.”⁴⁵⁴

- July 9, 2015 – As part of a scientific assessment of well stimulation treatments, including fracking, the California Council on Science and Technology studied the potential impacts of well stimulation on human health in California. The risk factors directly attributable to well stimulation stem largely from the use of a very large number and quantity of stimulation chemicals. The unknown number and toxicity of chemicals that are mixed together in well stimulation fluids made it difficult to fully quantify risk to the environment and to human health, but the study highlighted the potential health risks from exposure to fracking-related air pollution for the people of Los Angeles, 1.7 million of whom live or work within one mile of an active oil or gas well.⁴⁵⁵ Jane Long, co-author, said, “officials should fully understand the toxicity and environmental profiles of all chemicals before allowing them to be used in California's oil operations,” according to the *Los Angeles Times*.⁴⁵⁶
- June 22, 2015 – A longtime midwife reported her personal analysis of an ongoing spike in infant deaths, miscarriages, and placental abnormalities in Utah’s Uintah Basin that has

⁴⁵³ Jemielita T., Gerton G. L., Neidell, M., Chillrud S., Yan B., Stute, M., . . . Panettieri, Jr., R. A. (2015), Unconventional gas and oil drilling is associated with increased hospital utilization rates. *PLoS ONE* 10(7), e0131093. doi: 10.1371/journal.pone.0131093

⁴⁵⁴Schlanger, Z. (2015, July 15). Living near fracking wells linked to increased hospitalization rates. *Newsweek*.

Retrieved from <http://www.newsweek.com/living-near-fracking-wells-linked-increased-hospitalization-rates-354093>

⁴⁵⁵ Shonkoff, S. B. C., Maddalena, R. L., Hays, J., Stringfellow, W., Wettstein, Z. S., Harrison, R., Sandelin, W., & McKone, T. E. (2015, July 9). Potential impacts of well stimulation on human health in California, in California Council of Science and Technology and Lawrence Berkeley National Laboratory, *An Independent Scientific Assessment of Well stimulation in California, vol. 2: Potential Environmental Impacts of Hydraulic Fracturing and Acid Stimulations*. Retrieved from <http://ccst.us/publications/2015/2015SB4-v2.pdf>

⁴⁵⁶ Cart, J. (2015, July 9). Water and wildlife may be at risk from fracking’s toxic chemicals, panel finds. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/lanow/la-me-california-science-panel-warns-that-fracking-poses-unknown-risk-20150709-story.html>

followed the advent of drilling and fracking activity there and appears linked to air pollution episodes.⁴⁵⁷

- June 3, 2015 – A University of Pittsburgh study linked fracking to low birthweight in three heavily drilled Pennsylvania counties. The more exposure a pregnant woman had to gas wells, the higher her risk for a smaller-than-normal baby. Exposure was determined as proximity and density of wells in relation to the residence of the pregnant woman. Compared to mothers whose homes had the fewest surrounding gas wells, mothers whose homes were nearest to a high density of wells were 34 percent more likely to have babies who were “small for gestational age,” meaning they weighed significantly less than expected for the number of weeks of pregnancy. Although the study did not investigate mechanisms, researchers identified air as the likely route of exposure. They supported this argument by referencing another study done in Western Pennsylvania where airborne particulate pollution correlated with low birth weight and by noting that particulates are established shale gas infrastructure emissions.^{458, 459} Low birth weight is a leading cause of infant mortality.
- March 3, 2015 – A follow-up study of 21 case studies from five states found that the distribution of symptoms in animals and humans affected by nearby fracking operations was, since 2012, unchanged for humans and companion animals. In food animals, reproductive problems decreased over time while respiratory problems and growth problems increased. “This longitudinal case study illustrates the importance of obtaining detailed epidemiological data on the long-term health effects of multiple chemical exposures and multiple routes of exposure that are characteristic of the environmental impacts of unconventional drilling operations.”⁴⁶⁰
- March 3, 2015 – A cross-sectional study by Yale University School of Medicine researchers using companion animals as sentinels of human exposure to fracking-related chemicals investigated possible associations between reported health conditions of companion and backyard animals in Southwest Pennsylvania and household proximity to drilling and fracking operations. Among dogs living in households located less than one kilometer from a gas well, risks for health problems were elevated, especially for dermal conditions, compared to animals living more than two kilometers from a well.⁴⁶¹

⁴⁵⁷ Solotaroff, P. (2015, June 22). What’s killing the babies of Vernal, Utah? *Rolling Stone*. Retrieved from <http://www.rollingstone.com/culture/features/fracking-whats-killing-the-babies-of-vernal-utah-20150622>

⁴⁵⁸ Shaina, L. S., Brink, L. L., Larkin, J. D., Sadovsky, Y., Goldstein, B. C., Pitt, B. R., & Talbot, E. O. (2015). Perinatal outcomes and unconventional natural gas operations in southwest Pennsylvania. *PLoS One*, *10*, e0126425. doi: 10.1371/journal.pone.0126425

⁴⁵⁹ Preidt, R. (2015, June 3). ‘Fracking’ linked to low birth weight babies, *WebMD*. Retrieved from <http://www.webmd.com/parenting/baby/news/20150603/fracking-linked-to-low-birth-weight-babies>

⁴⁶⁰ Bamberger, M. & Oswald, R. E. (2015). Long-term impacts of unconventional drilling operations on humans and animal health. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, *50*, 447-59. doi: 10.1080/10934529.2015.992655

⁴⁶¹ Slizovskiy, I. B., Conti, L. A., Trufan, S. J., Reif, J. S., Lamers, V. T., Stowe, M. H., Dziura, J., & Rabinowitz, P. M. (2015). Reported health conditions in animals residing near natural gas wells in southwestern Pennsylvania, *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, *50*(5), 473-481, doi: 10.1080/10934529.2015.992666

- January 1, 2015 – A Yale-led team studied the relationship between household proximity to drilling and fracking operations and reported health symptoms in Washington County, Pennsylvania where 624 gas wells were in active operation, most of which had been drilled in the past five to six years. Researchers found that health symptoms reported by residents increased in frequency as distance between household and gas wells decreased. Among persons living less than one kilometer from drilling and fracking operations, rashes and upper respiratory problems were more prevalent. The authors of this study, the largest to date on the link between reported symptoms and natural gas drilling activities, say that their findings are “... consistent with earlier reports of respiratory and dermal conditions in persons living near natural gas wells.” They also cite literature demonstrating the biological plausibility of a link between oil and gas extraction activities and both categories of health effects reported.⁴⁶²
- December 17, 2014 – As part of a lengthy review that became the foundation for New York State’s ban on high volume hydraulic fracturing, the New York State Department of Health (NYS DOH) identified environmental problems associated with fracking that could contribute to adverse public health impacts. Among them: air pollution (particulate matter, ozone, diesel exhaust, and VOCs) that could affect respiratory health; drinking water contamination from underground migration of methane and/or fracking chemicals associated with faulty well construction or seismic activity; drinking water contamination from inadequate water treatment of fracking waste or from surface spills of fracking chemicals or wastewater; earthquakes and the creation of fissures; increased vehicle traffic; increased noise; increased demand for housing and medical care; and public health problems related to climate change impacts from methane and other greenhouse gas emissions into the atmosphere. The NYS DOH Public Health Review also discussed findings from surveys of health symptoms among residents living near high volume hydraulic fracturing activities. These included skin rash, nausea or vomiting, abdominal pain, breathing difficulties, cough, nosebleed, anxiety, stress, headache, dizziness, eye irritation, and throat irritation in populations living near drilling and fracking operations. The NYS DOH Public Health Review noted that ongoing studies by both government agencies and several academic institutions were exploring the public health risks and impacts of fracking but that many of these studies were years from completion. The review concludes:

... significant gaps exist in the knowledge of potential public health impacts from [high volume hydraulic fracturing].... The existing science investigating associations between [high volume hydraulic fracturing] activities and observable adverse health outcomes is very sparse and the studies that have been published have significant scientific limitations. Nevertheless, studies are suggestive of potential public health risks related to [high volume hydraulic fracturing] activity that warrant further careful evaluation.

⁴⁶² Rabinowitz, P. M. Slizovskiy, I. B, Lamers, V., Trufan, S. J., Holford, T. R., Dziura, J. D., ... Stowe, M. H. (2015). Proximity to natural gas wells and reported health status: results of a household survey in Washington County, Pennsylvania. *Environmental Health Perspectives*, 123, 21-26. doi: 10.1289/ehp.1307732. See also footnote 29.

In an accompanying letter to the New York State Department of Environmental Conservation, Health Commissioner Howard Zucker, MD, concluded,

... the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with [high volume hydraulic fracturing], the likelihood of the occurrence of adverse health outcomes and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health. Until the science provides sufficient information to determine the level of risk to public health from [fracking] to all New Yorkers and whether the risks can be adequately managed, DOH recommends that high volume hydraulic fracturing should not proceed in NYS.⁴⁶³

- October 13, 2014 – According to the North Dakota Health Department, the number of HIV and AIDS cases in North Dakota more than doubled between 2012 and 2014, and cases were shifting to the state’s western oil fields, where 35-40 percent of all new cases occurred. Previously, only 10 percent of cases were in that region.⁴⁶⁴ This trend followed on the heels of an upsurge in sexually transmitted chlamydia cases in the same region. The North Dakota state director of disease control, Kirby Kruger, attributed the uptick in HIV cases to the drilling and fracking industry and attempted to spread HIV prevention messages at the “man camps” that house young male workers in the oil industry.⁴⁶⁵ Human trafficking for purposes of prostitution accompanied the fracking boom, but there was a shortage of medical professionals to address this public health crisis, according to Kruger, who noted that it was difficult to hire nurses and medical staff who could live in the area on a public health wage.
- October 2, 2014 – According to researchers from the University of Pennsylvania’s Center of Excellence in Environmental Toxicology, an increasing number of gas wells in Pennsylvania is significantly correlated with inpatient rates of hospitalization. The research team collected data from seven different insurance providers for three counties; the study’s publication is forthcoming.⁴⁶⁶
- September 11, 2014 – In Texas, commercial vehicle accidents have increased more than 50 percent since 2009 when the state’s ongoing drilling and fracking boom began,

⁴⁶³ New York State Department of Health. (2014, December 17). *A public health review of high volume hydraulic fracturing for shale gas development*. Retrieved from http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

⁴⁶⁴ Associated Press. (2014, October 13). North Dakota HIV/AIDS rate rises with population growth. Retrieved from http://billingsgazette.com/news/state-and-regional/montana/north-dakota-hiv-aids-rate-rises-with-population-growth/article_a939fed6-f737-5cfb-957f-ab800673f4d7.html

⁴⁶⁵ Heitz, D. (2014, September 30). Oil boom helps fuel surge in HIV in North Dakota. *HealthlineNews*. Retrieved from <http://www.healthline.com/health-news/oil-boom-helps-fuel-hiv-surge-north-dakota-093014#1>

⁴⁶⁶ Skrapits, E. (2014, October 2). Study: More gas wells in area leads to more hospitalizations. *The Citizen’s Voice*. Retrieved from <http://citizensvoice.com/news/study-more-gas-wells-in-area-leads-to-more-hospitalizations-1.1763826>

according to an investigation by the *Houston Chronicle* and Houston Public Media News 88.7. “For six decades, highway deaths have dropped steadily all across the United States.... But in Texas all motor vehicle fatalities – and accidents involving commercial trucks – have turned back upward since the state’s oil drilling and fracking boom began in 2008.” This rising motor vehicle death toll is especially felt in formerly rural counties in the Eagle Ford and Permian Basin, now places of heavy drilling and fracking. A new Department of Public Safety “Road Check” program finds annually, “27 to 30 percent of Texas’ commercial trucks shouldn’t be operating at all due to potentially life-threatening safety problems like defective brakes, bald tires, inoperable safety lights and unqualified, unfit or intoxicated drivers.”^{467, 468}

- August 3, 2014 – Hospitals in the Bakken Shale region reported a sharp rise in ambulance calls and emergency room visits after 2006. “Mercy Medical Center in Williston and the Tioga Medical Center in neighboring Williams County saw their ambulance runs increase by more than 200 percent. Tioga’s hospital saw a staggering leap in trauma patients by 1,125 percent. Mercy had a 373 percent increase.” Drugs (including overdoses of prescription drugs, methamphetamine, and heroin) explain many of the cases, with oilfield related injuries such as “fingers crushed or cut off, extremity injuries, burns and pressure burns” accounting for 50 percent of the cases in one of the region’s hospital emergency rooms.⁴⁶⁹
- May 21, 2014 – Raising questions about possible links to worsening air pollution from the Uintah Basin’s 11,200 oil and gas wells, health professionals reported that infant deaths in Vernal, Utah, rose to six times the normal rate over the past three years. Physician Brian Moench said, “We know that pregnant women who breathe more air pollution have much higher rates of virtually every adverse pregnancy outcome that exists.... And we know that this particular town is the center of an oil and gas boom that’s been going on for the past five or six years and has uniquely high particulate matter and high ozone.”⁴⁷⁰ Although it formerly had pristine air quality, Uintah County, Utah received a grade “F” for ozone in the American Lung Association’s 2013 State of the Air Report.⁴⁷¹
- January 28, 2014 – Congenital heart defects, and possibly neural tube defects in newborns, were associated with the density and proximity of natural gas wells within a 10-mile radius of mothers’ residences in a study of almost 25,000 births from 1996 to 2009 in rural Colorado. The researchers note that natural gas development emits several

⁴⁶⁷ Olsen, L. (2014, 11 September). Fatal truck accidents have spiked during Texas’ ongoing fracking and drilling boom. *Houston Chronicle*. Retrieved from <http://www.houstonchronicle.com/news/article/Fracking-and-hydraulic-drilling-have-brought-a-5747432.php?cmpid=email-premium&cmpid=email-premium&t=1a9ca10d49c3f0c8a9#0>

⁴⁶⁸ Schneider, A. (2014, 12 October). In Texas, traffic deaths climb amid fracking boom. *National Public Radio*. Retrieved from <http://www.npr.org/2014/10/02/352980756/in-texas-traffic-deaths-climb-amid-fracking-boom>

⁴⁶⁹ Bryan, K. J. (2014, August 3). Drugs, oilfield work, traffic pushing more people through doors of Watford City ER. *Bakken Today*. Retrieved from <http://www.bakken.today.com/event/article/id/37101/>

⁴⁷⁰ Schlanger, Z. (2014, May 21). In Utah boom town, a spike in infant deaths raises questions. *Newsweek*. Retrieved from <http://www.newsweek.com/2014/05/30/utah-boom-town-spike-infant-deaths-raises-questions-251605.html>

⁴⁷¹ American Lung Association. (2013). American Lung Association state of the air 2013. Retrieved from <http://www.stateoftheair.org/2013/states/utah/uintah-49047.html>

chemicals known to increase risk of birth defects (teratogens).⁴⁷²

- January 4, 2014 – Preliminary data from researchers at Princeton University, Columbia University, and MIT showed elevated rates of low birthweight among infants born to mothers living near drilling and fracking operations during their pregnancies.⁴⁷³
- October 2013 – A preliminary study of the health impacts of oil and gas extraction on infant health in Colorado found that proximity to wells—linked with air pollutants from fracking operations—was associated with reductions in average birthweight and length of pregnancy as well as increased risk for low birthweight and premature birth.⁴⁷⁴ A study by the same author, currently under review, which analyzed births to Pennsylvania mothers residing close to a shale gas well in Pennsylvania from 2003 to 2010, also identified increased risk of adverse effects. This includes low birth weight, as well as a 26 percent increase in APGAR scores under 8. (APGAR—or American Pediatric Gross Assessment Record—is a measure of newborn responsiveness. Scores of less than 8 predict an increase in the need for respiratory support.)⁴⁷⁵
- August 26, 2013 – Medical experts at a rural clinic in heavily-drilled Washington County, Pennsylvania reported case studies of 20 individuals with acute symptoms consistent with exposure to air contaminants known to be emitted from local fracking operations.^{476, 477}
- May 2, 2013 – A community-based participatory research study in Pennsylvania tested air and water quality and surveyed self-reported health symptoms of more than 100 residents living near drilling and fracking operations. The team detected a total of 19 volatile organic compounds (VOCs) in ambient air sampled outside of homes. The reported health symptoms closely matched the established effects of chemicals detected through air and water testing at those nearby sites. Moreover, those symptoms occurred at significantly higher rates in households closer to the gas facilities than those farther away.⁴⁷⁸ Indicative of the growing prevalence of such health impacts in the state, a poll

⁴⁷² McKenzie, L. M., Guo, R., Witter, R. Z., Savitz, D. A., Newman, L. S., & Adgate, J. L. (2014). Birth outcomes and maternal residential proximity to natural gas development in rural Colorado. *Environmental Health Perspectives*, 122, 412-417. doi: 10.1289/ehp.1306722

⁴⁷³ Whitehouse, M. (2014, January 4). Study shows fracking is bad for babies. *Bloomberg*. Retrieved from <http://www.bloombergvew.com/articles/2014-01-04/study-shows-fracking-is-bad-for-babies>

⁴⁷⁴ Hill, E. L. (2013, October). The impact of oil and gas extraction on infant health in Colorado. Retrieved from <http://www.elainehill.com/research>

⁴⁷⁵ Hill, E. L. (2013, December). Shale gas development and infant health: Evidence from Pennsylvania (under review). Retrieved from <http://www.elainehill.com/research>.

⁴⁷⁶ Abrams, L. (2013, August 26). Fracking's real health risk may be from air pollution. *Salon*. Retrieved from http://www.salon.com/2013/08/26/frackings_real_health_risk_may_be_from_air_pollution/

⁴⁷⁷ Dyrzka, L., Nolan, K., & Steingraber, S. (2013, August 27). *Statement on preliminary findings from the Southwest Pennsylvania Environmental Health Project study* [Press release]. Concerned Health Professionals of NY. Retrieved from <http://concernedhealthny.org/statement-on-preliminary-findings-from-the-southwest-pennsylvania-envir...>

⁴⁷⁸ Steinzor, N., Subra, W., & Sumi, L. (2013). Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, 23(1), 55-83. doi: 10.2190/NS.23.1.e

showed that two-thirds of Pennsylvanians support a moratorium on fracking because of concern about negative health impacts.⁴⁷⁹

Noise pollution, light pollution, and stress

Drilling and fracking operations and ancillary infrastructure expose workers and nearby residents to continuous noise and light pollution that is sustained for periods lasting many months. Chronic exposure to light at night is linked to adverse health effects, including breast cancer. Sources of fracking-related noise pollution include blasting, drilling, flaring, generators, compressor stations, and truck traffic. Exposure to environmental noise pollution is linked to cardiovascular disease, cognitive impairment, and sleep disturbance. Oil and gas production noise may be disrupting wildlife health in protected areas. Workers and residents whose homes, schools, and workplaces are in close proximity to well sites are at risk from these exposures as well as from related stressors. Existing “setback distances” may not be adequate to reduce public health threats, especially for vulnerable populations. A UK Health Impact Assessment (HIA) identified stress and anxiety resulting from drilling-related noise—as well as from a sense of uncertainty about the future and eroded public trust—as key public health risks related to fracking operations.

- May 5, 2017 – Oil and gas production was one of the main anthropogenic noise sources (though the proportion for which it was responsible was not determined) in a study that quantified the degree and extent of noise pollution in U.S. protected areas (PAs) and critical habitat for endangered species. Authors “compared noise pollution among land management and protection status and investigated sources responsible for generating noise across PAs.” The team of biologists and engineers found that human-caused noise doubled background sound in 63 percent of U.S. protected areas, and produced a tenfold or greater increase in 21 percent of protected areas. These levels are “known to interfere with human visitor experience and disrupt wildlife behavior, fitness, and community composition.” Researchers also found a 10-fold increase in sound levels in 14 percent of critical habitats of endangered species.⁴⁸⁰
- April 3, 2017 – A University of Maryland team conducted a pilot study of noise pollution at eight homes located less than a half mile (750 meters) from natural gas compressor stations in West Virginia and compared decibel levels to those collected from homes located further away. They found that daytime and nighttime noise levels were higher at properties located closer to a compressor, as measured both inside and outside the homes. Five of six homes that were monitored for a full 24-hour period had combined day-night indoor average noise levels that exceed 60 decibels (dBA), which exceeds both EPA’s recommended limits for chronic noise exposure as well those recommended by the World

⁴⁷⁹ Phillips, S. (2013, May 14). Poll shows support for a drilling moratorium in Pennsylvania. *StateImpact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2013/05/14/poll-shows-support-for-a-drilling-moratorium-in-pennsylvania/>

⁴⁸⁰ Buxton, R. T., McKenna, M. F., Mennitt, D., Fristrup, K., Crooks, K., Angeloni, L., & Wittemyer, G. (2017). Noise pollution is pervasive in U.S. protected areas. *Science*, 356 (6337), 531-533. doi: 10.1126/science.aah4783

Health Organization. To date, no federal noise standards exist for oil and gas operations. Noting that noise exposure has been associated in previous studies with sleep disruption, poor academic performance, and hypertension, the authors conclude, “Findings indicate that living near natural gas compressor stations could potentially result in high environmental noise exposures. Larger studies are needed to confirm these findings and evaluate potential health impacts and protections measures.”⁴⁸¹

- December 9, 2016 – A review analyzing the relevant scientific literature on the potential public health impacts of ambient noise related to unconventional oil and gas development found that “oil and gas activities produce noise at levels that may increase the risk of adverse health outcomes, including annoyance, sleep disturbance, and cardiovascular disease.” The team of environmental and occupational health scientists collected available measurements of noise levels at oil and gas operations and analyzed the data with established noise standards. Authors stated that many noise sources from fracking operations are similar to those of conventional oil and gas development, but that high-volume hydraulic fracturing activities present additional noise risks. These arise from conditions including four to five times the length of time needed to drill the well, and the much greater volume of water and higher pressures needed, compared to a traditional vertical well. They described the complexity of noise associated with oil and gas operations, including both intermittent and continuous noise, varying in intensities. The review included focus on vulnerable populations, including children, the elderly, and the chronically ill. Authors noted that existing “setback distances” – already often the result of political compromise and not evidence-based – may be insufficient to reduce public health threats, and that maximum allowable noise levels should be lower for schools and hospitals.⁴⁸²
- July 9, 2015 – As part of its assessment of potential health impacts, the California Council of Science and Technology looked at the impacts of noise and light pollution from oil and gas operations in California. The researchers noted that a number of activities associated with drilling and fracking generated noise at levels considered dangerous to public health. Noise is a biological stressor that can aggravate or contribute to the development of hypertension and heart problems. In California, noise from well stimulation was associated with both sleep disturbance and cardiovascular disease in a dose-response relationship. Exposure to artificial light at night has been linked to breast cancer in women, although almost no research has been conducted on the public health implications of light pollution from oil and gas extraction specifically.⁴⁸³

⁴⁸¹ Boyle, M. D., Soneja, S., Quirós-Alcalá, L., Dalemarre, L., Sapkota, A. R., Sangaramoorthy, T. ... Sapkota, A. (2017). A pilot study to assess residential noise exposure near natural gas compressor stations. *PLoS ONE*, 12(4), e0174310. doi: 10.1371/journal.pone.0174310

⁴⁸² Hays, J., McCawley, M., & Shonkoff, S. B. C. (2016). Public health implications of environmental noise associated with unconventional oil and gas development. *Science of the Total Environment*, 580, 448-556. doi: 10.1016/j.scitotenv.2016.11.118

⁴⁸³ Shonkoff, S. B. C., Jordan, P., Hays, J., Stringfellow, W. T., Wettstein, Z. S., Harrison, R., Sandelin, W., & McKone, T. E. (2015, July 9). Volume II, Chapter 6: Potential impacts of well stimulation on human health in California. In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from <http://ccst.us/publications/2015/vol-II-chapter-6.pdf>

- December 17, 2014 – The New York State Department of Health (NYS DOH) identified community impacts related to noise as a potential contributor to a variety of negative health impacts from drilling and fracking operations but noted that considerable scientific uncertainty remains on the issue of noise exposure per se as a risk factor. Noise, air pollution, traffic, vibration, odors, and nighttime lighting may all increase together as proximity to a drilling site decreases.⁴⁸⁴
- December 1, 2014 – Range Resources Corporation warned supervisors in Pennsylvania’s Donegal Township that a “big burn” natural gas flare will continue for as long as a week and “will produce a continuous noise of as much as 95 decibels at the well pad. Sustained decibel levels between 90 and 95 can result in permanent hearing loss, but workers will be equipped with ear protection.” Township supervisor Doug Teagarden expressed concern for residents, saying, “They told us the flare would be double the size of other well flares, and the noise will be like a siren on a firetruck... There are houses within a couple of hundred yards of the well pad, and those folks are going to hear it.”⁴⁸⁵
- November 6, 2014 – Sakthi Karunanithi, Director of Public Health in Lancashire, UK, reported on a Health Impact Assessment (HIA) of the two proposed shale gas exploration sites in Lancashire. Karunanithi’s study determined that key risks to the health and well-being of the residents who live near the two proposed sites in Lancashire include stress and anxiety from uncertainty that could lead to “poor mental wellbeing,” and noise-related health effects due to continuous drilling. The HIA also noted a lack of public trust and confidence.^{486, 487}
- September 2014 – The Ohio Shale Country Listening Project, a collaborative effort to solicit, summarize, and share the perspectives and observations of those directly experiencing the shale gas build out in eastern Ohio, found that the more shale gas wells a community has, the less popular the oil and gas industry becomes. Many residents reported that they had not experienced the economic benefits promised by the oil and gas industry. They complained of increased rents and costs of gas and groceries, an influx of out-of-state workers, more vehicular accidents, road destruction from large trucks, and damaged landscape and cropland. Locals reported feeling less secure and more

⁴⁸⁴ New York State Department of Health. (2014, December 17). *A public health review of high volume hydraulic fracturing for shale gas development*. Retrieved from http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

⁴⁸⁵ Hopey, D. (2014, December 1). Gas flare to light up part of Washington County. *Pittsburgh Post Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/companies-powersource/2014/12/01/Gas-flare-to-light-up-part-of-Washington-County/stories/201411250224>

⁴⁸⁶ Karunanithi, S. (2014, November 6). Potential health impacts of the proposed shale gas exploration sites in Lancashire. *Reported at a meeting of the Lancashire County Council Cabinet, Thursday, 6th November, 2014 at 2.00 pm in Cabinet Room 'B' - County Hall, Preston, Item 9 on the agenda(1-68)*. Retrieved from <http://council.lancashire.gov.uk/documents/b11435/Potential%20Health%20Impacts%20of%20the%20Proposed%20Shale%20Gas%20Exploration%20Sites%20in%20Lancashire%2006th-Nov-2014%2014.pdf?T=9>

⁴⁸⁷ Dunkley, E. (2014, November 7). Fracking in Lancashire 'may affect mental health', report finds. *BBC NEWS Lancashire*. Retrieved from <http://www.bbc.com/news/uk-england-lancashire-29944212>

financially strapped.⁴⁸⁸

- June 20, 2014 – In its discussion of “Oil and Gas Drilling/Development Impacts,” the U.S. Office of Indian Energy and Economic Development detailed noise pollution from bulldozers, drill rigs, diesel engines, vehicular traffic, blasting, and flaring of gas. “If noise-producing activities occur near a residential area, noise levels from blasting, drilling, and other activities could exceed the U.S. Environmental Protection Agency (EPA) guidelines. The movement of heavy vehicles and drilling could result in frequent-to-continuous noise.... Drilling noise would occur continuously for 24 hours per day for one to two months or more depending on the depth of the formation.”⁴⁸⁹ Exposure to chronic noise can be deadly. The World Health Organization has documented the connection between environmental noise and health effects, including cardiovascular disease, cognitive impairment, sleep disturbance, and tinnitus. At least one million “healthy life years” are lost every year from traffic-related noise in the western part of Europe.⁴⁹⁰
- February 24, 2014 – In a review of the health effects from unconventional gas extraction published in the journal *Environmental Science & Technology*, leading researchers noted, “Noise exposure is a significant hazard due to the presence of multiple sources, including heavy equipment, compressors, and diesel powered generators. Loud continuous noise has health effects in working populations. It is likely that exposure to noise is substantial for many workers, and this is potentially important for health because drilling and servicing operations are exempt from some sections of the Occupational Safety and Health Administration noise standard.” They noted that research should investigate stressors such as noise and light in the context of drilling and fracking operations in order to understand the overall effect of chemical and physical stressors together.⁴⁹¹
- May 30, 2014 – The *Denver Post* reported that in order to help meet Colorado’s noise limits for fracking operations in suburban neighborhoods (and partially block the glare of floodlights), Encana Oil and Gas erected 4-inch-thick polyvinyl walls up to 32 feet high and 800 feet long. Residents said that the plastic walls do not completely solve the problem.⁴⁹²

⁴⁸⁸ Ohio Organizing Collaborative (OOC)’s Communities United for Responsible Energy (CURE), with support from the Ohio Environmental Council (OEC), FracTracker.org, and Laborers Local 809 of Steubenville. (2014, September). Ohio Shale Country Listening Project. Retrieved from http://carrollconcernedcitizens.org/uploads/2014_Shale_Report_small.pdf

⁴⁸⁹ Oil and Gas Drilling/Development Impacts. (n.d.). *Oil and gas drilling/development impacts*. Retrieved from <http://teeic.indianaffairs.gov/er/oilgas/impact/drilldev/index.htm>

⁴⁹⁰ Rodier, G. (2011, June 1). Burden of disease from environmental noise - Quantification of healthy life years lost in Europe. *WHO*. Retrieved from http://www.who.int/quantifying_ehimpacts/publications/e94888/en/

⁴⁹¹ Adgate, J. L., Goldstein, B. D., & McKenzie, L. M. (2014). Potential public health hazards, exposures and health effects from unconventional natural gas development. *Environmental Science & Technology* 48(15), 8307-20. doi: 10.1021/es404621d

⁴⁹² Finley, B. (2014, May 29). Oil and gas industry building giant walls to try to ease impact. *The Denver Post*. Retrieved from http://www.denverpost.com/ci_25859469/oil-and-gas-industry-building-giant-walls-try

- October 25, 2013 – An analysis of well location and census data by the *Wall Street Journal* revealed that at least 15.3 million Americans now live within a mile of a well that has been drilled since 2000. According to this investigation, the fracking boom has ushered in “unprecedented industrialization” of communities across wide swaths of the nation and, with it, “24/7” industrial noise, stadium lighting, earth-moving equipment, and truck traffic.⁴⁹³
- April 16, 2013 – In a presentation on oil field light pollution for a conference on “Sustainable Environment and Energy: Searching for Synergies,” Roland Dechesne of the Royal Astronomical Society of Canada described problems of “light trespass,” glare, and poorly-aimed fixtures in oil fields in Alberta. He described resulting “mass waterfowl mortality” linked to artificial illumination and other biochemical impacts of light pollution on wildlife, as well as the possibility of these effects on humans, including circadian disruption, melatonin suppression, and possible resulting hormonally-linked diseases.⁴⁹⁴ Known to have ecological impacts, outdoor light pollution from drilling and fracking operations may also be linked to artificial light-associated health effects documented in humans, including breast cancer.⁴⁹⁵
- April 2013 – Led by the University of Pittsburgh Graduate School of Public Health, a study of community members living in proximity to Marcellus Shale drilling in Pennsylvania found adverse impacts to mental health, with stress the most frequently reported symptom. At least half of all respondents in each set of interviews reported these specific stressors, including: being taken advantage of; health concerns; concerns/complaints ignored; corruption; denied information or provided with false information. Many also reported the desire to move or leave community, estrangement from community, and financial damages. Researchers noted that stress can result in direct health impacts.⁴⁹⁶ Notably, mounting evidence indicates that chronic stress magnifies individuals’ susceptibility to effects of pollution; for children, this interactive effect can begin during prenatal life.⁴⁹⁷
- September 7, 2011 – A study by researchers at Boise State University and Colorado State University at Fort Collins modeled the potential impacts of compressor station noise from oil and gas operations on Mesa Verde National Park in Colorado. The study found the sound of 64 compressors outside Mesa Verde elevated the sound level within the park by

⁴⁹³ Gold, R. & McGinty, T. (2014, Oct. 25). Energy boom puts wells in America’s backyards. *The Wall Street Journal*. Retrieved from <http://online.wsj.com/news/articles/SB10001424052702303672404579149432365326304>

⁴⁹⁴ Dechesne, R. (2013). Limiting oil field light pollution for safety and the environment. Sustainable Environment and Energy CPANS 2013 Conference. Retrieved from <http://www.cpans.org/assets/Uploads/Presentations/NewFolder/Session-46Roland-Dechesne.pdf>

⁴⁹⁵ Chepesiuk, R. (2009). Missing the dark: Health effects of light pollution. *Environmental Health Perspectives*, 117(1), A20–A27.

⁴⁹⁶ Ferrar, K. J., Kriesky, J., Christen, C. L., Marshall, L. P., Malone, S. L., Sharma, R. K., Michanowicz, D. R., & Goldstein, B.D. (2013). Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus Shale region. *International Journal of Occupational & Environmental Health*, 19(2),104-112. doi: 10.1179/2049396713Y.0000000024

⁴⁹⁷ Cooney, C.M. (2011). Stress–pollution interactions: An emerging issue in children’s health research. *Environmental Health Perspectives*, 119, a430-a435. <http://dx.doi.org/10.1289/ehp.119-a430>

34.8 decibels on average, and by 56.8 decibels on the side of the park located closest to the compressors. According to the EPA, 55 decibels is the highest “safe noise level” to avoid damage to the human ear.⁴⁹⁸

Earthquakes and seismic activity

A growing body of evidence from Ohio, Arkansas, Texas, Oklahoma, Kansas, and Colorado links fracking wastewater injection (disposal) wells to earthquakes of magnitudes as high as 5.8, in addition to swarms of minor earthquakes. Both the U.S. Geological Survey (USGS) and state geological agencies such as the Oklahoma Geological Survey now acknowledge that earthquakes can be caused by wastewater injection. Many recent studies focus on the mechanical ability of pressurized fluids to trigger seismic activity by unclamping stressed faults. In some cases, and especially in Canada, the fracking process itself has been linked to earthquakes as significant as magnitude 4.4. Emerging evidence suggests that risk of earthquakes can continue to rise for years after waste injection and cannot be prevented through “proper” fracking protocols or by solely limiting the rate or volume of injected fluid. The question of what to do with fracking wastewater remains a problem with no viable, safe solution.

- November 24, 2017 – A team of geologists confirmed conclusively that recent earthquakes in Texas’ Fort Worth Basin were induced by underground injection of fracking waste that caused deep, critically stressed faults to slip.⁴⁹⁹ The authors of this study employed a classical structural geology analysis that relied on high-resolution seismic reflection imaging, described in an interview with geophysical researcher Maria Magnani as “a little bit like an ultrasound.”⁵⁰⁰ Maps of the seismically active faults in the Fort Worth Basin show no evidence of previous motion over the past millions of years and instead have been “sleeping” for approximately the past 300 million years until “awakened” at the start of the 2008 earthquake swarm associated temporally with extensive wastewater injection activities.⁵⁰¹
- October 21, 2017 – Extending the findings of two previous studies, an investigation of earthquakes in the Raton Basin along the border of New Mexico and Colorado identified

⁴⁹⁸ Barber, J. R., Burdett, C.L., Reed, S. E., Warner, K.A., Formichella, C., Crooks, K.R., Theobald, D.M., & Fristrup, K. M. (2011). Anthropogenic noise exposure in protected natural areas: estimating the scale of ecological consequences. *Landscape Ecology*, 26(9), 1281-1295.

⁴⁹⁹ Magnani, M. B., Blanpied, M. L., DeShon, H. R., & Hornbach, M. J. (2017). Discriminating between natural versus induced seismicity from long-term deformation history of intraplate faults. *Science Advances*, 3(11), e1701593. doi: 10.1126/sciadv.1701593

⁵⁰⁰ Guarino, B. (2017, November 24). Oil and gas industry is causing Texas earthquakes, a ‘landmark’ study suggests. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/speaking-of-science/wp/2017/11/24/fracking-and-other-human-activities-are-causing-texas-earthquakes-study-suggests/?tid=ss_tw&utm_term=.02bfff4181f1

⁵⁰¹ Kuchment, A. (2017, November 24). Drilling reawakens sleeping faults in Texas, leads to earthquakes. *Scientific American*. Retrieved from https://www.scientificamerican.com/article/drilling-reawakens-sleeping-faults-in-texas-leads-to-earthquakes/?utm_source=newsletter&utm_medium=email&utm_campaign=weekly-review&utm_content=link&utm_term=2017-11-29_featured-this-week

wastewater injection wells as the cause of the quakes and identified a mechanism.⁵⁰² All together, the location of the earthquakes, modeled pore pressures, and the direct correlation between cumulative volume of injected waste in nearby wells and the number of quakes show that seismicity in the Raton Basin is likely induced, and that elevated pore pressures deep underground are “well above earthquake-triggering thresholds.”⁵⁰³

- September 14, 2017 – An investigation by *Politico* found that the U.S. crude oil storage hub in Cushing, Oklahoma—the world’s largest store of oil—was not designed with seismic considerations in mind, nor are there seismic regulations in place for its 250,000-barrel oil tanks, which are under the purview of the Department of Transportation’s Pipeline and Hazardous Materials Safety Administration. Central Oklahoma, where Cushing is located, became seismically active about five years ago when “wastewater injection and other fracking-related activities changed the seismic face of Oklahoma in dramatic fashion.”⁵⁰⁴ [See also entry below for November 8, 2016.]
- May 3, 2017 – Studying two patterns of fracking waste injection in Oklahoma, geologists observed a large, unexpected impact on seismic activity at sites where injection rates drastically changed in recent years, as compared with those whose injection volumes held steady. They demonstrated that, in addition to direct pore pressure effects, deformations due to fluid flows (“poroelastic effects”) play an important role in generating earthquake activity. Elevated risks for earthquakes can persist years after fracking waste is injected underground. Their findings also showed that the “magnitude of the initial change in injection rate is particularly important, but the opposite effect occurs in the transition to zero injection” (i.e., shut-in or closing a well). This result implies that “in certain faulting regimes it is theoretically possible to mitigate damaging effects of rapid shut-in by carefully tapering injection rates.”⁵⁰⁵ Geophysicist Andrew Barbour, lead author of the study, said that fluctuating injection rates likely have a “profound effect” on earthquake risk.⁵⁰⁶ These findings suggest that the 2016 Pawnee earthquake, the strongest earthquake ever recorded in Oklahoma, may have been triggered by pulses of underground oil and gas activity years earlier.⁵⁰⁷

⁵⁰² Nakai, J. S., Weingarten, M., Sheehan, A. F., Bilek, S. L., & Ge, S. (2017). A possible causative mechanism of Raton Basin, New Mexico and Colorado earthquakes using recent seismicity patterns and pore pressure modeling. *Journal of Geophysical Research: Solid Earth*, 122. doi: 10.1002/2017JB014415

⁵⁰³ Scott, J. (2017, October 24). Raton Basin earthquakes linked to oil and gas fluid injections. *University of Colorado Boulder*. Retrieved from <https://www.colorado.edu/today/2017/10/24/raton-basin-earthquakes-linked-oil-and-gas-fluid-injections>

⁵⁰⁴ Ogrocki, S. (2017, September 24). How man-made earthquakes could cripple the U.S. economy. *Politico*. Retrieved from <http://www.politico.com/magazine/story/2017/09/14/earthquakes-oil-us-economy-fracking-215602>

⁵⁰⁵ Barbour, A. J., Norbeck, J. H., & Rubinstein, J. L. (2017). The effects of varying injection rates in Osage County, Oklahoma, on the 2016 Mw 5.8 Pawnee earthquake. *Seismological Research Letters*, 88(4), 1040-1053. Doi: 10.1785/0220170003

⁵⁰⁶ Jones, C. (2017, May 7). USGS study 'strongly suggests' short-term variations in disposal volumes served as trigger for Pawnee earthquake. *Tulsa World*. Retrieved from http://www.tulsaworld.com/earthquakes/usgs-study-strongly-suggests-short-term-variations-in-disposal-volumes/article_97de08d5-9327-505d-8b51-adbc716d6c69.html

⁵⁰⁷ Wertz, J. (2017, May 4). Study links pulse of oil-field wastewater to Oklahoma’s strongest earthquake. *StateImpact Oklahoma*. Retrieved from <https://stateimpact.npr.org/oklahoma/2017/05/04/study-links-pulse-of-oil-field-wastewater-to-oklahomas-strongest-earthquake/>

- April 27, 2017 – Recognizing that increased seismicity from both hydraulic fracturing and underground disposal of fracking wastewater poses a hazard to critical infrastructure, such as large dams, a Canadian geologist proposed strategies to keep the likelihood of high-failure consequences under one per ten thousand per year.⁵⁰⁸ The primary strategy is the creation of “no frack” exclusion zones with a 5-kilometer (3.1 mile) radius that would surround vulnerable, critical facilities. In a larger ring beyond the exclusion zone, to approximately 25 kilometers (15.5 miles), monitoring and response protocols would be used.⁵⁰⁹
- March 1, 2017 – Despite decreases of up to 40 percent in the volume of fracking wastewater injected underground in Oklahoma, researchers from the USGS Earthquake Hazard Program forecasted that seismic hazards would remain significantly elevated there throughout 2017, with the odds of damage from induced earthquakes within the next year “similar to that of natural earthquakes in high-hazard areas of California.” About three million people in Oklahoma and southern Kansas now live with continuing increased potential for damaging shaking from induced seismicity.⁵¹⁰ According to Mark Petersen, chief of the USGS National Seismic Hazard Mapping Project, the hazard risk remains “hundreds of times higher than before man-made activity began.”⁵¹¹
- February 17, 2017 – Pennsylvania’s Department of Environment Protection (PA DEP) announced that a series of small earthquakes in Lawrence County had been induced by fracturing of wells in the Utica Shale.⁵¹² PA DEP officials held a webinar to discuss the situation and formulate “procedures to reduce seismic risk going forward,” but no formal report or regulatory changes have yet been made public.⁵¹³
- December 20, 2016 – In an attempt to reduced the risk of earthquakes caused directly by fracking, the Oklahoma Corporation Commission’s Oil and Gas Conservation Division introduced monitoring and response guidelines that include provisions requiring oil producers to “implement mitigation plans following an earthquake of magnitude 2.5 or more and to suspend operations following a quake of magnitude 3.5 or greater.”⁵¹⁴

⁵⁰⁸ Atkinson, G. M. (2017). Strategies to prevent damage to critical infrastructure due to induced seismicity. *FACETS*, 2, 374–394. doi: 10.1139/facets-2017-0013

⁵⁰⁹ Nikiforuk, A. (2017, July 24). Earthquake expert proposes ‘no frack zone’ around critical infrastructure. *The Tyee*. Retrieved from <https://thetyee.ca/News/2017/07/24/Critical-Infrastructure-No-Frack-Zone/>

⁵¹⁰ Petersen, M. D., Mueller, C. S., Moschetti, M. P., Hoover, S. M., Shumway, A. M., McNamara, D. E., ... Rukstales, K.S., (2017). 2017 one-year seismic-hazard forecast for the central and eastern United States from induced and natural earthquakes. *Seismological Research Letters*, 88(3). doi: 10.1785/0220170005

⁵¹¹ Wilmoth, A. (2017, March 1). Oklahoma considered at ‘significant potential’ for damaging earthquakes. *News OK*. Retrieved from <http://newsok.com/article/5539785https://mail.google.com/mail/u/0/>

⁵¹² Legere, L. (2017, February 17). DEP links Lawrence County earthquakes to fracking. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/policy-powersource/2017/02/16/DEP-Pennsylvania-Lawrence-County-earthquakes-appear-linked-to-fracking-Hilcorp-Energy/stories/201702160176>

⁵¹³ Pennsylvania Department of Environmental Protection. (2017, February 17). *Advisory – Department of Environmental Protection to hold webinar on 2016 Lawrence County seismic events*. Retrieved from <http://www.ahs.dep.pa.gov/NewsRoomPublic/articleviewer.aspx?id=21145&typeid=1>

⁵¹⁴ Hampton, L. (2016, December 20). Oklahoma's new fracking guidelines aim to reduce quake risk. *Reuters*. Retrieved from <https://www.reuters.com/article/us-oklahoma-quake-rules/oklahomas-new-fracking-guidelines-aim-to-reduce-quake-risk-idUSKBN1492R6>

- November 17, 2016 – A study of fault activation found a connection between fracking and earthquake activity in a region of Alberta, Canada that had previously been seismically quiescent. The researchers demonstrated that new earthquake activity in the Fox Creek area was tightly spatially correlated with hydraulic fracturing activities. Their findings further suggested that seismic activity resulted from “stress changes due to the elastic response of the rockmass to hydraulic fracturing,” as well as “pore-pressure changes due to fluid diffusion along a permeable fault zone.”⁵¹⁵ In contrast to the central United States, where induced seismic activity is primarily caused by massive underground disposal of fracking waste, these findings pointed to the fracking process itself as the trigger. In an interview with the *New York Times*, co-author David Eaton compared fracking to a series of “small underground explosions” that travel into the rock formation and “rapidly change the stress patterns within.” These stress changes can be sufficient to trigger a slip at a critically stressed, previously undetected fault.⁵¹⁶
- November 17, 2016 – An investigation by the *Dallas Morning News* chronicled a pattern of corruption and regulatory failings at the Texas Railroad Commission, the state agency charged with overseeing the oil and gas industry, in its disregard of evidence linking fracking waste disposal to earthquakes in North Texas.⁵¹⁷
- November 8, 2016 – On November 6, 2016, a magnitude 5.0 earthquake struck Cushing, Oklahoma near the oil hub where 60 million barrels of crude oil were stored. The quake injured one, damaged more than 40 buildings, closed a school, and triggered evacuations. Oil infrastructure was not damaged.⁵¹⁸ [See also entry above for September 14, 2017.]
- October 7, 2016 – The EPA recommended a moratorium on the underground injection of fracking wastewater in certain earthquake-prone parts of Oklahoma after a 5.8 earthquake struck near Pawnee on September 3, 2016.⁵¹⁹ The strongest in Oklahoma’s history, the Pawnee earthquake was felt by residents in five states and prompted a state of emergency declaration as well as an order from state regulators to shut down 67 wastewater disposal wells in the area.^{520, 521}

⁵¹⁵ Bao, X., & Eaton, D. W. (2016). Fault activation by hydraulic fracturing in western Canada. *Science*, aag2583. doi: 10.1126/science.aag2583

⁵¹⁶ Fountain, H. (2016, November 17). In Canada, a direct link between fracking and earthquakes. *The New York Times*. Retrieved from <https://www.nytimes.com/2016/11/18/science/fracking-earthquakes-alberta-canada.html?mtrref=www.google.com&gwh=535A4330D3C30EF6934E1739AC62D5DA&gwt=pay>

⁵¹⁷ Thompson, S., & Kuchment, A. (2016, November 17). Seismic denial: Why Texas won’t admit fracking wastewater is causing earthquakes. *Dallas Morning News*. Retrieved from http://interactives.dallasnews.com/2016/seismic-denial/#_ga=2.247990020.202656599.1515906987-1750807308.1515724730

⁵¹⁸ Philips, M. (2016, November 8). Why Oklahoma can’t turn off its earthquakes. *Bloomberg Businessweek*. Retrieved from <http://www.bloomberg.com/news/articles/2016-11-08/why-oklahoma-can-t-turn-off-its-earthquakes>

⁵¹⁹ Soraghan, M. (2016, October 7). EPA suggests partial disposal moratorium in Okla. *E&E EnergyWire*. Retrieved from <http://www.eenews.net/energywire/stories/1060043991>

⁵²⁰ U.S. Geological Survey. (2016, September 3). M5.8 – 14 km NW of Pawnee, Oklahoma. Retrieved from <http://earthquake.usgs.gov/earthquakes/eventpage/us10006jxs#executive>

⁵²¹ Oklahoma Corporation Commission. (2016, September 12). *Latest action regarding Pawnee area* [Press release]. Retrieved from <https://www.occeweb.com/News/2016/09-12-16Pawnee%20Advisory.pdf>

- September 22, 2016 – A study using satellite-based radar imagery found that the earth’s surface rose, by 3 millimeters per year, in areas of fracking waste injection. Underground pore pressures for this area exceeded those known to trigger earthquakes. These findings provide proof that the migration of fracking wastewater into faults increased pressures in ways that triggered a 4.8 magnitude earthquake in east Texas in 2012. The researchers emphasized that pore pressure elevation and propagation from fracking wastewater injection may evolve over periods of months to years before affecting critically stressed faults.⁵²²
- September 14, 2016 – Researchers from the USGS used a newly deployed seismic monitoring network to document the rupture of a fault plane that set off a magnitude 4.9 earthquake in Milan, Kansas in 2014, immediately following a rapid increase in fracking wastewater injection nearby.⁵²³
- May 2016 – In a study that has “far-reaching implications for assessment of induced-seismicity hazards,” a Canadian team of researchers determined that hydraulic fracturing itself is linked to earthquake swarms in western Canada, in contrast to the central United States where disposal of fracking waste is the cause of most induced seismicity. Furthermore, lowering the volume of injected fluid may not be sufficient to prevent quakes. In the Western Canada Sedimentary Basin, “it appears that the maximum-observed magnitude of events associated with hydraulic fracturing may exceed the prediction of an often-cited relationship between the volume of injected fluid and the maximum expected magnitude.... Rather, we propose that the size of the available fault surface that is in a critical state of stress may control the maximum magnitude.... Our results indicate that the maximum magnitude of induced events for hydraulic fracturing may not be well correlated with net injected fluid volume.”⁵²⁴
- April 29, 2016 – Five small earthquakes in one 24-hour period originated in an area in Lawrence County, Pennsylvania near a fracking operation that was drilling into the deep Utica Shale at the time. Quoted in the *Pittsburg Post-Gazette*, researchers noted that it is very difficult for operators to avoid areas with faults because their locations are very often unknown.⁵²⁵
- March 28, 2016 – A summary of the evidence linking drilling and fracking activities to earthquakes appeared in *Scientific American*. Emerging data suggests that pressure

⁵²² Shirzaei, M., Ellsworth, W. L., Tiampo, K. F., Gonzalez, P. J., & Manga, M. (2016). Surface uplift and time-dependent seismic hazard due to fluid injection in eastern Texas. *Science*, 353(6306). doi: 10.1126/science.aag0262

⁵²³ Choy, G. L., Rubenstein, J. L., Yeck, W. L., McNamara, D. E., Mueller, C. S., & Boyd, O. S. (2016). A rare moderate-sized (Mw 4.9) earthquake in Kansas: Rupture process of the Milan, Kansas, earthquake of 12 November 2014 and its relationship to fluid injection. *Seismological Research Letters*, 87. doi: 10.1785/0220160100

⁵²⁴ Atkinson, G. M., Eaton, D. W., Ghofrani, H., Walker, D., Cheadle, B., Schultz, R. ... Kao, H. (2016). Hydraulic fracturing and seismicity in the Western Canada Sedimentary Basin. *Seismological Research Letters*, 87(3). doi: 10.1785/0220150263

⁵²⁵ Legere, L. (2016, April 29). State studying link between fracking, Lawrence County earthquakes. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/companies/2016/04/29/State-studying-link-between-fracking-and-Lawrence-County-earthquakes/stories/201604290099>

changes caused by fracking wastewater injection can migrate for years before encountering a geological fault and altering stresses in ways that allow for slippage. In this way, earthquake risks can spread out over both time and space—traveling for miles beyond the disposal well and persisting for a decade or more as injected fluids travel underground. In spite of increasing scientific clarity about these mechanisms, regulators have been slow to respond.⁵²⁶

- February 1, 2016 – An article in the *Texas Journal of Oil, Gas, and Energy Law* exhaustively reviewed the literature on earthquake activity in areas of six states (Arkansas, Colorado, Kansas, Ohio, Oklahoma, and Texas) where fracking takes place or drilling wastes are disposed underground and concluded that courts should impose strict liability for earthquake damage caused either by fracking itself or by the underground injection of fracking fluids. “Earthquakes sometimes occur when subsurface formations are properly fractured. Likewise, the risk of earthquake damage is not substantially mitigated by the exercise of due care when frack fluids are injected into the ground.”⁵²⁷
- January 22, 2016 – An international research team investigated a swarm of earthquakes in California’s Central Valley that occurred in 2005. Using hydrogeological modeling, the researchers concluded that the underground injection of wastewater from oil drilling operations had contributed to seismicity via changes in localized pressures along an active fault.⁵²⁸
- January 12, 2016 – As reported by *CBC News*, a Canadian regulatory agency ordered a drilling and fracking operation in northwestern Alberta to shut down after a magnitude 4.8 earthquake struck nearby. The operator was fracking at the time the earthquake happened.⁵²⁹
- November 15, 2015 – A spokesperson for the Oklahoma Corporation Commission, which regulates the oil and gas industry in the state, said that Oklahoma now leads the world in earthquake frequency.⁵³⁰
- October 29, 2015 – The Kansas Corporation Commission extended limits on the injection of wastewater from fracking operations after a drop in the frequency of earthquakes that

⁵²⁶ Kuchment, A. (2016, March 28). Drilling for earthquakes. *Scientific American*. Retrieved from <https://www.scientificamerican.com/article/drilling-for-earthquakes/>

⁵²⁷ Watson, B. A. (2016). Fracking and cracking: Strict liability for earthquake damage due to wastewater injection and hydraulic fracturing. *Texas Journal of Oil, Gas and Energy Law*, 11(1). Retrieved from <http://ssrn.com/abstract=2735862>

⁵²⁸ Goebel, T. H. W., Hosseini, S. M., Cappa, F., Hauksson, E., Ampuero, J. P., Aminzadeh, F., & Saleeby J. B. (2016). Wastewater disposal and earthquake swarm activity at the southern end of the Central Valley, California. *Geophysical Research Letters*, 43. doi: 10.1002/2015GL066948

⁵²⁹ *CBC News*. (2016, January 12). Fox Creek fracking operation closed indefinitely after earthquake. Retrieved from <http://www.cbc.ca/news/canada/edmonton/fox-creek-fracking-operation-closed-indefinitely-after-earthquake-1.3400605>

⁵³⁰ Miller, J. (2016, November 10). Oklahoma world’s no. 1 earthquake area. *Enid News and Eagle*. Retrieved from http://www.enidnews.com/news/local_news/oklahoma-world-s-no-earthquake-area/article_69b145b8-c180-5065-8f99-b2a7ec7ce913.html

followed an earlier order to limit such injections.⁵³¹ Between 2013 and October 2015, Kansas recorded more than 200 earthquakes. Before that, the average rate was one earthquake every two years.

- October 23, 2015 – *Bloomberg* explored the national security risks that fracking-induced earthquakes in Oklahoma create for the nation’s largest oil storage hub in Cushing, where aboveground tanks hold more than 60 million barrels of crude oil and serve as a way station for oil from North Dakota’s Bakken Shale as it heads to Gulf Coast refineries. Earthquake swarms have hit within a few miles of Cushing and may be harbingers of larger quakes in the future. “Now that quakes appear to have migrated closer to Cushing, the issue of what to do about them has morphed from a state issue to one of national security.... Not only is Cushing crucial to the financial side of the oil market, it is integral to the way physical crude flows around the country.”⁵³²
- September 21, 2015 – An international team of geologists investigated possible causes of the Lusi mudflow, which began suddenly in 2006 when mud began erupting from the ground in a volcano-like fashion in an urban area of Java in Indonesia. The ongoing disaster has, as of 2015, displaced 39,700 people and cost nearly \$3 billion in damages and disaster management. Looking at data on the emissions of subsurface gases before and after the eruption began, the team concluded that the likely cause was nearby gas drilling that forced fluid into the clay layer via the open well. “We therefore conclude that the Lusi eruption was not triggered naturally but was instead the consequence of drilling operations.”⁵³³ In interviews with the *New York Times*, lead author Mark Tinjay said, “We are now 99 percent certain that the drilling hypothesis is valid,” while other experts who were not authors of the paper expressed less certainty.⁵³⁴
- July 27, 2015 – During a seven-day period in late July, the state of Oklahoma experienced 40 earthquakes. According to the USGS, three registered above magnitude 4.0, one of which was strong enough to be felt by 1.9 million people, including residents of several surrounding states.⁵³⁵ In response, gas and oil operators voluntarily shut down two nearby wastewater injection wells and reduced operations by half at a third well.⁵³⁶ According to the Oklahoma Geological Survey, the recent quakes are occurring along a fault line that extends north of Oklahoma City and signal greater potential for a larger

⁵³¹ Kansas Corporation Commission. (2015, October 29). *Kansas Corporation Commission approves order extending wastewater injection limits*. [Press release.] Retrieved from <http://www.kcc.state.ks.us/pi/press/15-13.htm>

⁵³² Phillips, M. (2015, October 23). Oklahoma earthquakes are a national security threat. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/articles/2015-10-23/oklahoma-earthquakes-are-a-national-security-threat>

⁵³³ Tingay, M. R. P., Rudolph, M. L., Manga, M., Davies, R. J., & Wang, C-Y. (2015). Initiation of the Lusi mudflow disaster. *Nature Geoscience*, 8. doi:10.1038/ngeo2472

⁵³⁴ Nuwer, R. (2015, September 21). Indonesia’s ‘mud volcano’ and nine years of debate about its muck. *The New York Times*. Retrieved from http://www.nytimes.com/2015/09/22/science/9-years-of-muck-mud-and-debate-in-java.html?rref=collection%2Fsectioncollection%2Fscience&_r=0

⁵³⁵ U.S. Geological Survey, (2015, July 27). M4.5 – 6 km NNE of Crescent, Oklahoma. Retrieved from http://earthquake.usgs.gov/earthquakes/eventpage/us200030gd#impact_pager

⁵³⁶ Oklahoma Corporation Commission (2015, July 28). Media advisory: new actions taken in response to earthquake activity in the Crescent area. Retrieved from <http://www.occeweb.com/News/Crescent%20wells.pdf>

earthquake.⁵³⁷ Ten days before the voluntary shutdowns, the Oklahoma Corporation Commission, which regulates the oil and gas industry, put 211 wastewater disposal wells under extra review.⁵³⁸ The next month, Oklahoma regulators, acknowledging that previous efforts have been unsuccessful in reducing seismic activity, asked operators of 23 injection wells to decrease the amount of wastewater injected by 38 percent and signaled that more sweeping regulatory actions may follow.⁵³⁹

- July 1, 2015 – Two researchers, from the USGS and the Geological Survey of Canada, offered a summary of the history, basic geology, and engineering of fracking fluid injection and induced seismicity. Noting that since 2001 Oklahoma had experienced two earthquakes of very large magnitude (5.0 and 5.3), the authors called for “a detailed understanding of the physical processes involved in inducing large magnitude events and a detailed understanding of the geology and hydrology at the site of the earthquakes.” They also noted that many important parameters are either unknown or not easily constrained, making it “difficult to determine the wells that will induce earthquakes and those that will not.”⁵⁴⁰
- June 30, 2015 – The Oklahoma Supreme Court ruled that homeowners who have sustained injuries or property damage that they believe is due to earthquakes caused by oil and gas operations can sue for damages in state trial courts. The number of earthquakes with magnitude 3.0 or higher has skyrocketed in Oklahoma, with 1,100 predicted to occur in 2015. Earlier this year, scientists at the state’s geological survey reversed prior views and embraced the conclusion that the majority of the recent earthquakes in central and north-central Oklahoma were “very likely triggered” by underground wastewater disposal. Industry lawyers have complained that liability for such damages will be economically unsustainable. A separate class action lawsuit is planned.⁵⁴¹
- June 19, 2015 – By compiling a database of 187,570 injection wells in the central and eastern United States, University of Colorado Boulder and USGS researchers were able to test for associations between fracking waste disposal and earthquakes. Results showed far more injection wells were potentially related to earthquakes than had previously been realized, and active disposal-only wells were more than 1.5 times more likely than active oil extraction wells to be associated with an earthquake. In addition, high-rate injection

⁵³⁷ Murphy, S. (2015, July 28). 2 injection wells shut down after Oklahoma quakes. *Associated Press*. Retrieved from <http://www.santacruzsentinel.com/business/20150728/2-injection-wells-shut-down-after-oklahoma-quakes>

⁵³⁸ Oklahoma Corporation Commission (2015, July 17). *OCC announces next step in continuing response to earthquake concerns, 200-plus more disposal wells added to action list* [Press release]. Retrieved from <http://www.occeweb.com/News/DIRECTIVE-2.pdf>

⁵³⁹ Wines, M. (2015, August 4). Oklahoma acts to limit earthquake risk at oil and gas wells. *The New York Times*. Retrieved from http://www.nytimes.com/2015/08/05/us/oklahoma-acts-to-limit-earthquake-risk-at-oil-and-gas-wells.html?_r=0

⁵⁴⁰ Rubenstein, J. L., & Mahani, A. B. (2015). Myths and facts on wastewater injection, hydraulic fracturing, enhanced oil recovery, and induced seismicity. *Seismological Research Letters*, 86(4), 1060-1067. doi: 10.1785/0220150067

⁵⁴¹ Oppel Jr., R.A. (2015, June 30). Oklahoma court rules homeowners can sue oil companies over quakes. *The New York Times*. Retrieved from http://www.nytimes.com/2015/07/01/us/oklahoma-court-rules-homeowners-can-sue-oil-companies-over-quakes.html?emc=edit_tnt_20150630&nid=66402583&tntemail0=y&_r=0

wells, receiving more than 300,000 barrels of fluid per month, were much more likely than lower-rate wells to be associated with an earthquake, while other factors, including wellhead injection pressure, appeared unrelated to increased earthquake activity. The study called for managing injection rates as “a useful tool to minimize the likelihood of induced earthquakes.” The researchers did not address the impact of hydrofracturing activities *per se* as a potential confounding variable.^{542, 543}

- June 18, 2015 – Close examination of several areas in Oklahoma by Stanford University geophysicists revealed that dramatic increases in recent earthquake activity followed 5- to 10-fold increases in deep-well injection of briny “produced water,” the highly salty fluid that rises to the surface from water-bearing oil reserves and requires disposal. The rate of earthquake occurrence, which began to increase in 2009, is now 600 times higher than it was before the onset of widespread fracking in the state. The disposal of this type of waste in Oklahoma mostly occurs via injection into geological formations that appear to be in hydraulic communication with potentially active faults in the crystalline basement. The study proposed that increasing pressure, spreading away from injection wells over time, could eventually trigger slips on critically stressed faults, resulting in earthquake activity. It is likely that, “even if injection from many wells were to stop immediately, seismicity would continue as pressure continues to spread out from past injection.”⁵⁴⁴
- June 12, 2015 – Researchers in France uncovered an unexpected mechanism by which subsurface fluid injections, such as those used in high volume hydrofracturing, can cause earthquakes. They found that injection of pressurized water can cause fault lines to “creep” rather than slip suddenly as occurs during earthquakes. Earthquakes did follow this slow movement but took place in a portion of the fault outside the pressurized zone. This research demonstrated that subsurface injection of fluids under pressure can cause primary gradual slippage of fault planes leading to secondary sudden seismic activity.^{545, 546}
- June 11, 2015 – As reported by the Vancouver news magazine *The Tyee*, seismic events of magnitude greater than 2.0 (but less than 4.0) in the Fox Creek area were reported in Alberta, Canada since the initiation in February of a novel “traffic light system” for responding to measured seismic activity. The system requires varying responses according to the magnitude of the event, ranging from no action up to ceasing operations and informing the Alberta Energy Regulator for events at magnitudes greater than 4.0. Experts noted that the system does not work well when the largest event in the sequence

⁵⁴² Weingarten, M. Ge, S., Godt, J. W., Bekins, B. A., & Rubinstein, J. L. (2015). High-rate injection is associated with the increase in U.S. mid-continent seismicity. *Science*, 348(6241), 1336-1340. doi: 10.1126/science.aab1345

⁵⁴³ Rosen, J. (2015). Pumped up to rumble: Massive studies of wastewater injection wells show fast pumping raises earthquake risk. *Science*, 368(6241), 1299. doi: 10.1126/science.aac6857

⁵⁴⁴ Wall, F.R. III, & Zoback, M.D. (2015). Oklahoma’s recent earthquakes and saltwater disposal. *Science Advances*, 1(5), e1500195.

⁵⁴⁵ Guglielmi, Y., Cappa, F., Avouac, J.-P., Henry, P., & Elsworth, D. (2015). Seismicity triggered by fluid injection-induced aseismic slip. *Science*, 348(6240), 1224-1226. doi: 10.1126/science.aab0476

⁵⁴⁶ Johnson, S. K. (2015, June 11). Making tiny earthquakes to understand fracking-driven quakes. *arstechnica*. Retrieved from <http://arstechnica.com/science/2015/06/making-tiny-earthquakes-to-understand-fracking-driven-quakes/>

is the first event. Moreover, once a sequence of earthquakes is initiated, the sequence may continue, sometimes with larger earthquakes, long after potentially causally related drilling or injection activities have ceased.⁵⁴⁷

- June 1, 2015 – In a data-rich presentation, a team of researchers from St. Louis University, Colorado State University, and USGS concluded that “a fundamental change in the earthquake-triggering process has occurred” in central Oklahoma. Using advanced field monitoring and high-performance software, computer models illustrate active earthquake sequences associated with long fault structures “that might be capable of supporting large earthquakes (M 5 to 6)” and possibly cascades of earthquakes, which could occur near population centers and expensive infrastructure associated with the oil and gas industry, such as a large underground crude-oil storage facility.⁵⁴⁸
- May 11, 2015 – A series of directives from the Oklahoma Corporation Commission revealed a slowly evolving approach to the regulation of disposal well operations in that state, and the gradual tightening of a “traffic light system” introduced in 2013 to determine whether disposal wells for fracking waste should be permitted, permitted only with special restrictions and requirements, or not permitted, in light of the now-proven connection between the injection of liquid waste and the soaring frequency of earthquakes in Oklahoma. Since 2013, earthquake activity in Oklahoma has continued to increase in rate and intensity.^{549, 550}
- April 23, 2015 – In a first-of-its-kind approach, the USGS is updating its National Seismic Hazard Model to address the rapidly increasing, highly variable, and difficult-to-predict hazards of induced earthquakes.⁵⁵¹ This initial report identified 17 areas within eight states (Alabama, Arkansas, Colorado, Kansas, New Mexico, Ohio, Oklahoma, and Texas) with increased rates of induced seismicity, including many areas experiencing earthquakes of large magnitude.⁵⁵² Two days before the release of this report, Oklahoma’s state government acknowledged for the first time that wastewater disposal related to oil and gas drilling is “very likely” to blame for the huge surge of earthquakes

⁵⁴⁷ Nikiforuk, A. (2015, June 11). More industry linked earthquakes recorded in Alberta. *TheTyee.ca*. Retrieved from <http://thetyee.ca/News/2015/06/11/More-Fracking-Earthquakes/>

⁵⁴⁸ McNamara, D. E., Rubinstein, J. L., Myers, E., Smoczyk, G., Benz, H. M., Williams, R. A., . . . Earle, P. (2015). Efforts to monitor and characterize the recent increasing seismicity in central Oklahoma. *The Leading Edge*, 34(6). doi: 10.1190/tle34060628.1

⁵⁴⁹ Oklahoma Corporation Commission, Oil & Gas Conservation Division. (2015, May 11). Media advisory: Ongoing OCC earthquake response. Retrieved from <http://www.occeweb.com/News/2015/ADVISORY%20-%20TRAFFIC%20LIGHT.pdf>

⁵⁵⁰ Oklahoma Corporation Commission. (n.d.) Seismic statement. Retrieved from <http://www.occ.state.ok.us/SeismicStatementB.pdf>

⁵⁵¹ Petersen, M. D., Mueller, C. S., Moschetti, M. P., Hoover, S. M., Rubinstein, J. L., Llenos, A. L., . . . Anderson, J. G. (2015). Incorporating induced seismicity in the 2014 United States National Seismic Hazard Model—Results of 2014 workshop and sensitivity studies: U.S. Geological Survey Open-File Report 2015–1070. Retrieved from <http://dx.doi.org/10.3133/ofr20151070>

⁵⁵² USGS. (2015, April 23). New insight on ground shaking from man-made earthquakes. *USGS Newsroom*. Retrieved from http://www.usgs.gov/newsroom/article_pf.asp?ID=4202

in many areas of Oklahoma, the *New York Times* reported.⁵⁵³ Several states have developed protocols to shut down existing wells and halt drilling of new disposal wells following an upsurge in earthquake activity.

- April 21, 2015 – Analyzing the unusual increase of seismicity in north Texas since 2008, researchers from Southern Methodist University, the USGS, and University of Texas at Austin concluded that observed earthquake swarms were associated both with extraction (of gas and brine formation waters) and injection (of fracking wastewater), via significant stress changes at earthquake depths. The research team noted that baseline pressure monitoring data, though easy to obtain and routinely collected by industry at well sites, were currently “neither required nor typically available for analysis.” Greater transparency and cooperation in regional seismic monitoring is needed to generate more comprehensive data sets that are necessary for robust earthquake hazard analysis, they asserted.^{554, 555}
- April 21, 2015 – In a statement reporting on an increase in earthquakes in Oklahoma of greater than magnitude 3.0 from less than two per year historically to over two per day in 2015, the Oklahoma Geological Society acknowledged that the primary, suspected source of “triggered seismicity” is the injection and disposal of produced water associated with oil and gas production.⁵⁵⁶
- March 30, 2015 – *Bloomberg Business* reported that Oklahoma state seismologists had received pressure from oil industry representatives to downplay the evidence linking fracking wastewater disposal to the soaring frequency of earthquakes in the state.⁵⁵⁷
- March 6, 2015 – A careful and detailed analysis of historical data coupled with onsite, real-time measurements of seismic activity in central Oklahoma via rapidly deployed seismic sensors revealed that reactivated ancient faults responsible for thousands of earthquakes in Oklahoma are capable of causing larger seismic events. Current hazard maps did not include induced seismicity and therefore underestimate earthquake hazard, the USGS reported. Until new hazard maps become available, providing information about the type, length, and location of these reactivated faults could provide guidance to the oil and gas industry and help inform public policy decisions.⁵⁵⁸ In addition, noted lead

⁵⁵³ Pérez-Peña, R. (2015, April 23). U.S. maps pinpoint earthquakes linked to quest for oil and gas. *The New York Times*. Retrieved from http://www.nytimes.com/2015/04/24/us/us-maps-areas-of-increased-earthquakes-from-human-activity.html?ref=us&_r=1

⁵⁵⁴ Hornbach, M. J., DeShon, H. R., Ellsworth, W. L., Stump, B. W., Hayward, C., Frohlich, C., . . . Luetgert, J.H. (2015). Causal factors for seismicity near Azle, Texas. *Nature Communications*, 6(6728). doi: 10.1038/ncomms7728

⁵⁵⁵ Richter, M. (2015, April 21). Small north Texas quakes likely linked to oil, gas operations – study. *Reuters*. Retrieved from <http://www.reuters.com/article/2015/04/21/us-usa-texas-earthquake-idUSKBN0NC2DY20150421>

⁵⁵⁶ Andrews, R.D. & Holland, A. (2015, April 21). Statement on Oklahoma Seismicity. Retrieved from http://wichita.ogs.ou.edu/documents/OGS_Statement-Earthquakes-4-21-15.pdf

⁵⁵⁷ Elgin, B., & Phillips, M. (2015, March 30). Big oil pressured scientists over fracking wastewater’s link to quakes. *Bloomberg Business*. Retrieved from <http://www.bloomberg.com/news/articles/2015-03-30/big-oil-pressured-scientists-over-fracking-wastewater-s-link-to-quakes>

⁵⁵⁸ McNamara, D. E., Benz, H. M., Herrmann, R. B., Bergman, E. A., Earle, P., Holland, A., Baldwin, R., & Gassner, A. (2015). Earthquake hypocenters and focal mechanisms in central Oklahoma reveal a complex system of

author Dan McNamara, such information can “aid in adapting building codes to ensure that structures can withstand more damaging earthquakes.”⁵⁵⁹

- February 20, 2015 – Scientists with the USGS reported in *Science* about grappling with an unexpected increase in injection-related seismic activity across the middle of North America. In 2014, the number of measured earthquakes with magnitude of 3 or greater in Oklahoma exceeded that in California, and observations increasingly suggested that the effects of fluid injection were not confined to the target formation but instead were communicated, sometimes to greater depths, along pre-existing faults. Making hazard modeling more difficult, “most of these faults are only detected when they are imaged by well-located induced earthquakes.” Consequently, predicting and controlling such seismic activity may not be possible, leading to a recommendation that injection projects should be sited away from population centers.⁵⁶⁰
- February 5, 2015 – Citing an association between increased water use and fracking-induced seismic activity, a research scientist at the Geological Survey of Canada offered the quantity of water injected underground as his hypothesis for an observed increase in the frequency and magnitude of earthquake activity in areas near fracking wells. Although the Council of Canadian Academies in 2014 called for more monitoring and data collection, there are only ten monitoring stations in British Columbia, overseeing the operations of thousands of fracking wells, reported the *Vancouver Observer*.⁵⁶¹
- January 29, 2015 – The industry-funded Alberta Energy Regulator confirmed that the location of an earthquake of magnitude 4.4 near Fox Creek, Alberta, was “consistent with being induced by hydraulic fracturing operations,” making it the largest felt earthquake yet believed to be related to fracking. Despite claims from industry that tremors related to deep-level fracking could never reach magnitudes that would allow them to be felt on the surface, Gail Atkinson, who holds the Canada Research Chair in Induced Seismicity Hazards at Western University in Ontario, noted, “With fracking, the magnitudes have been increasing every year.”⁵⁶²
- January 6, 2015 – Using a specialized program, Miami University researchers analyzed data from multiple seismic stations and determined that a cluster of 77 earthquakes in Poland Township, Ohio, which occurred over the course of a little more than a week, was related temporally and spatially to active hydraulic fracturing operations. When the

reactivated subsurface strike-slip faulting. *Geophysical Research Letters*, 42(8), 2742–2749. doi: 10.1002/2014GL062730

⁵⁵⁹ Koontz, H. (2015, March 6). *Reawakened Oklahoma faults could produce larger future events* [Press release]. Retrieved from http://www.usgs.gov/newsroom/article_pf.asp?ID=4144

⁵⁶⁰ McGarr, A., Bekins, B., Burkardt, N., Dewey, J., Earle, P., Ellsworth, W., Ge, S., ... Sheehan, A. (2015). Coping with earthquakes induced by fluid injection. *Science*, 347(6224), 830-831. doi: 10.1126/science.aaa0494

⁵⁶¹ Leahy, D. (2015, February 5). Fracking-induced earthquake puts B.C. gas bonanza on shaky ground. *Vancouver Observer*. Retrieved from <http://www.vancouverobserver.com/news/fracking-induced-earthquake-puts-bc-gas-bonanza-shaky-ground>

⁵⁶² Nikiforuk, A. (2015, January 29). Did Alberta just break a fracking earthquake world record? *TheTye.ca*. Retrieved from http://thetye.ca/News/2015/01/29/Alberta-Fracking-Earthquake/?utm_source=fb-page-editor-post&utm_medium=fb-page&utm_campaign=fb-01-2015

fracturing operations were shut down, the rate of earthquake activity declined to only 6 events in the next 12 hours and only a single event over approximately the next two months. Among this cluster of seismic activity, an earthquake of magnitude 3.0 ranks as one of the largest earthquakes in the United States to be induced by hydraulic fracturing. The mechanism for these earthquakes appears to be induction of slip along a pre-existing fault or fracture zone. Because “no known fault or historical seismicity had been [previously] identified in the area,” regulations prohibiting fracturing within three miles of a known fault would not have been protective.^{563, 564}

- December 18, 2014 – In Canada, an investigation by the British Columbia Oil and Gas Commission found that induced seismicity in the Horn River Basin could be attributed both to wastewater disposal and to hydraulic fracturing operations. The Commission recommended mitigation of induced seismicity from wastewater disposal by “reducing injection rates, limiting the increase in [subsurface] reservoir pressure, and locating distal from faults,” among other mitigation techniques.^{565, 566}
- October 23, 2014 – Researchers from USGS and the Global Seismological Services in Golden, Colorado, linked a 2011 magnitude 5.3 earthquake in Colorado, which damaged the foundations of several homes, to underground disposal of fracking wastewater. The study determined that the earthquake ruptured an 8-10 kilometer-long segment of normal faults—an unexpectedly long length for a magnitude 5.3 earthquake—suggesting that wastewater disposal may have triggered a low stress drop.⁵⁶⁷ Lead author Bill Barnhart, a USGS geophysicist, told *Reuters*, “We saw a big increase in seismicity starting in 2001, including magnitude 5 earthquakes, in many locations in the basin, and that coincided with a surge in gas production and injection of wastewater.”⁵⁶⁸
- September 23, 2014 – Youngstown State University geologist Ray Beiersdorfer described increased seismic activity in Youngstown, Ohio in an essay that explores how fracking and fracking-related processes are causing “earthquake epidemics” across the United

⁵⁶³ Skoumal, R. J., Brudzinski, M. R. & Currie, B. S. (2015). Earthquakes induced by hydraulic fracturing in Poland Township, Ohio. *Bulletin of the Seismological Society of America* 105(1). doi: 10.1785/0120140168

⁵⁶⁴ Wines, M. (2015, January 10). New research links scores of earthquakes to fracking wells near a fault in Ohio. *The New York Times*. Retrieved from http://www.nytimes.com/2015/01/08/us/new-research-links-scores-of-earthquakes-to-fracking-wells-near-a-fault-in-ohio.html?hp&action=click&pgtype=Homepage&module=first-column-region®ion=top-news&WT.nav=top-news&assetType=nyt_now&_r=0

⁵⁶⁵ BC Oil & Gas Commission (2014). *Investigation of observed seismicity in the Montney Trend*. Retrieved from <http://www.bcogc.ca/node/12291/download>

⁵⁶⁶ Nikiforuk, A. (2015, January 10). Fracking industry shakes up Northern BC with 231 tremors. *TheTyee.ca*. Retrieved from http://www.thetyee.ca/News/2015/01/10/Fracking_Industry_Shakes_Up_Northern_BC/

⁵⁶⁷ Barnhart, W. D., Benz, H.M., Hayes, G.P., Rubinstein, J.L., & Bergman, E. (2014). Seismological and geodetic constraints on the 2011 Mw5.3 Trinidad, Colorado earthquake and induced deformation in the Raton Basin, *J. Geophys. Res. Solid Earth*, 119, 7923–7933, doi: 10.1002/2014JB011227. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1002/2014JB011227/abstract>

⁵⁶⁸ Zuckerman, L. (2014, October 29). Gas wastewater likely triggered 2011 quake in Colorado: USGS. *Reuters*. Retrieved from <http://www.reuters.com/article/2014/10/29/us-usa-earthquake-colorado-idUSKBN0II2NP20141029>

States.⁵⁶⁹

- September 15, 2014 – Researchers at the National Energy Technology Laboratory teamed up with researchers from industry and academia to publish data and analysis from a closely watched project that involved field monitoring of the induced fracturing of six horizontal Marcellus Shale gas wells in Greene County, Pennsylvania. Touted in earlier media reports as demonstrating that, during short-term follow-up, fracking chemicals injected into these six wells did not spread to overlying aquifers⁵⁷⁰, the study’s most notable finding is striking documentation of fractures from three of the six wells extending vertically to reach above an overlying rock layer previously thought to create an impenetrable “frac barrier” (that is, an upper barrier to fracture growth). In one case, a fracture extended vertically 1,900 feet, a surprisingly far distance. No pre-existing fault had been detected at this location, suggesting that small “pre-existing fractures or small-offset (sub-seismic) faults may have focused the energy of hydraulic fractures on certain areas....” Perhaps because of the extremely small sample size and a design focused primarily on monitoring for potential gas and fluid migration, the study’s analysis includes no discussion of the seismic relevance of extremely long, vertical induced fractures.⁵⁷¹
- September 15, 2014 – Scientists from USGS ascribed causality to wastewater injection wells from coal-bed methane production for increases in seismic activity in New Mexico and Colorado and, in particular, for an earthquake that measured magnitude 5.3 in Colorado in 2011—the second largest earthquake to date for which there is clear evidence that the earthquake sequence was induced by fluid injection.⁵⁷²
- September 6, 2014 – The Ohio Department of Natural Resources suspended operations at two deep-injection wells for fracking wastewater near Warren in northeastern Ohio after discovering evidence that the operation possibly caused a magnitude 2.1 earthquake. The injection well operator, American Water Management Services, had recently received permission to increase pressures at the site of the wells. In 2012, Governor John Kasich had halted disposal of fracking wastewater surrounding a well site in the same region after a series of earthquakes were tied to a deep-injection well. The company that ran that well has disputed the link. The state placed seismic-monitoring devices in the Warren

⁵⁶⁹ Beiersdorfer, R. (2014, September 23). View: On fracking, earthquakes and Indian Point. *Journal Online*. Retrieved from <http://www.lohud.com/story/opinion/contributors/2014/09/23/view-geologist-warns-fracking-ties-earthquakes/16100755/>

⁵⁷⁰ Begos, K. (2014, July 19). DOE study: Fracking chemicals didn't taint water. *Associated Press*. Retrieved from <http://bigstory.ap.org/article/ap-study-finds-fracking-chemicals-didnt-spread>

⁵⁷¹ Hammack, R., Harbert, W., Sharma, S., Stewart, B. W., Capo, R. C., Wall, A. J., . . . Veloski, G. (2014). An evaluation of fracture growth and gas/fluid migration as horizontal Marcellus Shale gas wells are hydraulically fractured in Greene County, Pennsylvania. *NETL-TRS-3-2014: EAct Technical Report Series. US Dept of Energy, National Energy Technology Laboratory: Pittsburgh PA*. Retrieved from http://www.netl.doe.gov/File%20Library/Research/onsite%20research/publications/NETL-TRS-3-2014_Greene-County-Site_20140915_1_1.pdf

⁵⁷² Rubinstein, J. L., Ellsworth, W. L., McGarr, A. & Benz, H. M. (2014). The 2001-present induced earthquake sequence in the Raton Basin of Northern New Mexico and Southern Colorado [abstract]. *Bulletin of the Seismological Society of America*. Retrieved from <http://www.bssaonline.org/content/104/5/2162.abstract?stoc>

area under protocols adopted after the series of earthquakes in nearby Youngstown.⁵⁷³

- September 1, 2014 – Explaining the need for increased seismic monitoring, Andrew Beaton, Director of the Alberta Geological Survey, stated that over a long period of time, stresses increase in and around an injection well bore. Seismic movement can be caused if the rate of injection is too fast or if there is a geological feature, such as a fault or fracture in nearby areas. Although Albertans in rural areas have been reporting for years that they can feel tremors under their feet near oil and gas activity, especially around areas of fracking, the Alberta Energy Regulator noted that deep well injections have been shown to create more of an earthquake hazard than hydraulic fracturing. Alberta experienced 819 earthquakes between 1918 and 2009. In comparison, Saskatchewan recorded 13 in the same time period and British Columbia recorded more than 1,200 earthquakes in 2007 alone. There are currently 24 seismic monitors in Alberta, which are tied into other networks, such as those belonging to Environment Canada, University of Calgary, and University of Alberta.⁵⁷⁴
- August 26, 2014 – In a first-of-its-kind lawsuit, a resident of Prague, Oklahoma, sued two energy companies after rocks fell from her chimney and injured her leg during an earthquake of greater than magnitude 5. The lawsuit claims that underground injection of fracking wastewater conducted by New Dominion LLC and Spess Oil Company has caused shifts in fault lines that have resulted in earthquakes.⁵⁷⁵
- July 31, 2014 – William Ellsworth, a research geophysicist at the USGS Earthquake Science Center, reported that USGS is developing a hazard model that takes induced earthquakes into account. In addition, residents of Oklahoma, where a sharp spike in earthquake activity has been noted over the past decade, are showing an increased interest in obtaining earthquake insurance.⁵⁷⁶
- July 3, 2014 – Using data from the Oklahoma Corporation Commission, a team of researchers led by Cornell University geophysicist Katie Keranen found that a steep rise in earthquakes in Oklahoma can be explained by fluid migration from wastewater disposal wells. Moreover, injected fluids in high volume wells triggered earthquakes over 30 kilometers (over 18 miles) away. All of the wells analyzed were operated in compliance with existing regulations. Similar mechanisms may function in other states with high volumes of underground injection of wastewater from unconventional oil and

⁵⁷³ Smyth, J. C. (2014, September 6). Ohio halts injections at two wells for fracking wastewater after quake. *Associated Press*. Retrieved from <http://www.dispatch.com/content/stories/local/2014/09/06/ohio-halts-2-wells-for-fracking-wastewater-after-quake.html>

⁵⁷⁴ Maclean, R. (2014, September 1). Earthquake hazard linked with deep well injection in Alberta: Deep well disposal of oilfield waste over time leads to increased earthquake risk. *CBC News*. Retrieved from <http://www.cbc.ca/news/canada/calgary/earthquake-hazard-linked-with-deep-well-injection-in-alberta-1.2751963>

⁵⁷⁵ Rangel, L. (2014, August 26). Prague resident files lawsuit against two Okla. energy companies following earthquake injury. *Newschannel 4 (kfor.com)*. Retrieved from <http://kfor.com/2014/08/26/prague-resident-files-lawsuit-against-two-okla-energy-companies-following-earthquake-injury/>

⁵⁷⁶ Eaton, J. (2014, July 31). Oklahoma grapples with earthquake spike—and evidence of industry's role: Spike in seismic activity is linked with oil and gas wastewater disposal. *National Geographic*. Retrieved from <http://news.nationalgeographic.com/energy/2014/07/140731-oklahoma-earthquake-spike-wastewater-injection/>

gas production.⁵⁷⁷ Reporting on the study and the increase in earthquakes across the United States and the link to fracking and wastewater disposal, the *Associated Press* noted that some states, including Ohio, Oklahoma, and California, have introduced new rules compelling drillers to measure the volumes and pressures of their injection wells as well as to monitor seismicity during fracking operations.⁵⁷⁸

- July 1, 2014 – Seismologists linked the emergence of a giant sinkhole that formed in August 2012 near Bayou Corne in southeast Louisiana to tremors (earthquakes) caused by high-pressure pulses of either natural gas or water charged with natural gas. The surges of natural gas that caused the explosive tremors (earthquakes) may have weakened an adjacent salt cavern and caused its collapse. Alternatively, part of the salt cavern may have collapsed, causing a nearby gas pocket to give off surges of gas, later followed by the complete collapse of the salt cavern. These findings help illuminate the role of pressurized fluids in triggering seismic events.⁵⁷⁹
- June 24, 2014 – Following two earthquakes within a one-month period, the Colorado Oil and Gas Conservation Commission directed High Sierra Water Services to stop disposing wastewater into one of its Weld County injection wells. Monitoring by a team of seismologists from the University of Colorado had picked up evidence of continuing low-level seismic activity near the injection site, including a magnitude 2.6 event less than a month following a magnitude 3.4 earthquake that shook the Greeley area on May 31, 2014.⁵⁸⁰
- May 2, 2014 – The USGS and Oklahoma Geological Survey (OGS) jointly issued an official earthquake warning for Oklahoma, pointing out that the number of earthquakes in the state has risen 50 percent since just October—when the two agencies had issued a prior warning. The advisory stated that this dramatic increase in the frequency of small earthquakes “significantly increases the chance for a damaging quake in central Oklahoma.” Injection wells used for the disposal of liquid fracking waste have been implicated as the presumptive cause of the earthquake swarm. According to the OGS, about 80 percent of the state of Oklahoma is closer than ten miles from an injection well.⁵⁸¹ Since the joint earthquake advisory was released in May, the number of

⁵⁷⁷ Keranen, K. M., Weingarten, M., Abers, G. A., Bekins, B. A., & Ge, S. (2014). Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection. *Science*, 345(6195), 448-451. doi: 10.1126/science.1255802

⁵⁷⁸ Schmall, E. & Jouzavacius, J. (2014, July 14). States with fracking see surge in earthquake activity. *Associated Press*. Retrieved from http://www.huffingtonpost.com/2014/07/14/fracking-earthquake_n_5585892.html

⁵⁷⁹ Nayak, A. & Dreger, D. S. (2014). Moment tensor inversion of seismic events associated with the sinkhole at Napoleonville Salt Dome, Louisiana. *Bulletin of Seismological Society of America* 104(4), 1763-1776. doi: 10.1785/0120130260

⁵⁸⁰ Tomasic, J. (2014, June 24). Colorado drilling regulators halt injection-well activity in reaction to Greeley quake. *Colorado Independent*. Retrieved from <http://www.coloradoindependent.com/147934/colorado-drilling-regulators-halt-injection-well-activity-in-reaction-to-greeley-quake> (see also Baker, B. (2014, June 24). Colorado regulators halt fracking wastewater injection operation after earthquake strikes area for second time in a month. *Ecowatch*. Retrieved from <http://ecowatch.com/2014/06/24/colorado-wastewater-injection-earthquake/>)

⁵⁸¹ Geological Survey Joint Statement. (2014, May 2). Record number of Oklahoma tremors raises possibility of damaging earthquakes. United States Geological Survey. Retrieved from http://earthquake.usgs.gov/regional/ceus/products/newsrelease_05022014.php

earthquakes in Oklahoma has continued to rise. During the first four months of 2014, Oklahoma had experienced 109 earthquakes of magnitude 3 or higher on the Richter scale. By mid-June, the number of earthquakes had topped 200, exceeding the frequency of earthquakes in California.⁵⁸²

- May 2, 2014 – At the annual meeting of the Seismological Society of America, leading geologists warned that the risks and impacts of earthquakes from fracking and injection wells are even more significant than previously thought, pointing out that such earthquakes could occur tens of miles away from wells themselves, including quakes greater than magnitude 5.0. Justin Rubinstein, a research geophysicist at the USGS said, “This demonstrates there is a significant hazard. We need to address ongoing seismicity.”⁵⁸³ Seismologist Gail Atkinson reported, “We don’t know how to evaluate the likelihood that a [fracking or wastewater] operation will be a seismic source in advance.”⁵⁸⁴
- April 11, 2014 – State geologists reported a link between fracking and a spate of earthquakes in Ohio, prompting the Ohio Department of Natural Resources to place a moratorium on drilling in certain areas and to require greater seismic monitoring.⁵⁸⁵
- April 3, 2014 – Researchers linked earthquakes in Mexico to fracking in the Eagle Ford Shale, which extends beneath both southern Texas and northern Mexico. They also noted a statistical correlation between seismic activity and fracking, particularly in the border state of Nuevo Leon, which registered at least 31 quakes between magnitude 3.1 and 4.3.⁵⁸⁶
- April 2014 – Researchers from the University of Alberta and the Alberta Geological Survey published a study in the *Journal of Geophysical Research* that found wastewater injection in Alberta is highly correlated with spikes of seismic activity between October 2006 and March 2012.⁵⁸⁷ On November 13, 2014, *CBC News* reported on a more recent

⁵⁸² Branson-Potts, H. (2014, June 17). Oklahoma coming to terms with unprecedented surge in earthquakes. *Los Angeles Times*. Retrieved from <http://www.latimes.com/nation/la-na-oklahoma-earthquakes-20140618-story.html#page=1>

⁵⁸³ Walsh, B. (2014, May 1). The seismic link between fracking and earthquakes. *Time*. Retrieved June 9, 2014, from <http://time.com/84225/fracking-and-earthquake-link/>

⁵⁸⁴ Kiger, P. J. (2014, May 2). Scientists warn of quake risk from fracking operations. *National Geographic*. Retrieved from <http://news.nationalgeographic.com/news/energy/2014/05/140502-scientists-warn-of-quake-risk-from-fracking-operations/>

⁵⁸⁵ Dave, P. (2014, April 12). Ohio finds link between fracking and sudden burst of earthquakes. *Los Angeles Times*. Retrieved from <http://www.latimes.com/nation/nationnow/la-na-nn-ohio-finds-link-fracking-earthquakes-20140411-story.html#axzz2yrnpHW1h>

⁵⁸⁶ Godoy, E. (2014, April 3). Fracking, seismic activity grow hand in hand in Mexico. *Inter Press Service*. Retrieved from <http://www.ipsnews.net/2014/04/fracking-seismic-activity-grow-hand-hand-mexico/>

⁵⁸⁷ Schultz, R., Stern, V. & Gu, Y. J. (2014). An investigation of seismicity clustered near the Cordel Field, west central Alberta, and its relation to a nearby disposal well. *Journal of Geophysical Research: Solid Earth*, 119, 3410–3423. doi: 10.1002/2013JB010836

increase in earthquakes, which may also be linked to injection wells.⁵⁸⁸

- March 7, 2014 – USGS researchers published a study confirming that Oklahoma’s damaging magnitude 5.7 earthquake in 2011 was caused by fracking wastewater injection.⁵⁸⁹ One of the authors of the study, seismologist Elizabeth Cochran, noted, “Even if wastewater injection only directly affects a low-hazard fault, those smaller events could trigger an event on a larger fault nearby.”⁵⁹⁰
- January 30, 2014 – A USGS research team linked the rise in earthquakes in Colorado to fracking wastewater injection wells and announced that a study will be published in six to nine months.⁵⁹¹
- December 12, 2013 – The *New York Times* detailed the growing link between fracking wastewater injection wells and earthquakes, as well as between fracking itself and earthquakes, with a focus on Oklahoma and a recent magnitude 4.5 earthquake there. As the *New York Times* noted, “Oklahoma has never been known as earthquake country, with a yearly average of about 50 tremors, almost all of them minor. But in the past three years, the state has had thousands of quakes. This year has been the most active, with more than 2,600 so far, including 87 last week. . . . State officials say they are concerned, and residents accustomed to tornadoes and hail are now talking about buying earthquake insurance.”⁵⁹²
- November 19, 2013 – *Reuters* reported that a series of Oklahoma earthquakes in September of 2013 damaged several homes, and that more scientists in a number of states are concerned about earthquakes related to oil and gas development. Seismologist Austin Holland with the University of Oklahoma said, “This is a dramatic new rate of seismicity.”⁵⁹³

⁵⁸⁸ Trynacity, K., & Siekierska, A. (2014, November 13). Fracking linked to Alberta earthquakes, study indicates. *CBC News*. Retrieved from <http://www.cbc.ca/news/canada/edmonton/fracking-linked-to-alberta-earthquakes-study-indicates-1.2829484>

⁵⁸⁹ Sumy, D. F., Cochran, E. S., Keranen, K. M., Wei, M., & Abers, G. A. (2013). Observations of static Coulomb stress triggering of the November 2011 M5.7 Oklahoma earthquake sequence [Abstract]. *Journal of Geophysical Research: Solid Earth*, 119(3), 1904-1923. doi: 10.1002/2013JB010612

⁵⁹⁰ Oskin, B. (2014, March 07). Wastewater injection triggered Oklahoma's earthquake cascade. *Live Science*. Retrieved from <http://www.livescience.com/43953-wastewater-injection-earthquake-triggering.html>

⁵⁹¹ McClurg, L. (2014, January 30). Earthquakes in southern Colorado linked to oil and gas production. *Colorado Public Radio*. Retrieved from <http://www.cpr.org/news/story/earthquakes-southern-colorado-linked-oil-and-gas-production#sthash.UVvw0JWe.UQwWtYJS.dpuf>

⁵⁹² Fountain, H. (2013, December 12). Experts eye oil and gas industry as quakes shake Oklahoma. *The New York Times*. Retrieved from <http://www.nytimes.com/2013/12/13/science/earth/as-quakes-shake-oklahoma-scientists-eye-oil-and-gas-industry.html>

⁵⁹³ Gillam, C. (2013, November 19). In Oklahoma, water, fracking - and a swarm of quakes. *Reuters*. Retrieved from <http://www.reuters.com/article/2013/11/19/us-usa-earthquakes-fracking-oklahoma-idUSBRE9AI12W20131119>

- July 19, 2013 – A study from the Lamont-Doherty Earth Observatory linked 109 earthquakes in Youngstown, Ohio to fracking wastewater disposal.^{594, 595}
- July 11, 2013 – A study in *Science* by Columbia University’s Lamont-Doherty Earth Observatory showed that deep-well injection of fracking waste can stress geological faults in ways that make them vulnerable to slipping. The research shows that distant natural earthquakes triggered swarms of smaller earthquakes on critically stressed faults. The researchers wrote, “The fluids [in wastewater injection wells] are driving the faults to their tipping point.... Areas with suspected anthropogenic earthquakes are more susceptible to earthquake-triggering from natural transient stresses generated by the seismic waves of large remote earthquakes.”⁵⁹⁶
- April 2013 – A group of British researchers stated that hydraulic fracturing itself was the likely cause of at least three earthquakes powerful enough to be felt by human beings at the surface. The researchers proposed that increases in the fluid pressure in fault zones were the causal mechanism for these three known instances of “felt seismicity” in the United States, Canada, and the United Kingdom. The largest of these earthquakes was a magnitude 3.8 in the Horn River Basin, Canada.⁵⁹⁷
- March 26, 2013 – Scientists from the University of Oklahoma, Columbia University and USGS linked a 2011 swarm of earthquakes in Oklahoma to fracking waste disposal in that state.⁵⁹⁸ This included a magnitude 5.7 earthquake—possibly the largest ever triggered by wastewater injection—that injured two people, destroyed 14 homes, and was felt across 17 states.⁵⁹⁹ The research team concluded in a paper in the journal *Geology* that their data called into question the previously predicted maximum size of injection-induced earthquakes.^{600, 601}

⁵⁹⁴ Kim, W. (2013). Induced seismicity associated with fluid injection into a deep well in Youngstown, Ohio. *Journal of Geophysical Research: Solid Earth*, 118(7), 3506-3518. doi: 10.1002/jgrb.50247

⁵⁹⁵ Chameides, B. (2013, September 5). Fracking waste wells linked to Ohio earthquakes. *Scientific American*. Retrieved from <http://www.scientificamerican.com/article/fracking-waste-wells-linked-to-ohio-earthquakes/>

⁵⁹⁶ Begley, S. (2013, July 11). Study raises new concern about earthquakes and fracking fluids. *Reuters*. Retrieved from <http://www.reuters.com/article/2013/07/11/us-science-fracking-earthquakes-idUSBRE96A0TZ20130711>

⁵⁹⁷ Davies, R., Foulger, G., Bindley, A., & Styles, P. (2013). Induced seismicity and hydraulic fracturing for the recovery of hydrocarbons. *Marine and Petroleum Geology*, 45, 171-185. doi: 10.1016/j.marpetgeo.2013.03.016

⁵⁹⁸ Drajem, M., & Efstathiou, J., Jr. (2013, March 26). Quake tied to oil-drilling waste adds pressure for rules. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2013-03-26/oklahoma-earthquake-in-2011-tied-to-wastewater-wells-in-fracking.html>

⁵⁹⁹ Behar, M. (2013, March/April). Fracking's latest scandal? Earthquake swarms. *Mother Jones*. Retrieved from <http://www.motherjones.com/environment/2013/03/does-fracking-cause-earthquakes-wastewater-dewatering?page=1>

⁶⁰⁰ Keranen, K. M., Savage, H. M., Abers, G. A., & Cochran, E.S. (2013). Potentially induced earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence. *Geology*. doi: 10.1130/G34045.1

⁶⁰¹ Diep, F. (2013, March 28). Study: wastewater injection caused Oklahoma's largest-ever earthquake. *Popular Science*. Retrieved from <http://www.popsci.com/science/article/2013-03/largest-earthquake-ever-linked-lightly-regulated-wastewater-wells>

- December 14, 2012 – At a 2012 American Geophysical Union meeting, scientists presented data and concluded that some U.S. states, including Oklahoma, Texas and Colorado, have experienced a significant rise in seismic activity coinciding with a boom in gas drilling, fracking and wastewater disposal. Scientists further found that Oklahoma has seen a significant increase in earthquakes linked to wastewater injection, that a 5.3 earthquake in New Mexico was linked to wastewater injection, and that earthquakes were increasingly common within two miles of injection wells in the Barnett Shale region of Texas. Art McGarr, a researcher at the USGS Earthquake Science Center, concluded that, “The future probably holds a lot more in induced earthquakes as the gas boom expands.”⁶⁰²
- November 30, 2012, January 11, 2012, December 22, 2009 – In three different sets of comments on proposed fracking guidelines and regulations, citing scientific reports linking oil and gas infrastructure to seismic activity, the New York City Department of Environmental Protection (NYC DEP) raised serious concerns about the impacts of potential seismic activity from fracking-related activities on New York City’s water supply infrastructure.^{603, 604, 605} The NYC DEP has consistently raised concerns that seismic activity surrounding New York City’s aquifers and watershed infrastructure could threaten the city’s drinking water supply by triggering microseismic events and small induced earthquakes that, in turn, could threaten the integrity of the aging, 100-mile-long aqueducts that carry drinking water from the Catskill Mountains into the New York City metropolitan area. The agency expressed specific concerns about the ability of hydraulic fracturing fluids to migrate underground and to intercept and reactivate faults miles away.
- September 6, 2012 – The British Columbia Oil and Gas Commission determined that fracking itself causes earthquakes, pointing to the results of a probe into 38 seismic events near fracking operations in the Horn River Basin. The report noted that no quakes had been recorded in the area prior to April 2009, before fracking began. The report recommended that the link between fracking and seismic activity be further examined.⁶⁰⁶

⁶⁰² Leber, J. (2012, December 14). Studies link earthquakes to wastewater from fracking. *MIT Technology Review*. Retrieved from <http://www.technologyreview.com/news/508151/studies-link-earthquakes-to-wastewater-from-fracking/>

⁶⁰³ New York City Department of Environmental Protection. (2009, December 22). *New York City comments on: Draft supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program - Well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus Shale and other low-permeability gas reservoirs* (Rep.). Retrieved from http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/nycdep_comments_final_12-22-09.pdf

⁶⁰⁴ New York City Department of Environmental Protection. (2012, January 11). *Comments on the revised draft supplemental generic environmental impact statement*. (Rep.). Retrieved from http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/nycdep_comments_on_rdsgeis_for_hvhf_20120111.pdf

⁶⁰⁵ New York City Department of Environmental Protection. (2012, November 30). *Comments on the revised high-volume hydraulic fracturing regulations* (Rep.). Retrieved from http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/revised_high_volume_hydraulic_fracturing_regulations_comments_letter_010713.pdf

⁶⁰⁶ The Canadian Press. (2012, September 6). Fracking causes minor earthquakes, B.C. regulator says. *CBC News*. Retrieved from <http://www.cbc.ca/news/canada/british-columbia/fracking-causes-minor-earthquakes-b-c-regulator-says-1.1209063>

- March 29, 2012 – The USGS found that between 2001 and 2011, there was a six-fold increase in earthquakes greater than magnitude 3.0 in the middle of the United States that “are almost certainly manmade.” The agency further reported that the increase appears to be linked to oil and gas production and deep injection of drilling wastewater.^{607, 608}
- July 31, 2011 – Numerous earthquakes in Arkansas motivated the Arkansas Oil and Gas Commission to shut down a disposal well and enact a permanent moratorium on future disposal wells in a nearly 1,200 square-mile area of the Fayetteville Shale.⁶⁰⁹
- March 10, 2010 – In Texas, a 2008-2009 swarm of earthquakes in the Dallas-Fort Worth area was linked to produced water disposal wells.⁶¹⁰
- June 12, 2009 – *The Wall Street Journal* reported that earthquakes shook Cleburne, Texas, a small town at the epicenter of fracking activity. More earthquakes were detected during that period of fracking activity than in the previous 30 years combined.⁶¹¹

Abandoned and active oil and natural gas wells as pathways for gas and fluid migration

An estimated 2.6 million oil and gas wells across the United States are no longer in production. The location and status of the vast majority are not recorded in state databases, and most remain unplugged. Whether plugged or unplugged, abandoned wells are a significant source of methane leakage into the atmosphere and, based on findings from New York and Pennsylvania, may exceed cumulative total leakage from oil and gas wells currently in production. No state or federal agency routinely monitors methane leakage from abandoned wells. Abandoned wells also serve as underground pathways for fluid migration, heightening risks of groundwater contamination. Fluid can migrate upward through vertical channels when fractures from new drilling and fracking operations intersect with old wells. Industry experts, consultants, and government agencies including the U.S. Environmental Protection Agency (EPA), the U.S. Government Accountability Office (GAO), Texas Department of Agriculture, New York State

⁶⁰⁷ Ellsworth, W. (2011, April 18). Are seismicity rate changes in the midcontinent natural or manmade? Retrieved from http://www2.seismosoc.org/FMPro?-db=Abstract_Submission_12&-sortfield=PresDay&-sortorder=ascending&-sortfield=Special+Session+Name+Calc&-sortorder=ascending&-sortfield=PresTimeSort&-sortorder=ascending&-op=gt&PresStatus=0&-lop=and&-token.1=ShowSession&-token.2=ShowHeading&-recid=224&-format=%2Fmeetings%2F2012%2Fabstracts%2Fsessionabstractdetail.html&-lay=MtgList&-find

⁶⁰⁸ Soraghan, M. (2012, March 29). ‘Remarkable’ spate of man-made quakes linked to drilling, USGS team says. *E&E Publishing, LLC*. Retrieved from <http://www.eenews.net/stories/1059962190>

⁶⁰⁹ Zilk, C. (2011, July 31). Permanent disposal-well moratorium issued. *Arkansas Online*. Retrieved from <http://www.arkansasonline.com/news/2011/jul/31/permanent-disposal-well-moratorium-issued-20110731/>

⁶¹⁰ Fröhlich, C., Hayward, C., Stump, B., & Potter, E. (2011). The Dallas-Fort Worth Earthquake Sequence: October 2008 through May 2009. *Bulletin of the Seismological Society of America*, 101(1), 327-340. doi: 10.1785/0120100131

⁶¹¹ Casselman, B. (2009, June 12). Temblors rattle Texas town. *Wall Street Journal*. Retrieved from <http://online.wsj.com/news/articles/SB124476331270108225>

Department of Environmental Conservation (NYS DEC), Pennsylvania Department of Environmental Protection (PA DEP), Illinois Environmental Protection Agency, and the British Columbia Oil and Gas Commission have all warned about problems with abandoned wells due to the potential for pressurized fluids and gases to migrate through inactive and, in some cases, active wells.

- Dec 26, 2017 – In 1965, a blowout at a gas well in northeastern Netherlands caused the formation of quicksand, which swallowed up an entire drill rig. Eventually, the area was turned into a park. More than 50 years later, a team of researchers discovered that the site is still leaking methane. They found in the groundwater high levels of methane with an isotopic composition that matched that of the gas reservoir. An analysis of groundwater flow conditions showed that this methane is not a remnant of the blowout but the result of ongoing leakage. “Combined, the data reveal the long-term impact that underground gas well blowouts may have on groundwater chemistry, as well as the important role of anaerobic oxidation in controlling the fate of dissolved methane.”^{612, 613}
- June 28, 2017 – *The Tyee* made public the results of an unreleased 2016 report by the Alberta Energy Regulator (AER) showing that 36 of 335 abandoned oil and gas wells that are located close to occupied buildings in urban areas of Alberta are leaking methane. Six abandoned wells were leaking at levels (10,000 ppm) that pose explosion risks and are considered life-threatening. (Natural background level is about 1.9 ppm.) Based on these findings, the report also estimated that 17,000 of 170,000 abandoned wells in rural Alberta were likely also leaking. The author of the unreleased report said in an interview with *The Tyee* that AER, a corporation that functions in part as a regulatory agency, does not have the capacity to evaluate the potential threat to public health and safety. “The expertise to assess the health risk of abandoned wells really doesn’t exist in house.”^{614, 615}
- March 27, 2017 – In an experimental study, Canadian researchers injected methane gas into a shallow sand aquifer over a 72-day period and monitored methane migration for eight months. After 72 days, they found that half of the methane had vented into the atmosphere and half remained in the groundwater, traveling laterally a greater distance than expected and degrading at a rate less than expected. “Our findings demonstrate that

⁶¹² Schout, G., Hartog, N., Hassanizadeh, S. M., & Griffioen, J. (2018). Impact of an historic underground gas well blowout on the current methane chemistry in a shallow groundwater system. *Proceedings of the National Academy of Sciences*, 115(2), 296-301. Advance online publication. doi: 10.1073/pnas.1711472115

⁶¹³ Yirka, B. (2017, December 29). Methane still leaking from the ground at site of gas explosion decades ago. *Phys.org*. Retrieved from <https://phys.org/news/2017-12-methane-leaking-ground-site-gas.html>

⁶¹⁴ Nikiforuk, A. (2017, June 28). Energy industry legacy: Hundreds of abandoned wells leaking methane in Alberta communities. *The Tyee*. Retrieved from <https://thetyee.ca/News/2017/06/28/Energy-Industry-Legacy/>

⁶¹⁵ Nikiforuk, A. (2017, July 4). Alberta failing on risk from leaking oil and gas wells, says expert. *The Tyee*. Retrieved from <https://thetyee.ca/News/2017/07/04/Alberta-Failing-Leaking-Oil-Gas-Wells-Risk/>

even small-volume releases of methane gas can cause extensive and persistent free phase and solute plumes.”^{616, 617}

- December 21, 2016 – The *Texas Tribune* investigated abandoned oil wells in Texas where the Texas Railroad Commission, which is charged with regulating the oil and gas industry, has tracked and mapped 6,628 unplugged, orphaned wells. The commission is struggling with a ballooning inventory of inactive, leaking wells and decreasing clean-up funds to deal with them. The most recent oil boom, involving horizontal drilling with fracking, added to the problem as drillers cut corners in the rush to bring oil to market. “Just drill the well as fast as possible, because they were under such pressure to get cash flow going,” according to a geoscientist interviewed for the story who had recently retired as a groundwater advisor for the Railroad Commission.⁶¹⁸
- November 14, 2016 – Methane emissions from abandoned wells vary widely, with a few high emitters responsible for a disproportionately large share of the problem. Using new field measurement and data mining techniques, a Stanford University-led team investigated gas leaks at 88 inactive wells in Pennsylvania in an attempt to identify the characteristics of these “super-emitters.” Their results showed that unplugged gas wells and wells located in coal areas had the highest methane flow rates. Well plugging does not always reduce methane emission, especially when the wells are vented. In many areas with extensive coal layers, decommissioning requirements for wells included mandatory venting. Using comprehensive databases, the team also estimated the number of abandoned wells in Pennsylvania to be between 470,000 and 750,000, considerably more than previous estimates of 300,000 to 500,000. The research team calculated that, all together, Pennsylvania’s abandoned wells contribute 5-8 percent of the state’s annual greenhouse gas emissions.^{619, 620}
- June 20, 2016 – Pennsylvania’s attorney general began reviewing regulations requiring drillers to document abandoned oil and gas wells within 1,000 feet of a new fracking site. According to a *Bloomberg* investigation, “This puts Pennsylvania among states such as California, Texas, Ohio, Wyoming and Colorado confronting the environmentally catastrophic legacy of booms as fracking and home development expand over former drilling sites. As the number of fracked wells increases, so does the chance they might

⁶¹⁶ Cahill, A. G., Steelman, C. M., Forde, O., Kuloyo, O., Ruff, S. E., Mayer, B., ... Parker, B. L. (2017). Mobility and persistence of methane in groundwater in a controlled-release field experiment. *Nature Geoscience*, 10, 289–294. doi: 10.1038/ngeo2919

⁶¹⁷ Nikiforuk, A. (2017, April 11). Methane leaks from energy wells affects groundwater, travels great distances, study confirms. *The Tyee*. Retrieved from <https://thetyee.ca/News/2017/04/11/Methane-Leaks-from-Energy-Wells-Affects-Groundwater/>

⁶¹⁸ Malewitz, J. (2016, December 21). Abandoned Texas oil wells seen as “ticking time bombs” of contamination. *Texas Tribune*. Retrieved from <https://www.texastribune.org/2016/12/21/texas-abandoned-oil-wells-seen-ticking-time-bombs-/>

⁶¹⁹ Kang, M., Christian, S., Celia, M. A., Mauzerall, D. L., Bill, M., Miller, A. R., ... Jackson, R. B. (2016). Identification and characterization of high methane-emitting abandoned oil and gas wells. *Proceedings of the National Academy of Sciences*, 113(48), 13636-13641. doi: 10.1073/pnas.1605913113

⁶²⁰ Than, K. (2016, November 14). Stanford study of abandoned oil and gas wells reveals new ways of identifying and fixing the worst methane emitters. *Stanford News*. Retrieved from <https://news.stanford.edu/2016/11/14/study-abandoned-oil-gas-wells-reveals-new-ways-fixing-worst-methane-emitters/>

interact with lost wells.” As noted by *Bloomberg*, state databases document only about 10 percent of the nation’s 2.6 million abandoned oil and gas wells; the whereabouts of the vast majority are unknown. Current efforts in Pennsylvania to increase documentation on the location and status of inactive wells rely on “citizen scientists” equipped with GPS and methane sniffers, as well as home and farm-owners living on top of abandoned wells. Over a period of three decades, PA DEP has located and plugged only about 3,000 abandoned wells.⁶²¹

- May 30, 2016 – New developments of houses, schools, and shopping centers are being built over abandoned oil and gas wells, according to a report by Wyoming Public Media. In most states there is no requirement for homeowners to be notified about abandoned wells on their properties, and these wells are not systematically monitored for leaks, nor are their locations well mapped. A builder who worked in the oil and gas industry for decades and suffered cardiac arrest when methane from an abandoned well he was inadvertently working atop exploded, said that there were “no signs” that a well was there.⁶²²
- January 26, 2016 – Researchers tested soil methane levels at 102 United Kingdom decommissioned oil and gas wells between 8 and 79 years old. Thirty percent of the wells had methane at the soil surface that was significantly higher than their control samples in nearby fields. Thirty-nine percent of well sites had significantly lower surface soil methane than their respective controls. Researchers suggested several explanations for the latter results, including replaced soils.⁶²³
- October 20, 2015 – Abandoned oil and gas wells near fracking sites can be conduits for methane escape that is not currently being measured, according to University of Vermont researchers. Fractures in the surrounding rock may connect to existing unused oil and gas wells in the area during fracking processes, thus providing a pathway for methane to migrate to the surface. The study used a mathematical model based on the large part of southern New York State underlain by the Marcellus Shale, incorporating “the depth of a new fracturing well, the vertical growth of induced fractures, and the depths and locations of existing nearby wells.” The researchers concluded the probability that new fracking-induced fractures would connect to a pre-existing well to be .03 percent to 3 percent. Density of nearby abandoned wells was the largest factor, and researchers pointed out the continuing problem of undocumented abandoned wells.⁶²⁴ As noted in an accompanying press release, probabilities are likely much higher: “Industry-sponsored information made

⁶²¹ Oldham, J. (2016, June 20). In the birthplace of U.S. oil, methane gas is leaking everywhere. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/articles/2016-06-20/in-the-birthplace-of-u-s-oil-methane-gas-is-leaking-everywhere>

⁶²² Editor. (2016, May 30). Danger below? New properties hide abandoned oil and gas wells. *Wyoming Public Media*. Retrieved from <http://wyomingpublicmedia.org/post/hidden-abandoned-dangerous-old-gas-and-oil-wells-neighborhoods>

⁶²³ Boothroyd, I. M., Almond, S., Qassim, S. M., Worrall, F., & Davies, R. J. (2016). Fugitive emissions of methane from abandoned, decommissioned oil and gas wells. *Science of the Total Environment*, 547, 461-469. doi: 10.1016/j.scitotenv.2015.12.096

⁶²⁴ Montague, J. A. & Pinder, J. F. (2015). Potential of hydraulically induced fractures to communicate with existing wellbores. *Water Resources Research*, 51, 8303–8315. doi: 10.1002/2014WR016771

public since the paper was published vastly increased assumptions about the area impacted by a set of six to eight fracking wells known as a well pad – to two square miles – increasing the probabilities cited in the paper by a factor of 10 or more.”⁶²⁵

- July 9, 2015 – As part of an extensive, peer-reviewed assessment of fracking in California, the California Council on Science and Technology identified leakage through failed, inactive wells as a known mechanism for fracking-related water contamination in other states, including Texas and Ohio, and said that it is not known whether abandoned wells in California likewise function as conduits for groundwater contamination and gas leakage. In California, there are more inactive than active wells. Of the state’s nearly one-quarter million oil and gas wells, more than half (116,000) have been plugged and abandoned, while another 1,800 inactive wells are “buried” with only an approximate location known. The locations of another 338 old wells are entirely unknown. California also has 110 orphaned wells, that is, abandoned wells with no owners. Most of California’s abandoned wells (53 percent) are located in Kern County.⁶²⁶
- May 11, 2015 – *CBC News* reported that falling gas and oil prices have prompted many smaller companies to abandon their operations in Alberta, Canada, leaving the provincial government to close down and dismantle their wells. In the past year alone, the number of orphaned wells in Alberta increased from 162 to 702. At the current rate of work, deconstructing the inventory of wells abandoned just in the past year alone will be a 20-year task.⁶²⁷
- April 27, 2015 – In a peer-reviewed study, researchers with the U.S. Fish and Wildlife Service documented 5,002 wells located on National Wildlife Refuge System units, in addition to 1,339 miles of pipeline. Almost half of the wells were inactive, while one-third were active and the remainder either plugged and abandoned or with status unknown. Highlighting the impacts of leaks, spills, and routine operation and maintenance on wildlife conservation efforts, the authors called for regular on-site ecological assessments, improved efforts to plug inactive wells and restore inactive well sites, and a “consolidated and robust regulatory framework” to protect the public’s interests.⁶²⁸
- March 24, 2015 – Analyzing data from 42 abandoned oil and gas wells in western Pennsylvania, a Princeton and Stanford team documented a wide range of leakage potentials. As a group, gas wells have higher permeability than oil wells. Among gas wells, methane flow rates are positively correlated with permeability. Subterranean

⁶²⁵ Newswise. (2015, October 20). Dirty pipeline: Methane from fracking sites can flow to abandoned wells, new study shows. *Newswise*. Retrieved from <http://www.newswise.com/articles/view/641581/>

⁶²⁶ Stringfellow, W. T., Cooley H., Varadharajan, C., Heberger, M., Reagan, M. T., Domen, J.K., . . . Houseworth, J. E. (2015, July 9). Volume II, Chapter 2: Impacts of well stimulation on water resources. In: *An Independent Scientific Assessment of Well Stimulation in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from <http://ccst.us/publications/2015/vol-II-chapter-2.pdf>

⁶²⁷ Johnson, T. (2015, May 11). Alberta sees huge spike in abandoned oil and gas wells. *CBC News*. Retrieved from <http://www.cbc.ca/news/canada/calgary/alberta-sees-huge-spike-in-abandoned-oil-and-gas-wells-1.3032434>

⁶²⁸ Ramirez Jr., P. & Mosley, S. B. (2015). Oil and gas wells and pipelines on U.S. wildlife refuges: Challenges for managers. *PLoS ONE*, 10(4). doi: 10.1371/journal.pone.0124085

temperatures and pressures, along with well depth, are all variables that can influence leakage potentials of abandoned wells. The leakage potential of wells drilled prior to 1960 is moderate to high, and plugged wells, as well as unplugged wells, can leak. The authors note that cement plugs are imperfect barriers that can develop defects that allow fluids to flow through gaps between the plug and surrounding hole, through pores or fissures within the plug itself, or directly through cracks in the well casing.⁶²⁹

- December 8, 2014 – A Princeton University team found that abandoned oil and gas wells in Pennsylvania, left over from prior decades of conventional drilling, leak significantly more methane than previously thought. Between 300,000 and 500,000 abandoned oil and gas wells are located in Pennsylvania, and many go unchecked and unmonitored for leaks. Nearly three-quarters are unplugged. Based on direct measurements of methane flow from 19 such wells, most of which were a half century old or older, the researchers estimated that the methane leaks from abandoned wells alone could account for between 4 and 7 percent of human-caused methane emissions in the state. Based on these measurements of positive methane flow from decades-old wells, the authors concluded that cumulative emissions from these abandoned wells “may be significantly larger than the cumulative leakage associated with oil and gas production, which has a shorter lifetime of operation.” Further, methane flow rates from plugged wells measured in this study were not consistently lower than unplugged wells and indeed were sometimes higher, even though wells are plugged for the precise purpose of limiting the escape of gases. The authors noted that an estimated three million abandoned oil and gas wells are scattered across the United States and likely represent “the second largest potential contribution to total US methane emissions above US Environmental Protection Agency estimates.” In the United States, no regulatory requirements for monitoring methane leaks from abandoned wells exist.^{630, 631}
- December 1, 2013 – An analysis of reports from the NYS DEC found that three-quarters of the state’s abandoned oil and gas wells were never plugged. New York State has approximately 48,000 such wells; many of their locations remain unknown.⁶³²
- Aug. 4, 2011 – A report from the EPA to Congress in 1987—and discovered by the *New York Times*—concluded that abandoned natural gas wells may have served as a pathway for hydraulic fracturing fluids to migrate underground from a shale gas well to a water well in West Virginia. In noting that the water well was polluted due to hydraulic fracturing and that such contamination was “illustrative” of contamination from oil and

⁶²⁹ Kang, M., Baik, E., Miller, A. R., Bandilla, K. W., & Celia, M. A. (2015). Effective permeabilities of abandoned oil and gas wells: analysis of data from Pennsylvania. *Environmental Science & Technology*, 49(7). doi: 10.1021/acs.est.5b00132

⁶³⁰ Kang, M., Kanno, C. M., Reid, M. C., Zhang, X., Mauzerall, D. L., Celia, M. A., . . . Onstott, T. C. (2014, December 8). Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania. *Proceedings of the National Academy of Sciences*. Advance online publication. doi: 10.1073/pnas.1408315111

⁶³¹ Magill, B. (2014, June 19). Derelict oil wells may be major methane emitters. *Climate Central*. Retrieved from <http://www.climatecentral.org/news/abandoned-oil-wells-methane-emissions-17575>

⁶³² Bishop, R. E. (2014). Historical analysis of oil and gas well plugging in New York: Is the regulatory system working? *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, 21, 103-116. Retrieved from <http://baywood.metapress.com/media/16ut607yqg1yrw9ydad3/contributions/b/0/4/7/b047j34r87552325.pdf>

natural gas drilling, the report suggested that additional cases of groundwater contamination from hydraulic fracturing may exist.⁶³³

- April 4, 2011 – *ProPublica* reported that abandoned wells have caused problems across the nation including contamination of drinking water in Colorado, Kentucky, Michigan, New York, Texas, and other states. *ProPublica* also found that a draft report from the Pennsylvania DEP described a 2008 incident in Pennsylvania in which a person died in an explosion triggered by lighting a candle in a bathroom after natural gas had seeped into a septic system from an abandoned well. The same draft report documented at least two dozen additional cases in which gas leaked from old wells, and three in which gas from new wells migrated into old wells, seeping into water supplies and requiring the evacuation of homes.⁶³⁴
- May 20, 2010 – The British Columbia Oil and Gas Commission issued a safety advisory after hydraulic fracturing caused a large “kick,” or unintentional entry of fluid or gas, into a nearby gas well. The commission reported that it knew of 18 incidents in British Columbia and one in Western Alberta in which hydraulic fractures had entered nearby gas wells. “Large kicks resulted in volumes up to 80 cubic meters [about 100 cubic yards] of fluids produced to surface. Invading fluids have included water, carbon dioxide, nitrogen, sand, drilling mud, other stimulation fluids and small amounts of gas.” These cases occurred in horizontal wells with a distance between wellbores of up to 2,300 feet. The Commission wrote, “It is recommended that operators cooperate through notifications and monitoring of all drilling and completion operations where fracturing takes place within 1000m [3,280 feet] of well bores existing or currently being drilled.” Such communication between active wells raises the potential that similar communication can occur between active wells and abandoned wells.⁶³⁵
- 2010 – The NYS DEC cautioned that “abandoned wells can leak oil, gas and/or brine; underground leaks may go undiscovered for years. These fluids can contaminate ground and surface water, kill vegetation, and cause public safety and health problems.” As the agency reported, “DEC has at least partial records on 40,000 wells, but estimates that over 75,000 oil and gas wells have been drilled in the State since the 1820s. Most of the wells date from before New York established a regulatory program. Many of these old wells were never properly plugged or were plugged using older techniques that were less reliable and long-lasting than modern methods.”⁶³⁶ The agency published similar comments in 2008 and 2009.
- January 2009 – In a presentation before the Society of Petroleum Engineers, industry consultant Michael C. Vincent reported on evidence that fractures from hydraulically

⁶³³ Urbina, I. (2011, August 4). A tainted water well, and concern there may be more. *The New York Times*. Retrieved from <http://www.nytimes.com/2011/08/04/us/04natgas.html>

⁶³⁴ Kusnetz, N. (2011, April 4). Danger in honeycomb of old wells. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/nation/2011/04/04/Danger-in-honeycomb-of-old-wells/stories/201104040149>

⁶³⁵ British Columbia Oil & Gas Commission. (2010, May 20). Safety advisory: communication during fracture stimulation. Retrieved from <https://www.bcogc.ca/node/5806/download>

⁶³⁶ New York State Department of Environmental Conservation. (2010). New York oil, gas and mineral resources 2010. Retrieved from http://www.dec.ny.gov/docs/materials_minerals_pdf/10anrpt1.pdf

fractured wells can communicate with nearby oil and gas wells. In spite of numerous examples of fractures intersecting with adjacent wellbores, the industry is reluctant to publish reports documenting these cases because “such information could unnecessarily alarm regulators or adjacent leaseholders.” Vincent added, “Although computing tools have improved, as an industry we remain incapable of fully describing the complexity of the fracture, reservoir, and fluid flow regimes.” These findings raise the possibility that there could be similar communications between existing fracked wells that are fractured and abandoned wells and that operators cannot accurately predict how these will interact.⁶³⁷

- 2005 – M.K. Fisher, Vice President of Business Management at Pinnacle, a service of Halliburton that specializes in hydraulic fracturing, reported in an article published by the Society of Petroleum Engineers that a single fracture produced during a fracking operation in the Texas Barnett Shale had unexpectedly spread 2,500 feet laterally in two directions. He also described fractures in the Barnett Shale as “extremely complex.”⁶³⁸ These findings raise the possibility that well communication over very large distances could occur due to fractures that spread “unexpectedly.”
- October 1999 – The U.S. Department of Energy reported that there were approximately 2.5 million abandoned oil and gas wells in the U.S.⁶³⁹
- Early 1990s – An underground waste disposal well in McKean County, Pennsylvania, contaminated groundwater when the wastewater traveled up a nearby abandoned, unmapped, and unplugged oil well. Owners of private water wells that were contaminated by the incident eventually had to be connected to a public water system.⁶⁴⁰
- July 1989 – In the past, the investigative agency for Congress, the U.S. General Accounting Office (now the Government Accountability Office—GAO) studied oil and natural gas underground injection disposal wells and found serious cases of contamination. The agency reported that, in several cases, wastewater from oil and natural gas operations had migrated up into abandoned oil and natural gas wells, contaminating underground water supplies. The GAO found that “if these abandoned wells are not properly plugged—that is, sealed off—and have cracked casings, they can serve as pathways for injected brines [waste fluids from natural gas and oil drilling] to enter drinking water.... Because groundwater moves very slowly, any contaminants that

⁶³⁷ Vincent, M. C. (2009, January 19). Examining our assumptions – Have oversimplifications jeopardized our ability to design optimal fracture treatments? Lecture presented at Society of Petroleum Engineers hydraulic fracturing technology conference in The Woodlands, Texas. See <http://www.spe.org/dl/docs/2010/MikeVincent.pdf>

⁶³⁸ Fisher, M., Wright, C., Davidson, B., Steinsberger, N., Buckler, W., Goodwin, A., & Fielder, E. (2005). Integrating fracture-mapping technologies to improve stimulations in the Barnett Shale. *SPE Production & Facilities*, 20(2). doi: 10.2118/77441-PA

⁶³⁹ United States Department of Energy, Office of Fossil Energy. (1999, October 5). *Environmental benefits of advanced oil and gas exploration and production technology*. (Rep.). Retrieved from <http://www.netl.doe.gov/kmd/cds/disk25/oilandgas.pdf>

⁶⁴⁰ Hopey, D. (2012, January 3). Wastewater disposal wells under scrutiny following Irvin leak. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/news/environment/2012/01/03/Wastewater-disposal-wells-under-scrutiny-following-Irvin-leak.html>

enter it will remain concentrated for long periods of time, and cleanup, if it is technically feasible, can be prohibitively costly.”⁶⁴¹

- December 1987 – The EPA submitted a report to Congress on oil and natural gas wastes in which the agency cautioned that abandoned wells must be plugged with cement in order to avoid “degradation” of ground and surface waters as a result of pressurized brine or injected waste from wastewater disposal wells migrating into aquifers, rivers, or streams.⁶⁴² While the EPA did not address the potential for contamination through abandoned wells as a result of hydraulic fracturing, both hydraulic fracturing and underground injection disposal wells require underground injection of fluid under pressure, raising the potential that there is a similar risk of groundwater contamination when hydraulic fracturing occurs near abandoned wells.
- 1985 – In an investigation of 4,658 complaints due to oil and natural gas production, the Texas Department of Agriculture found that “when a water well is experiencing an oilfield pollution problem (typically, high chlorides), the pollution source is often difficult to track down. The source could be a leak in the casing of a disposal well, leakage behind the casing due to poor cement bond, old saltwater evaporation pits, or, most often, transport of contaminants through an *improperly plugged abandoned well*” (emphasis in original). The agency found more than a dozen confirmed or suspected cases in which pollutants had migrated up abandoned wells and contaminated groundwater. In one case, drilling wastewater migrated up an abandoned well a half mile away from where the wastewater was injected underground for disposal.⁶⁴³
- November 1978 – In a report later cited by the EPA in its 1987 report to Congress (cited above), the state of Illinois Environmental Protection Agency found that oil and natural gas wastes injected underground could migrate through abandoned oil and natural gas wells and contaminate groundwater. The agency wrote, “In old production areas, abandoned wells may pose a serious threat to ground water quality. Unplugged or improperly plugged wells provide possible vertical communication between saline and fresh water aquifers.”⁶⁴⁴

⁶⁴¹ United States Government Accountability Office. (1989, July 5). Drinking water: Safeguards are not preventing contamination from injected oil and gas wastes. Retrieved from <http://www.gao.gov/products/RCED-89-97>. (2, 4, Rep.).

⁶⁴² U.S. Environmental Protection Agency. (1987). *Report to Congress: Management of wastes from the exploration, development, and production of crude oil, natural gas, and geothermal energy* (III-47, Rep.). Retrieved from <http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=20012D4P.pdf>

⁶⁴³ Texas Department of Agriculture, Department of Natural Resources. (1985). *Agricultural land and water contamination: From injection wells, disposal pits, and abandoned wells used in oil and gas production* (pp. 5, 12-15). Austin, TX: Dept. of Agriculture, Office of Natural Resources.

⁶⁴⁴ Illinois Environmental Protection Agency, Water Quality Management Planning. (1978). *Illinois oil field brine disposal assessment* (pp. 44-45, Rep.).

Flood risks

Fracking exacerbates flood risks in two ways. First, massive land clearing and forest fragmentation that necessarily accompany well site preparation increase erosion, run-off, and risks for catastrophic flooding. The construction of access roads, easements for pipelines, and build-out of other related infrastructure further contribute to the problem. Compared to an acre of forest or meadow, an acre of land subject to fracking construction activity releases 1,000-2,000 times more sediment during rainstorms. In addition, in some cases, operators choose to site well pads on flood-prone areas in order to have easy access to water for fracking, to abide by setback requirements intended to keep well pads away from inhabited buildings, or to avoid productive agricultural areas.

Second, the vulnerability of fracking sites to flooding increases the known dangers of unconventional gas extraction, heightening the risks of contamination of soils and water supplies, the overflow or breaching of containment ponds, and the escape of chemicals and hazardous materials. During Hurricane Harvey flooding in Texas in 2017, Eagle Ford operators reported 31 spills at oil and gas wells, storage tanks, and pipelines.

- September 15, 2017 – Hurricane Harvey and its resulting flooding affected various parts of metropolitan Houston’s vast oil and gas operations, as well as the Eagle Ford shale region of South Texas. *Reuters* reviewed company reports to the U.S. Coast Guard on the various releases of petrochemicals around the time of Harvey’s hit and subsequent flooding. In addition to more than 22,000 barrels of crude oil, gasoline, diesel, drilling wastewater, and petrochemicals spilled from refineries, storage terminals, and other facilities in the days after the storm, 27 million cubic feet (765,000 cubic meters) of natural gas was released.⁶⁴⁵ Pipeline operators are required to report oil and gas, but not drilling wastewater, spills to the Texas Railroad Commission. An environmental organization retrieved and listed this data, finding 31 spills at oil and gas wells, storage tanks, and pipelines during the hurricane’s flooding. The group notes that though the data contains many “produced water” spills, they are likely underreported since they are not mandatory.⁶⁴⁶ More than half the fracking rigs running in the region were estimated to have shut down. “Given that much of oil and gas activity occurs in areas only accessible via dirt roads, the heavy rainfall usually makes the movement of trucks and supplies much more difficult... The trucking and rail of sand, chemicals, and personnel to the well site will all take more time given the likely nasty condition of many Eagle Ford access roads,” according to an energy analyst.⁶⁴⁷

⁶⁴⁵ Flitter, E., & Valdmanis, R. (2017, September 15). Oil and chemical spills from Hurricane Harvey big, but dwarfed by Katrina. *Reuters.com*. Retrieved from <https://www.reuters.com/article/us-storm-harvey-spills/oil-and-chemical-spills-from-hurricane-harvey-big-but-dwarfed-by-katrina-idUSKCN1BQ1E8>

⁶⁴⁶ Environment Texas. (2017, September 12). *Report: Environmental and health concerns about oil and gas spills after Hurricane Harvey*. Retrieved from <https://environmenttexas.org/sites/environment/files/reports/Harvey%20Oil%20Gas%20Spills%20-%20Env%20TX%20-%209.22.17.pdf>

⁶⁴⁷ Wethe, D. (2017, August 31). Harvey's floods could delay 10% of U.S. fracking: Analyst. *Bloomberg L.P.* Retrieved from <https://www.bloomberg.com/news/articles/2017-08-31/harvey-s-floods-could-delay-10-percent-of-u-s-fracking-analyst>

- May 25, 2016 – The removal of photos of flood-related oil spills on a Texas state-run website appears to be an effort to hide visuals that “don’t portray the energy business in a flattering light,” according to the *El Paso Times* Editorial Board. The photos revealed potential environmental damage caused by flooding at fracking sites.⁶⁴⁸ As earlier reported by the *El Paso Times*, many of the photos shot during Texas’ recent floods “show swamped wastewater ponds at fracking sites, presumably allowing wastewater to escape into the environment—and potentially into drinking-water supplies.”⁶⁴⁹
- May 1, 2016 – Spring floods across Texas inundated oil wells and fracking sites, tipped over storage tanks, and flushed crude oil and fracking chemicals into rivers, as documented in an Associated Press story that referenced dozens of aerial photographs showing flooded production sites along the Sabine River on the Texas-Louisiana border. (The photographs were later removed from direct public access; see above.) Past president of the American Public Health Association Walter Tsou, MD, called the situation “a potential disaster.”⁶⁵⁰
- June 12, 2015 – At the beginning of 2015, after a month of record-breaking rainfall, Fish and Wildlife Service officials at the Hagerman National Wildlife Refuge in Texas found that floodwaters flowing through oil production well pads in the refuge had inundated dozens of jackpumps, pipelines, and other oil and gas infrastructure, leaving bubbling, oily water and a gassy stench. In 1989, the U.S. Government Accountability Office (GAO) called for “bold action” to address fossil fuel production activities incompatible with the mission of the refuge system. Subsequent reforms have been exceedingly slow, according to a report from *Greenwire*. In most cases, the Fish and Wildlife Service does not know how much fossil fuel is produced or spilled on refuges, and remediation efforts are inadequate. Severe weather events are expected to increase in frequency and severity as climate change progresses, amplifying flood related concerns.⁶⁵¹
- June 20, 2014 – The *Coloradoan* reported that Noble Energy storage tanks damaged by spring flooding in Colorado dumped 7,500 gallons of crude oil, fracking chemicals, and fracking wastewater into the Cache la Poudre River, which is both a National Heritage area and a habitat for Colorado’s only self-sustaining population of wild trout. Recent high river flows had undercut the bank where the oil tank was located, which caused the tank to drop and break a valve.⁶⁵²

⁶⁴⁸ *El Paso Times* Editorial Board. (2016, May 25). Editorial: Hiding bad news from Texans. *El Paso Times*. Retrieved from <http://www.elpasotimes.com/story/opinion/editorials/2016/05/25/editorial-hiding-bad-news-texans/84937054/>

⁶⁴⁹ Schladen, M. (2016, April 30). Flooding sweeps oil, chemicals into rivers. *El Paso Times*. Retrieved from <http://www.elpasotimes.com/story/news/2016/04/30/flooding-sweeps-oil-chemicals-into-rivers/83671348/>

⁶⁵⁰ Siron, C. (2016, May 1). Texas floods washing fracking chemicals, crude oil into rivers. *Dallas Morning News*. Retrieved from <http://thescoopblog.dallasnews.com/2016/05/texas-floods-washing-fracking-chemicals-crude-oil-into-rivers.html/>

⁶⁵¹ Hiar, C. (2015, June 12). Wildlife refuges: Floods expose weakness in FWS’s oil and gas oversight. *E&E Publishing*. Retrieved from <http://www.eenews.net/stories/1060020169>

⁶⁵² Handy, R. (2014, June 20). Crude oil spills into Poudre near Windsor. *Coloradoan*. Retrieved from <http://www.coloradoan.com/story/news/local/2014/06/20/crude-oil-spills-poudre-near-windsor/11161379/>

- March 2014 – An extraordinary flood that struck the Front Range of Colorado killed ten people, forced the evacuation of 18,000 more, destroyed more than 1,850 homes, and damaged roads, bridges, and farmland throughout the state. More than 2,650 oil and gas wells and associated facilities were also affected, with 1,614 wells lying directly within the flood impact zone. Many of these storm-damaged facilities and storage tanks leaked uncontrollably. In a later accounting, Matt Lepore, Director of the Colorado Oil and Gas Conservation Commission, estimated the flooding had resulted in the release to the environment of 48,250 gallons of oil or condensate and 43,479 gallons of fracking wastewater from 50 different spill sites across the state. In Colorado, more than 20,850 oil and gas wells lie within 500 feet of a river, stream, or other drainage. According to Director Lepore, setback requirements that keep drilling and fracking operations away from residential areas inadvertently encourage operators to drill in unoccupied floodplains. At the same time, oil and gas operators prefer locations close to supplies of water for use in fracking. These twin factors result in a clustering of drilling and fracking operations in low-lying areas prone to catastrophic flooding.⁶⁵³
- 2004-2013 – In at least six of the last ten years (2004, 2005, 2006, 2009, 2011, and 2013), several counties targeted for shale gas drilling in New York State have experienced serious flooding. These include the counties of Albany, Broome, Cattaraugus, Chautauqua, Chenango, Delaware, Erie, Greene, Madison, Orange, Otsego, Schoharie, Sullivan and Ulster. In at least five of the past 10 years (2004, 2005, 2006, 2009 and 2011), floods have exceeded 100-year levels in at least some of the counties.^{654, 655, 656, 657, 658, 659, 660}
- February 7, 2013 – In its 2012 annual report to investors, oil and gas drilling company Noble Energy stated, “Our operations are subject to hazards and risks inherent in the

⁶⁵³ Lepore, M. (2014, March). “Lessons Learned” in the front range flood of September 2013: a staff report to the commissioners of the Colorado Oil and Gas Conservation Commission. Retrieved from the Colorado Oil and Gas Conservation Commission website:

http://cogcc.state.co.us/Announcements/Hot_Topics/Flood2013/FinalStaffReportLessonsLearned20140314.pdf

⁶⁵⁴ Brooks, L. T. (2005). *Flood of September 18-19, 2004 in the upper Delaware River basin, New York* (Rep.).

Retrieved from United States Geological Survey website: <http://ny.water.usgs.gov/pubs/of/of051166/>

⁶⁵⁵ Suro, T. P., & Firda, G. D. (2006). *Flood of April 2–3, 2005, Neversink River basin, New York* (Rep.). Retrieved from United States Geological Survey website: <http://pubs.usgs.gov/of/2006/1319/>

⁶⁵⁶ Suro, T. P., Firda, G. D., & Szabo, C. O. (2009). *Flood of June 26–29, 2006, Mohawk, Delaware and Susquehanna River basins, New York* (Rep.). Retrieved from United States Geological Survey website: <http://pubs.usgs.gov/of/2009/1063/pdf/ofr2009-1063.pdf>

⁶⁵⁷ Szabo, C. O., Coon, W. F., & Nizio, T. A. (2010). *Flash floods of August 10, 2009, in the villages of Gowanda and Silver Creek, New York* (Rep.). Retrieved from United States Geological Survey website: <http://pubs.usgs.gov/sir/2010/5259/pdf/SIR%202010-5259.pdf>

⁶⁵⁸ Szabo, L. (2011, September 8). *Remnants of Tropical Storm Lee cause record flooding in the Susquehanna River basin* (Rep.). Retrieved from United States Geological Survey website: <http://ny.water.usgs.gov/leeindex.html>

⁶⁵⁹ Giordano, S. (2013, January 29). Several eastern counties in central New York under water after heavy flooding. *Syracuse Post-Standard*. Retrieved from

http://www.syracuse.com/news/index.ssf/2013/06/several_eastern_counties_in_ce.html

⁶⁶⁰ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (2-32, 33, Rep.).

drilling, production and transportation of crude oil and natural gas, including ... flooding which could affect our operations in low-lying areas such as the Marcellus Shale.”⁶⁶¹

- September 7, 2011 – The New York State Department of Environmental Conservation’s (NYS DEC) draft shale gas drilling plan recommended that drilling be prohibited within 100-year floodplains but acknowledged that many areas in the Delaware and Susquehanna River basins that were affected by flooding in 2004 and 2006 were located outside of officially designated flood zones.⁶⁶² In 2004, 2005, 2006, 2009, and 2011, flooding in New York exceeded 100-year levels in at least some of the counties where drilling and fracking may occur.
- 1992 – In its Generic Environmental Impact Statement (GEIS) for oil and natural gas drilling, which was predicated on conventional drilling, the NYS DEC raised concerns that storage tanks holding drilling wastewater, spent hydraulic fracturing fluid, or other contaminants could be damaged by flooding and leak. At the time, the GEIS called for at least some of these tanks to be properly secured.⁶⁶³ Shale gas extraction via horizontal fracking would require many more storage tanks for fracking fluids and wastewater than conventional drilling operations anticipated in 1992 when the agency estimated that oil and gas wells in the state would each require 20,000-80,000 gallons of fracking fluid.⁶⁶⁴ As of 2011, the agency anticipated that high volume, horizontally fracked shale gas wells in New York State would each require 2.4-7.8 million gallons of fluid—roughly 100 times the 1992 estimate.⁶⁶⁵

Threats to agriculture and soil quality

Drilling and fracking operations pose risks to the agricultural and timber sectors and damage the ecological value of healthy soils. In California, fracking wastewater illegally injected into aquifers threatens crucial irrigation supplies to farmers in a time of severe drought. Fracking wastewater reused for irrigation and livestock watering in California’s San Joaquin Valley may contain at least ten known or suspected chemical carcinogens, as well as over a dozen chemicals

⁶⁶¹ Noble Energy, Annual Report (Form 10-K) (Feb. 7, 2013) at 42.

⁶⁶² New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (ES-22, 2-32, 33, Rep.).

⁶⁶³ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (8-42, 8-43, 9-35, Rep.).

⁶⁶⁴ New York State Department of Environmental Conservation. (1992). *Generic environmental impact statement on the oil, gas and solution mining regulatory program* (Rep.). Retrieved from http://www.dec.ny.gov/docs/materials_minerals_pdf/dgeisv1ch8.pdf (9-26, Rep.).

⁶⁶⁵ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (ES-8, Rep.).

with no available toxicological data and many unidentified compounds currently classified as “trade secrets.” Agricultural uses of wastewater, as well as flowback water spills, raise questions about direct exposure of affected soils, contamination of food crops via bioabsorption through plant roots, and impacts on livestock due to ingestion. Studies and case reports from across the country have highlighted instances of deaths, neurological disorders, aborted pregnancies, and stillbirths in farm animals that have come into contact with wastewater. Additionally, farmers have expressed concern that nearby fracking operations can hurt the perception of agricultural quality and invalidate value-added organic certification. Land use changes and transport of invasive species by drilling and fracking operations have led to documented ecological and monetary harm to soils, forests, and natural areas.

- July 20, 2017 – Penn State University researchers identified a direct correlation between the spread of invasive, non-native plants in Pennsylvania's northern forests and specific aspects of fracking operations. Researchers surveyed 127 Marcellus Shale gas well pads and adjacent access roads in seven state forest districts in the Allegheny National Forest. The study “found that within less than a decade invasive non-native plants have spread to over half of the 127 well pads in our survey, and for the 85% of the pads that were less than 4 years old it occurred in a much shorter period of time.” Gravel shipments and mud on the tires and undercarriages of trucks carry and deposit seeds and propagules of invasive plants. “Given the fact that on average 1235 one-way truck trips delivering fracturing fluid and proppant are required to complete an unconventional well, the potential to transport invasive plant propagules is significant.”⁶⁶⁶ “The spread of invasive non-native plants could have long-term negative consequences for the forest ecosystem in a region where the ubiquitous woods provide timbering revenue, wildlife habitat, and ecotourism, warns team member David Mortensen, professor of weed and applied plant ecology.”⁶⁶⁷
- May 15, 2017 – By 2015, the annual ecological cost of fracking in the U.S. reached over \$272 million per year, according to a team of biologists from Hendrix College in Arkansas. They reached this value by estimating the impact of land-use changes on “ecosystem services,” the benefits that natural habitats provide to humans, such as carbon sequestration, flood mitigation, food security, ecotourism revenue, and genetic diversity. Authors considered this estimate to be conservative. In addition, they wrote, “[d]epending on future well-drilling rates, cumulative ecosystem services costs projected to the year 2040 range from US\$9.4 billion to US\$31.9 billion.” Their results showed, “that temperate grassland and deciduous forest are being disproportionately impacted by unconventional oil and gas development. Temperate grasslands are some of the most imperiled ecosystems in North America.” They found “considerable variation in

⁶⁶⁶ Barlow, K. M., Mortensen, D. A., Drohan, P. J., & Averill, K. M. (2017). Unconventional gas development facilitates plant invasions. *Journal of Environmental Management*, 202, 208e216. doi: 10.1016/j.jenvman.2017.07.005

⁶⁶⁷ Mulhollem, J. (2017, July 20). Shale gas development spurring spread of invasive plants in Pa. forests. *PennState News*. Retrieved from <http://news.psu.edu/story/475225/2017/07/20/research/shale-gas-development-spurring-spread-invasive-plants-pa-forests>

ecosystem services costs between different plays, with Haynesville, Bakken/Three Forks, and Fayetteville showing the highest annual costs.”⁶⁶⁸

- November 29, 2016 – A study by engineers and environmental scientists from China, the U.K., and the Republic of Korea investigated the impact of contaminated fracking flowback water on soil health, using soils from representative shale gas areas in China. They also performed a preliminary human health risk assessment of exposure to the arsenic found in such soils. The solutions they tested were representative of flowback water from various stages following a fracked well’s establishment, and their study found that the temporal change in the composition of these wastewaters “leads to different environmental implications.” They tested heavy metal mobility and bioaccessibility, finding that even though mobility was reduced by high ionic strength of flowback water, the metals maintained relatively high bioaccessibility. Soil toxicity moderately increased after a month “aging” with the flowback water treatment. Arsenic, one of the metals included in the testing, is a known human carcinogen and therefore the focus of the human health risk assessment. Results indicated “a low level of cancer risk through exposure via ingestion.”⁶⁶⁹
- October 4, 2016 – A research team from Lawrence Berkeley National Laboratory, University of California Berkeley, and University of the Pacific released preliminary results from a first-ever hazard assessment of chemicals used in California oil drilling operations that reuse wastewater for livestock watering and other agricultural purposes in the San Joaquin Valley. This evaluation, compiled as a technical report by PSE Healthy Energy and Lawrence Berkeley National Laboratory, revealed that more than one-third of the 173 chemicals used are classified as trade secret and their identities are therefore unknown. Of the remainder, ten are classified as either carcinogenic or possibly carcinogenic in humans, 22 are classified by the state of California as toxic air contaminants, and 14 had no ecotoxicity or mammalian toxicity data available. “It is difficult or impossible to estimate risks to consumers, farmworkers or the environment,” the authors concluded, “when identification of chemical additives remains in trade secret form and/or lacks toxicity and environmental profile information.”⁶⁷⁰
- June 1, 2016 – “Co-contaminant interaction effects” can occur when multiple chemicals are involved in spills of oil and gas wastewater on agricultural soils, according to a study by a Colorado State University research team. Through simulations, researchers analyzed

⁶⁶⁸ Moran, M. D., Taylor, N. T., Mullins, T. F., Sardar, S. S., & McClung, M. R. (2017). Land-use and ecosystem services costs of unconventional US oil and gas development. *Frontiers in Ecology and the Environment*, 15(5), 237–242. doi: 10.1002/fee.1492

⁶⁶⁹ Chen, S. S., Suna Y., Tsang, D. C. W., Grahamc, N. J. D., Ok, Y. S., Feng, Y., & Li, X.-D. (2016). Potential impact of flowback water from hydraulic fracturing on agricultural soil quality: Metal/metalloid bioaccessibility, Microtox bioassay, and enzyme activities. *Science of the Total Environment*, 579, 1419–1426. doi: 10.1016/j.scitotenv.2016.11.141

⁶⁷⁰ Shonkoff, S. B. C., Stringfellow, W. T., & Domen, J. K. (2016, September). *Hazard assessment of chemicals additives used in oil field that reuse produced water for agricultural irrigation, livestock watering, and groundwater recharge in the San Joaquin Valley of California: Preliminary results*. Retrieved from https://www.psehealthyenergy.org/wp-content/uploads/2017/04/Preliminary_Results_13267_Disclosures_FINAL-1.pdf

how degradation was affected when combinations of three fracking-related organic chemicals spilled, alone or together: polyethylene glycol, a commonly used surfactant; glutaraldehyde, a biocide to prevent pipe corrosion from microbial activity; and polyacrylamide, a friction reducer. In addition to interactions between the chemicals, they analyzed the role of naturally occurring salts. Results showed that polyethylene glycol surfactants alone can break down in topsoil within 42–71 days, but, in the presence of the biocide glutaraldehyde or salt concentrations typical of fracking wastewater, their biodegradation was impeded or halted altogether. Authors emphasized that the interactions they studied account for only a fraction of the hundreds of fracking chemicals in use, but that their results “show a complex picture of co-contaminant fate and toxicity” that has, so far, been ignored in the regulatory process.⁶⁷¹

- December 12, 2015 – A research team at the University of Aberdeen found high levels of selenium, molybdenum, and arsenic in rock samples collected from a region in northern England that has been targeted for fracking. The finding is important due to the possible risk that these toxic elements will be released into groundwater during shale gas operations. Selenium poisoning has occurred among Irish horses confined to pastures underlain by black shale. While small amounts of selenium are essential for metabolism, high levels (which, in the case of human consumption, is above 400 µg/day) are toxic. Possible consequences include neurotoxicity, cancer and diabetes.⁶⁷²
- November 23, 2015 – Gas-related impacts on Pennsylvania farmers may include pipelines criss-crossing fields and forests, as well as jeopardization of organic certification, according to a report covering a State Agriculture Department spokesman’s presentation, on the Potter County government website. The spokesman said, “steps should be taken to steer this development in ways that diminish impact on soil quality and fragmentation.” “With trees and other vegetation being cleared from pipeline rights-of-way, he noted, it’s important for the acreage to be replanted with plant species that are beneficial to agriculture—pollinating plants, as an example.”⁶⁷³
- October 24, 2015 – More than 180 million gallons of wastewater from oil and gas operations spilled from 2009 to 2014, according to an Associated Press analysis of data from leading oil- and gas-producing states (Texas, North Dakota, California, Alaska, Colorado, New Mexico, Oklahoma, Wyoming, Kansas, Utah and Montana). A *Dallas Morning News* report focused on how the resulting contamination of groundwater and soils has affected agricultural and ranching. In one case, wastewater from pits seeped beneath a cotton and nut farm near Bakersfield, California and forced the grower to remove 2,000 acres from production. In western Texas, pipeline failures and illegal

⁶⁷¹ McLaughlin, M. C., Borch, T., & Blotvogel, J. (2016). Spills of hydraulic fracturing chemicals on agricultural topsoil: biodegradation, sorption, and co-contaminant interactions. *Environmental Science & Technology*, 50(11). doi: 10.1021/acs.est.6b00240

⁶⁷² Parnell, J., Brolly, C., Spinks, S., & Bowden, S. (2015). Selenium enrichment in Carboniferous Shales, Britain and Ireland: Problem or opportunity for shale gas extraction? *Applied Geochemistry*, 66, 82-87. doi:10.1016/j.apgeochem.2015.12.008

⁶⁷³ *Potter County Today*. (2015, November 23). Shale gas impact on agriculture ‘profound.’ Retrieved from <http://today.pottercountypa.net/shale-gas-impact-on-agriculture-profound/>

dumping of frack waste contaminated ranches and pastures.⁶⁷⁴

- May 2, 2015 – The *Los Angeles Times* reported that farmers in Kern County, California purchased over 21 million gallons per day of treated oil field wastewater to use for crop irrigation. The article identified lingering questions about chemicals remaining after treatment and their potential impact both on the crops and those who consume them. Independent testing identified chemicals including acetone and methylene chloride, along with oil, in the treated irrigation water.⁶⁷⁵ Acetone and methylene chloride are powerful industrial solvents that are highly toxic to humans, and samples of the wastewater contained concentrations of both that were higher than those seen at oil spill disaster sites. (Chevron’s own report confirmed the presence of acetone, benzene, and xylene, though in lesser concentrations; Chevron did not appear to test for methylene chloride.⁶⁷⁶) Broader testing requirements involving chemicals covered under California’s new fracking disclosure regulations went into effect June 15, 2015.⁶⁷⁷
- April 24, 2015 – Unconventional technologies in gas and oil extraction facilitated the drilling of an average of 50,000 new fractured wells per year in North America over the past 15 years. An interdisciplinary study published in *Science* demonstrated that the accumulating land degradation has resulted in continent-wide impacts, as measured by the reduced amount of carbon absorbed by plants and accumulated as biomass. This is a robust metric of essential ecosystem services, such as food production, biodiversity, and wildlife habitat, and its loss “is likely long-lasting and potentially permanent.” The land area occupied by well pads, roads, and storage facilities built during this period is approximately three million hectares, roughly the land area of three Yellowstone National Parks. The authors concluded that new approaches to land use planning and policy are “necessary to achieve energy policies that minimize ecosystem service losses.”⁶⁷⁸
- January 26, 2015 – Two Colorado scientists performed a detailed analysis of vegetative patterns—followed chronologically—over a selected group of well pads in Colorado managed by the U.S. Bureau of Land Management, including two undisturbed reference sites. They documented the disturbance of plant and soil systems linked to contemporary oil and gas well pad construction, and found that none of the oil and gas well pads

⁶⁷⁴ Flesher, J. (2015, October 24). Fatal flow: Brine from oil, gas drilling fouls land, kills wildlife at alarming rate. *Dallas Morning News*. Retrieved from <http://www.dallasnews.com/news/local-news/20151024-fatal-flow-brine-from-oil-gas-drilling-fouls-land-kills-wildlife-at-alarming-rate.ece>

⁶⁷⁵ Cart, J. (2015, May 2). Central Valley's growing concern: Crops raised with oil field water. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/california/la-me-drought-oil-water-20150503-story.html#page=1>

⁶⁷⁶ Amec Foster Wheeler Environment & Infrastructure, Inc. (2015, June 15). Technical report: Reclaimed water impoundments sampling, Cawelo Water District Ponds, Kern River Oil Field, Kern County, California, Prepared for Chevron U.S.A. Inc. Retrieved from <https://drive.google.com/file/d/0B1ccgD60cwq7dWE5Y0c2ZDh5WnM/view>

⁶⁷⁷ Ross, D. (2015, June 19). Has our food been contaminated by Chevron's wastewater? *Truthout*. Retrieved from <http://www.truth-out.org/news/item/31470-has-our-food-been-contaminated-by-chevron-s-wastewater>

⁶⁷⁸ Allred, B. W., Kolby Smith, W., Tridwell, D., Haggerty, J. H., Running, S. W., Naugle, D. E., & Fuhlendorf, S. D. (2015). Ecosystem services lost to oil and gas in North America. *Science*, 348 (6233), 401-402.

included in the study returned to pre-drilling condition, even after 20-50 years. Full restoration may require decades of intensive effort.⁶⁷⁹

- October 14, 2014 – State documents obtained by the Center for Biological Diversity show that almost three billion gallons of fracking wastewater have been illegally dumped into central California aquifers that supply drinking water and farming irrigation. The California Water Board confirmed that several oil companies used at least nine of 11 injection wells that connect with high-quality water sources for disposal of fracking wastewater, which included high levels of arsenic, thallium, and nitrates. The California Division of Oil, Gas and Geothermal Resources has shut down 11 oil field injection wells and is scrutinizing almost 100 others for posing a “danger to life, health, property, and natural resources.” At least one farming company has sued oil producers in part for contaminating groundwater that farms use for irrigation.⁶⁸⁰
- September 6, 2014 – *Al Jazeera America* examined the challenges that North Dakota farmers are facing in light of wastewater spills from oil and gas development. Notably, in heavily drilled Bottineau County, some levels of chloride, from sites where an estimated 16,800-25,200 gallons of wastewater had seeped into the ground, were so high that they exceeded the levels measurable with the North Dakota Department of Health’s test strips. State records, testimonies from oil workers and various residents, and the decades-long failure of contaminated fields to produce crops indicate that wastewater spills are a significant hazard in the current fracking boom.⁶⁸¹
- August 6, 2014 – The Pennsylvania Department of Environmental Protection (PA DEP) found that leaks of fracking wastewater from three impoundments contaminated soil and groundwater. The findings prompted the state to issue a violation and increase testing.⁶⁸²
- August 5, 2014 – Michelle Bamberger, a veterinarian and researcher, and Robert Oswald, a professor of molecular medicine at Cornell University, published a book that describes their research into the impacts of drilling and fracking on agriculture and animal health. They detail results of 24 case studies from six gas drilling states, including follow-up on cases they previously published in the peer-reviewed literature, raising concerns about the effects of drilling and fracking on agriculture and the health of animals.⁶⁸³

⁶⁷⁹ Minnick, T. J., & Alward, R. D. (2015). Plant–soil feedbacks and the partial recovery of soil spatial patterns on abandoned well pads in a sagebrush shrubland. *Ecological Applications*, 25(1), 3-10.

⁶⁸⁰ Dechert, S. (2014, October 14). Fracking wastewater spoils California drinking, farm supplies. *Clean Technica*. Retrieved from <http://cleantechnica.com/2014/10/14/fracking-wastewater-spoils-california-drinking-farm-supplies/>

⁶⁸¹ Gottesdiener, L. (2014, September 6). In shadow of oil boom, North Dakota farmers fight contamination. *Al Jazeera America*. Retrieved from <http://america.aljazeera.com/articles/2014/9/6/north-dakota-wastewaterlegacy.html>

⁶⁸² Hopey, D. (2014, August 6). State: Fracking waste tainted groundwater, soil at three Washington County sites. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/local/washington/2014/08/06/Pa-finds-tainted-water-soil-at-three-Washington-County-shale-sites/stories/201408050198>

⁶⁸³ Bamberger, M., & Oswald, R. (2014). *The real cost of fracking: How America's shale gas boom is threatening our families, pets, and food*. Boston: Beacon Press.

- August 1, 2014 – At least 19,000 gallons of hydrochloric acid spilled during completion of a fracking well on an alfalfa farm in Kingfisher County, Oklahoma. The Oklahoma Corporation Commission reported concerns about rain pushing chemical runoff into a nearby creek that flows into the town of Hennessey’s water system. The responsible company, Blake Production, planned to pay for the alfalfa crop for six years. The landowner and a neighbor were pursuing litigation.⁶⁸⁴
- May 4, 2014 – In an analysis of state data from Colorado, the *Denver Post* reported that fracking related to oil and gas drilling is putting soil quality and farmlands at risk due to significant amounts of toxic fluids penetrating the soil. According to report, 578 spills were reported in 2013, which means that, on average in the state, a gallon of toxic liquid penetrates the ground every eight minutes. Colorado State University soil scientist Eugene Kelly, said that the overall impact of the oil and gas boom “is like a death sentence for soil.”⁶⁸⁵
- November 28, 2012 – In conjunction with the Food & Environment Reporting Network, *The Nation* reported that serious risks to agriculture caused by fracking are increasing across the country and linked these concerns to risks to human health.⁶⁸⁶
- January 2012 – A study of gas drilling’s impacts on human and animal health concluded that the drilling process may lead to health problems. The study reported and analyzed a number of case studies, including dead and sick animals in several states that had been exposed to drilling or hydraulic fracturing fluids, wastewater, or contaminated ground or surface water.⁶⁸⁷ The researchers cited 24 cases in six states where animals and their owners were potentially affected by gas drilling. In one case, a farmer separated 96 head of cattle into three areas, one along a creek where fracking wastewater was allegedly dumped and the remainder in fields without access to the contaminated creek; the farmer found that, of the 60 head exposed to the creek, 21 died and 16 failed to produce, whereas the unexposed cattle experienced no unusual health problems. In another case, a farmer reported that of 140 head of cattle exposed to fracking wastewater, about 70 died, and there was a high incidence of stillborn and stunted calves in the remaining cattle.⁶⁸⁸
- January 2011 – U.S. Forest Service researchers reported dramatic negative effects on vegetation caused by the drilling and fracking of a natural gas well in an experimental

⁶⁸⁴ Passoth, K. (2014, August 1). Major oil field spill in Kingfisher Co. *KOCO.com Oklahoma City*. Retrieved from <http://www.koco.com/news/major-oil-field-spill-in-kingfisher-county/27236612>

⁶⁸⁵ Finley, B. (2014, May 4). Colorado faces oil boom “death sentence” for soil, eyes microbe fix. *Denver Post*. Retrieved from http://www.denverpost.com/environment/ci_25692049/colorado-faces-oil-boom-death-sentence-soil-eyes

⁶⁸⁶ Royte, E. (2012, November 28). Fracking our food supply. *The Nation*. Retrieved from <http://www.thenation.com/article/171504/fracking-our-food-supply>

⁶⁸⁷ Bamberger, M., & Oswald, R. E. (2012). Impacts of gas drilling on human and animal health. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, 22(1), 51-77. doi: 10.2190/NS.22.1.e

⁶⁸⁸ Ramanujan, K. (2012, March 7). Study suggests hydrofracking is killing farm animals, pets. *Cornell Chronicle*. Retrieved from <http://www.news.cornell.edu/stories/2012/03/reproductive-problems-death-animals-exposed-fracking>

forest in northeastern West Virginia.⁶⁸⁹ In June 2008, the researchers found browning of foliage near the well pad, a lack of ground foliage, and that many trees nearby had dropped their foliage. They attributed these impacts to the loss of control of the wellbore on May 29, 2008, which caused an aerial release of materials from the well. Trees showed no apparent symptoms the following summer.⁶⁹⁰ However, the researchers also found “dramatic impacts on vegetation” where drilling and fracking wastewater had been sprayed on the land as a disposal technique following completion of the well. Just after the spraying of approximately 60,000 gallons of wastewater at the first disposal site, the Forest Service researchers found 115 damaged trees and other evidence of harm. This figure grew to 147 trees almost a year later.⁶⁹¹ At a second site, where about 20,000 gallons of wastewater was sprayed, the damage was less dramatic, yet the researchers still found “considerable leaf browning and mortality of young northern red oak seedlings.”⁶⁹² The researchers concluded that the spraying of the drilling fluids resulted in an “extreme” dose of chlorides to the forest.⁶⁹³

- May 2010 – Pennsylvania’s Department of Agriculture quarantined 28 cows in Tioga County after the animals wandered through a spill of drilling wastewater and may have ingested some of it. The Department was concerned that beef eventually produced from the cows could be contaminated as a result of any exposure. In May 2011, only ten yearlings were still quarantined, but the farmer who owned the cows, Carol Johnson, told National Public Radio that of 17 calves born to the quarantined cows in the spring of 2011, only six survived, and many of the calves that were lost were stillborn. “They were born dead or extremely weak. It’s highly unusual,” she said, continuing, “I might lose one or two calves a year, but I don’t lose eight out of eleven.”⁶⁹⁴

⁶⁸⁹ Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). *Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest* (Rep.). Retrieved from United States Department of Agriculture website: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs76.pdf. (1-4, Rep.).

⁶⁹⁰ Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). *Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest* (Rep.). Retrieved from United States Department of Agriculture website: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs76.pdf. (10-11, Rep.).

⁶⁹¹ Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). *Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest* (Rep.). Retrieved from United States Department of Agriculture website: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs76.pdf. (11-15, Rep.).

⁶⁹² Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). *Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest* (Rep.). Retrieved from United States Department of Agriculture website: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs76.pdf. (15, Rep.).

⁶⁹³ Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). *Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest* (Rep.). Retrieved from United States Department of Agriculture website: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs76.pdf. (17, Rep.).

⁶⁹⁴ Phillips, S. (2011, September 27). Burning questions: Quarantined cows give birth to dead calves. *StateImpact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2011/09/27/burning-questions-quarantined-cows-give-birth-to-dead-calves/>

- March 2010 – A Pennsylvania State Extension analysis of dairy farms in the state found a decline in the number of dairy cows in areas where fracking was prevalent. Pennsylvania counties that had both more than 10,000 dairy cows and more than 150 Marcellus Shale wells experienced a 16-percent decline in dairy cows between 2007 and 2010.⁶⁹⁵
- April 28, 2009 – Seventeen cows in Caddo Parish, Louisiana died within one hour after apparently ingesting hydraulic fracturing fluids spilled at a well that was being fractured. “It seemed obvious the cattle had died acutely from an ingested toxin that had drained from the ‘fracking’ operation going on at the property,” Mike Barrington, a state veterinarian said in a document obtained from the state Department of Environmental Quality by the *Times-Picayune*.^{696, 697}
- August 1977 – A paper in the *Journal of Arboriculture* described how natural gas leaks in soil can damage plants and crops. The paper notes that vegetation dies in the vicinity of natural gas leaks. Due to the oxidation of methane by methane-consuming bacteria, gas leaks drive down the oxygen concentration to extremely low levels and cause carbon dioxide concentration to rise. The resulting low oxygen concentration is the greatest contributing factor in the death of trees and other vegetation near natural gas leaks.⁶⁹⁸

Threats to the climate system

Natural gas is not a climate-friendly fuel. Methane, which leaks from all parts of the natural gas extraction and distribution system, is a powerful greenhouse gas that traps 86 times more heat than carbon dioxide over a 20-year time frame. According to the best available evidence, fuel-switching that replaces coal with natural gas to generate electricity offers, at best, no clear climate benefits and may well represent a step backwards. As is now documented in many studies, fugitive methane emissions from U.S. drilling and fracking operations, storage, and ancillary infrastructure are higher than previously supposed. A significant proportion of these leaks are not preventable through engineering fixes. Total methane emissions increased by more than 30 percent between 2002 and 2014. All together, these studies disprove the claim that natural gas is a transitional “bridge” fuel that can lower greenhouse gas emissions while renewable energy solutions are developed.

As both satellite and ground measurements reveal, U.S. methane emissions are responsible for 30-60 percent of the recent upsurge in global atmospheric methane concentrations. Most of this

⁶⁹⁵ Penn State Extension. (2010, March). *Pennsylvania dairy farms and Marcellus shale, 2007–2010* (Rep.). Retrieved from

<http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PA%20Dairy%20Farms%20and%20Marcellus%202007%20to%202010.pdf>

⁶⁹⁶ Schleifstein, M. (2011, March 27). Haynesville natural gas field is the most productive in the U.S. *The Times-Picayune*. Retrieved from http://www.nola.com/politics/index.ssf/2011/03/haynesville_natural_gas_field.html

⁶⁹⁷ KSLA. (2009, April 28). Cows in Caddo Parish fall dead near gas well. *KSLA News*. Retrieved from <http://www.ksla.com/Global/story.asp?S=10268585>

⁶⁹⁸ Davis, S. H., Jr. (1977). The effect of natural gas on trees and other vegetation. *Journal of Arboriculture*, 3(8),153-154.

excess methane represents fugitive emissions from U.S. oil and gas operations. Many lines of evidence point to the important role of unconventional oil and gas extraction in driving greenhouse gas emissions upward. These include the atmospheric pattern of increased methane concentrations directly over intensively fracked areas of the United States; sharp upticks in global methane and co-occurring ethane levels that correspond to the advent of the U.S. fracking boom; and documentation of large pulses of methane released from storage facilities and other “super-emitting” sites. Further, the widely touted claim that the U.S. fracking boom has contributed to recent declines in carbon dioxide emissions in the United States has been overturned by research showing that almost all of the reductions in CO₂ emissions between 2007 and 2009 were the result of economic recession rather than coal-to-gas fuel switching. Other lines of research show that expanded use of natural gas impedes rather than encourages investments in, and deployment of, renewable energy infrastructure. In sum, fracking, as a major driver of rising methane emissions, is incompatible with climate stability and the goal of rapid decarbonization that it requires.

- October 17, 2017 – Using planes, an international team of researchers measured regional airborne methane and ethane emission rates from the Alberta oil and gas fields in Canada. They compared these results to emissions reported by the industries themselves, as part of an accounting system that requires operators to report flaring and venting volumes, and found large discrepancies. Based on the amounts of methane and ethane detected in the atmosphere above the oil and gas fields, the reported industry emissions in this region should be 2.5 ± 0.5 times higher. Such large discrepancies between actual methane emissions and industry-provided data represent a “reporting gap” and present a critical challenge when determining policy. Proposed regulations in Canada currently call for reducing methane emissions from Canadian fracking operations by 45 percent. However, these data indicate that most of the methane emissions from these operations arise from fugitive leaks that are not being measured at all and/or from episodes of unreported venting.⁶⁹⁹
- July 18, 2017 – A team of 15 climate scientists led by James Hansen at Columbia University conducted a study on the growth rate of greenhouse gas climate forcing, which has accelerated by 20 percent in the past decade. (Climate forcing is the difference between the amount of the sun’s energy that is absorbed by the Earth and amount that radiates back into space.) The authors note that methane (CH₄) is the largest climate-forcing gas after carbon dioxide. With an atmospheric lifetime of only about ten years, “there is potential to reduce climate forcing rapidly if CH₄ sources are reduced.” However, “there is a danger of increased leakage with expanded shale gas extraction.” Noting that the speed of ice sheet melting and sea level rise are difficult to predict, the authors assert that targets for limiting global warming should aim to keep global temperatures close to the preindustrial Holocene range rather than allow them to rise to those found during the prior Eemian period, when sea levels were 6-9 meters higher than today. Such targets require immediate phase-out of fossil fuel emissions, along with

⁶⁹⁹ Johnson, M. R., Tyner D. R., Conley, S., Schwietzke, S., & Zavala-Araiza, D. (2017). Comparisons of airborne measurements and inventory estimates of methane emissions in the Alberta upstream oil and gas sector. *Environmental Science & Technology*. 51(21), 13008–13017. doi: 10.1021/acs.est.7b03525

profound changes in farming and forestry practices. A delay in taking these measures to minimize irreversible climate impacts means that the next generation will be required to undertake risky, expensive, large-scale CO₂ extraction practices, such as carbon capture. “If high fossil fuel emissions continue, a great burden will be placed on the young. . . . Continued high fossil fuel emissions unarguably sentences young people to either a massive, implausible cleanup or growing deleterious climate impacts or both.”⁷⁰⁰

- July 8, 2017 – An investigative report from the Inter Press Service News Agency examined the climate impacts of methane emissions from Mexico, which is sixth among the world’s nations in technically recoverable shale gas reserves (after China, Argentina, Algeria, the United States, and Canada). Mexico’s current energy policy, introduced in 2014, emphasizes the exploitation of shale gas using fracking. Using data from the state-owned energy company Petroleos Mexicanos (PEMEX), the Inter Press Service story documents that as of 2017, more than 900 wells, located in six of Mexico’s 32 states, have been drilled and fracked. High volumes of methane are emitted during venting, and methane emissions have been increasing sharply. In 2016, the total methane emissions from Mexico’s PEMEX Exploration and Production operations were 641,517 metric tons, 38 percent higher than the previous year. According to researcher Ramón Torres, of the National Autonomous University of Mexico, who is quoted in the story, “Current regulations are based on best practices, but the philosophy of environmental protection has been abandoned. Exploitation is deepening inequities in a negative way, such as environmental impact. It is irresponsible to auction reserves without a proper evaluation of environmental and social impacts.”⁷⁰¹
- June 19, 2017 – A study that measured methane emissions from various components of drilling and fracking equipment on well pads located in four different shale basins in Colorado, Utah, Arkansas, and Wyoming found widely varying results. In Colorado and Utah, a small percentage of well pads leaked the vast majority of methane, whereas leakage was more equitably distributed among wells in Wyoming. The research team also found variations that were dependent on oil/gas/water content as well as on the numbers of wells per well pad. In sum, emissions from well pads contributed significantly to basin-wide methane emissions but varied depending on location. [Note: the authors identify XTO Energy as a cost share partner in this study.]⁷⁰²
- April 18, 2017 – San Juan Basin in the four-corner region of Utah, Arizona, New Mexico, and Colorado, is one of the largest coal-bed methane producing regions in North America. Between 2003 and 2015, natural gas production declined, and yet, as revealed by atmospheric sampling from aircraft flying over the basin, methane emissions did not decrease during this same time period. These results confirm earlier findings from a

⁷⁰⁰ Hansen, J., Sato, M., Kharecha, P., von Schuckmann, K., Beerling, D. J., Cao, J. . . . Ruedy, R. (2017). Young people’s burden: Requirement of negative CO₂ emissions. *Earth System Dynamics*, 8, 577-616. doi: 10.5194/esd-8-577-2017

⁷⁰¹ Godoy, E. (2017, July 8). Mexico’s methane emissions threaten the environment. *Inter Press Service News Agency*. Retrieved from <http://www.ipsnews.net/2017/07/mexicos-methane-emissions-threaten-environment/>

⁷⁰² Robertson, A. M., Edie, R., Snare, D., Soltis, J., Field, R. A., Burkhart, M. D., . . . Murphy, S. M. (2017). Variation in methane emission rates from well pads in four oil and gas basins with contrasting production volumes and compositions. *Environmental Science & Technology*, 51(15), 8832–8840. doi: 10.1021/acs.est.7b00571

satellite study that also showed no declines in regional methane concentrations in spite of significant declines in natural gas production. According to the authors, the likely explanation for the region's persistent, elevated methane levels is increased oil drilling in the basin.⁷⁰³

- February 9, 2017 – Using ground-based monitoring methods, a team led by Drexel University researchers monitored a range of emissions, including methane, in two intensively drilled regions of the Marcellus Shale basin in Pennsylvania. The goal was to understand the concentrations and sources of relevant air pollutants that had previously been reported as impacts of drilling and fracking operations. Airborne methane concentrations were higher in southwestern Pennsylvania as compared to northeastern Pennsylvania. The authors conclude that urban-like levels of air pollutants in rural Pennsylvania are likely due to emissions from oil and gas operations in the Marcellus Shale basin.⁷⁰⁴
- January 9, 2017 – A modeling study found that short-lived greenhouse gases, such as methane, contribute to thermal expansion of the ocean over much longer time scales than their brief atmospheric lifetimes might otherwise predict. “Actions taken to reduce emissions of short-lived gases could mitigate centuries of additional future sea-level rise.”⁷⁰⁵
- December 12, 2016 – As part of the interdisciplinary Global Carbon Project, a consortium of scientists undertook a meta-analysis that synthesizes many hundreds of individual studies in order to better understand the global methane cycle. Integrating atmospheric measurements with ground-based data, the researchers found more uncertainty in the emissions from natural sources than from human activities. For the 2003–2012 decade, global methane emissions were 558 teragrams per year (range of 540–568), with 60 percent of global methane emissions attributed to anthropogenic sources of all kinds and with a significant contribution (likely at least 39 percent) from oil and gas production operations.⁷⁰⁶
- December 12, 2016 – An editorial published in *Environmental Research Letters* by an international team of scientists urges immediate attention to quantify and reduce methane emissions. “Unlike CO₂, atmospheric methane concentrations are rising faster than at any time in the past two decades and, since 2014, are now approaching the most greenhouse-gas-intensive scenarios.” The authors present methods of evaluating anthropogenic and

⁷⁰³ Smith, M. L., Gvakharia, A., Kort, E. A., Sweeney, C., Conley, S. A., Faloona, I., ... Wolter, S. (2017). Airborne quantification of methane emissions over the four corners region. *Environmental Science & Technology*, 51(10), 5832–5837. doi: 10.1021/acs.est.6b06107

⁷⁰⁴ Goetz, J. D., Avery, A., Werden, B., Floerchinger, C., Fortner, E. C., Wormhoudt, J., ... DeCarlo, P. F. (2017). Analysis of local-scale background concentrations of methane and other gas-phase species in the Marcellus Shale.. *Elementa: Science of the Anthropocene*, 5(1). doi: <https://doi.org/10.1525/elementa.182>

⁷⁰⁵ Zickfeld, K., Solomon, S., & Gilford, D. M. (2017) Centuries of thermal sea-level rise due to anthropogenic emissions of short-lived greenhouse gases. *Proceedings of the National Academy of Sciences*, 114(4), 657-662. doi: 10.1073/pnas.1612066114

⁷⁰⁶ Saunio, M., Bousquet, P., Poulter, B., Peregon, A., Ciais, P., Canadell, J. G., ... Zhu, Q. (2016). The global methane budget 2000–2012. *Earth System Science Data*, 8, 697–751. doi: 10.5194/essd-8-697-2016

biogenic sources of methane, as from agricultural practices and project future methane emissions.⁷⁰⁷

- November 8, 2016 – The government of Scotland released a report confirming that the pursuit of unconventional oil and gas extraction would make more difficult the nation’s goal of meeting its climate targets on greenhouse gas emissions.⁷⁰⁸
- November 1, 2016 – A life cycle analysis of greenhouse gas emissions from fracking operations in the Marcellus Shale region found that upstream activities associated with the use and transportation of chemicals, water, and sand mining contributed relatively lower emissions than downstream phases of the fracking process, which include gas combustion, methane leakage, venting, and flaring.⁷⁰⁹
- October 5, 2016 – A new inventory of worldwide methane emissions from various sources finds that methane emissions from the fossil fuel industry are 20-60 percent higher than previously thought.⁷¹⁰ This discovery, based on isotopic fingerprinting of methane sources, has prompted researchers to call for revisions to current climate prediction models and for a renewed emphasis on reducing methane emissions as a necessary tool for combating climate change.⁷¹¹
- September 26, 2016 – In ratifying the Paris Climate Agreement, the United States pledged to reduce its greenhouse gas emissions 26-28 percent by 2025 as compared to 2005 levels. A research team from Lawrence Berkeley National Laboratory found that the United States is on track to miss this target, in large part because of soaring methane emissions.^{712, 713}
- September 12, 2016 – Using isotopic analysis and archived air samples collected from 1977 to 1998, as well as more contemporary data, a team of researchers from Oregon presented “strong evidence” that methane emissions from fossil fuel sectors were

⁷⁰⁷ Saunio, M., Jackson, R. B., Bousquet, P., Poulter, B., & Canadell, J.G. (2016). The growing role of methane in anthropogenic climate change. *Environmental Research Letters*, 11, 120207. doi: 10.1088/1748-9326/11/12/120207

⁷⁰⁸ Committee on Climate Change. (2016, November 8). Scottish unconventional oil and gas: Compatibility with Scottish greenhouse gas emissions targets. Retrieved from <http://www.gov.scot/Resource/0050/00509324.pdf>

⁷⁰⁹ Sibrizzi, C., & LaPuma, P. (2016). An assessment of life cycle greenhouse gas emissions associated with the use of water, sand, and chemicals in shale gas production of the Pennsylvania Marcellus Shale. *Journal of Environmental Health*, 79(4), 8-15. Retrieved from <https://www.neha.org/node/58673>

⁷¹⁰ Schwietzke, S., Sherwood, O. A., Bruhwiler, L. M. P., Miller, J. B., Etiope, G., Dlugokencky E. J., . . . Tans, P. P. (2016). Upward revision of global fossil fuel methane emissions based on isotope database. *Nature*, 538. 88-91. doi: 10.1038/nature19797

⁷¹¹ Vaughan, A. (2016, October 5). Fossil fuel industry’s methane emissions far higher than thought. *The Guardian*. Retrieved from <https://www.theguardian.com/environment/2016/oct/05/fossil-fuel-industrys-methane-emissions-far-higher-than-thought>

⁷¹² Greenblatt, J. R., & Wei, M. (2016). Assessment of the climate commitments and additional mitigation policies of the United States. *Nature Climate Change*, 6, 1090-93. doi: 10.1038/nclimate3125

⁷¹³ Mooney, C. (2016, September 26). The U.S. is on course to miss its emissions goals, and one reason is methane. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/09/26/the-u-s-is-on-course-to-miss-its-emissions-goals-and-one-reason-is-methane/?utm_term=.80df24676a21

approximately constant in the 1980s and 1990s but then increased significantly between 2000 and 2009. Over the same time period, methane emissions from biomass burning, rice cultivation, and wetlands decreased. These results contradict the findings of earlier studies that used atmospheric ethane as a marker for methane and had concluded that fugitive fossil fuel emissions fell during much of that period. (More recent studies show that ethane emissions are increasing again.)^{714, 715, 716}

- July 11, 2016 – A group of 130 environmental and health organizations signed a formal complaint with the Inspector General of the U.S. Environmental Protection Agency (EPA) about a pivotal 2013 study that was published in the *Proceedings of the National Academies of Sciences* and which was led by University of Texas chemist David T. Allen. The letter accused Allen of “systemic fraud, waste, and abuse” for his reliance on an inaccurate measurement device that was known to underestimate methane levels. Partially funded by the oil industry, Allen’s study reported very low methane emission rates as part of a large survey of 190 drilling and fracking sites across the nation. That flawed study was influential, said complainants, in preventing EPA from recognizing the magnitude of methane leakage from drilling and fracking operations.⁷¹⁷ (See also the entry below for March 24, 2015.)
- June 17, 2016 – A comparative assessment of emerging methods for measuring methane emissions from different sources recommends combining analytic methods with chemical mass balance (CMB) methods. The CMB system is currently used in the Barnett Shale oil and gas production region in Texas as an approach to tracing methane emissions back to their sources.⁷¹⁸
- May 25, 2016 – As part of the first field study to directly measure methane emissions from the heavily drilled Bakken Shale formation in northwestern North Dakota, a team led by atmospheric chemist Jeff Peischl at the National Oceanic and Atmospheric Administration (NOAA) flew research aircraft over the region in May 2014. The researchers derived a methane emission rate of 275,000 tons of methane per year, which is similar to the rate of methane leakage in the Front Range area of Colorado but significantly lower than previous studies of the Bakken area that relied on satellite remote sensing data during an earlier time period (2006-2011). Analyzing the chemical

⁷¹⁴ Rice, A. L., Butenhoff, C. L., Teama, D. G., Röger, F. H., Khalil, M. A. K., & Rasmussen, R. A. (2016). Atmospheric methane isotopic record favors fossil sources flat in 1980s and 1990s with recent increase. *Proceedings of the National Academy of Sciences*, 113(39). 10791–10796. doi: 10.1073/pnas.1522923113

⁷¹⁵ Harvey, C. (2016, September 13). Scientists may have solved a key mystery about the world’s methane emissions. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/09/13/the-answer-to-the-global-methane-mystery-fossil-fuels-a-study-finds/?utm_term=.64a94b9abf4e

⁷¹⁶ von Kaenel, C. (2016, September 13). Debate rises over real source of higher methane emissions. *Scientific American*. Retrieved from <https://www.scientificamerican.com/article/debate-rises-over-real-source-of-higher-methane-emissions/>

⁷¹⁷ Johnson, J. (2016, July 11). Pivotal study on methane leaks from U.S. oil and natural gas wells under fire. *Chemical & Engineering News*. Retrieved from <http://cen.acs.org/articles/94/i28/Pivotal-study-methane-leaks-US.html>

⁷¹⁸ Allen, D. (2016). Attributing atmospheric methane to anthropogenic emission sources. *Accounts of Chemical Research*, 49, 1344–1350. doi: 10.1021/acs.accounts.6b00081

composition of air samples, the NOAA team determined that almost all of the methane originated with oil and gas operations, rather than with natural or agricultural sources, and estimated a leakage rate of 4.2-8.4 percent.⁷¹⁹ Scaled to production, this emission rate is slightly lower than that estimated by EPA in its recently revised inventory.^{720, 721} (See April 15, 2016 entry below.)

- April 15, 2016 – In its 21st annual greenhouse gas inventory, which includes 2014 data, the EPA increased its leakage assessment from oil and gas operations by 34 percent. For oil production alone, the EPA more than doubled its estimates of methane emissions. Further, in an admission that the agency had been historically underestimating methane leaks, the EPA also retroactively increased estimates of past emissions from the fossil fuel sector as expressed in prior inventories.^{722, 723} In an accompanying news release, the agency said, “Data on oil and gas show that methane emissions from the sector are higher than previously estimated. The oil and gas sector is the largest emitting-sector for methane and accounts for a third of total U.S. methane emissions.”⁷²⁴ Past EPA inventories had identified livestock as the number one source of U.S. methane. These annual inventories fulfill the EPA’s obligations under the United Nations Framework Convention on Climate Change, signed and ratified by the United States in 1992, and attempt to identify and quantify U.S. anthropogenic sources and sinks of greenhouse gases for the time period 1990 and forward. The upward revision in both past and current inventories is a reflection of changing methodologies for measuring methane leaks.⁷²⁵ Older methods included the incorporation of “bottom-up” data supplied by the oil and gas industry, without attention to high-emitting or super-emitting sources or possible sources of error introduced by flawed measuring equipment. In addition, the use of a Global Warming Potential multiplier of 25 for methane, which is based on a 100-year time

⁷¹⁹ Peischl, J., Karion, A., Sweeney, C., Kort, E. A., Smith, M. L., Brandt, A. R., . . . Ryerson, T. B. (2016). Quantifying atmospheric methane emissions from oil and natural gas production in the Bakken shale region of North Dakota. *Journal of Geophysical Research: Atmospheres*, 121. doi: 10.1002/2015JD024631

⁷²⁰ National Oceanic and Atmospheric Administration. (2016, May 16). *North Dakota’s Bakken oil and gas field leaking 275,000 tons of methane per year* [Press release]. Retrieved from <http://www.noaa.gov/news/north-dakota-s-bakken-oil-and-gas-field-leaking-275000-tons-of-methane-year>

⁷²¹ MacPherson, J. (2016, May 11). A new study says the oil-producing region of North Dakota and Montana leaks 275,000 tons of methane annually. *U.S. News & World Report*. Retrieved from <http://www.usnews.com/news/science/articles/2016-05-11/study-bakken-oil-field-leaks-275-000-tons-of-methane-yearly>

⁷²² U.S. Environmental Protection Agency. (2016, April 15). *Inventory of U.S. greenhouse gas emissions and sinks: 1990-2014*. Retrieved from <https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf>

⁷²³ Johnson, J. (2016, April 25). Oil, natural gas operations now top U.S. methane emitters. *Chemical & Engineering News*. Retrieved from <http://cen.acs.org/articles/94/i17/Oil-natural-gas-operations-top.html?type=paidArticleContent>

⁷²⁴ U.S. Environmental Protection Agency. (2016, April 15). *EPA publishes 21st annual U.S. greenhouse gas inventory* [Press release]. Retrieved from <https://www.epa.gov/newsreleases/epa-publishes-21st-annual-us-greenhouse-gas-inventory>

⁷²⁵ Mooney, C. (2016, April 15). The U.S. has been emitting a lot more methane than we thought, says EPA. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/04/15/epa-issues-large-upward-revision-to-u-s-methane-emissions/?utm_term=.eca9c599ff09

horizon, rather than 86 for a 20-year time horizon, has come under sustained criticism given the urgency of the climate crisis.^{726, 727}

- April 7, 2016 – Since 2009, corresponding to the advent of the U.S. shale gas boom, North American ethane emissions have increased by 5 percent per year. This trend represents a reversal of a previous multi-decade decline (mid-1980s until the end of the 2000s) in the abundance of atmospheric ethane that had been attributed to the reduction of fugitive emissions from fossil fuel sources. These are the findings of an international research team, which analyzed remote sensing data gathered by the Network for the Detection of Atmospheric Composition Change at globally distributed ground-based sites. Ethane is a volatile organic compound (VOC) that readily reacts with nitrogen oxides in the presence of sunlight to create ground-level ozone (smog). Also a potent greenhouse gas, ethane is co-released along with methane from drilling and fracking sites. The source of two-thirds of the ethane in Earth’s atmosphere is leakage from natural gas wells and pipelines. Because ethane is co-emitted with methane and can serve as a marker for it, this documentation of a sharp, recent uptick in atmospheric ethane is part of a larger body of evidence suggesting that U.S. drilling and fracking operations are driving up global methane levels.⁷²⁸ (See also entry dated June 13, 2016 in Air Pollution section].)
- April 5, 2016 – A research team using infrared cameras and helicopters demonstrated that between 1 and 14 percent of oil and gas well pads surveyed were high emitters of hydrocarbons and VOCs, with the greatest number observed in oil producing areas and in areas with horizontal drilling.⁷²⁹ While some emissions were intentional or part of routine maintenance operations, fugitive, unplanned releases (as from malfunctioning equipment) were also common, as were combustion emissions (as from flares and compressor engine exhaust). Tank vents and hatches were the origin of the vast majority (>90 percent) of detected large emission sources, deeply undercutting the assumption in the EPA’s Oil & Gas Emission Estimation Tool of 100 percent capture efficiency by tank control systems. While emissions tended to be higher during the first few months of well production, predicting which wells or other sources would become high emitters was not possible. The lead author, speaking to *InsideClimate News*, concluded that the work “really

⁷²⁶ Sumner, T. (2016, April 14). EPA underestimates methane emissions. *ScienceNews*. Retrieved from <https://www.sciencenews.org/article/epa-underestimates-methane-emissions>

⁷²⁷ Profeta, T. (2016, March 3). Study, EPA spotlight methane emissions from oil and gas industry. *National Geographic*. Retrieved from <http://voices.nationalgeographic.com/2016/03/03/study-epa-spotlight-methane-emissions-from-oil-and-gas-industry/>

⁷²⁸ Franco, B., Mahieu, E., Emmons, L. K., Tzompa-Sosa, Z. A., Fischer, E. V., Sudo, K., ... Walker, K. A. (2016). Evaluating ethane and methane emissions associated with the development of oil and natural gas extraction in North America. *Environmental Research Letters*, 11. doi: 10.1088/1748-9326/11/4/044010

⁷²⁹ Lyon, D. R., Alvarez, R. A., Zavala-Araiza, D., Brandt, A. R., Jackson, R. B., & Hamburg, S. P. (2016). Aerial surveys of elevated hydrocarbon emissions from oil and gas production sites. *Environmental Science & Technology*, 50, 4877–4886. doi: 10.1021/acs.est.6b00705

demonstrates the importance of things like continuous detection or frequent monitoring to find these high emission sites.”⁷³⁰

- March 10, 2016 – Attempting to explain a methane plateau between 1999 and 2006 within otherwise almost continuously increasing levels of atmospheric methane since the dawn of the industrial revolution, an international team of atmospheric scientists reconstructed the global history of methane and used isotopic carbon fingerprinting to parse the sources of its emission. Thermogenic emissions were assumed to result from fossil-fuel sources, while biogenic sources were assumed to arise from wetlands and agricultural operations. Based on a geographic distribution of methane revealed by remote sensing, the authors concluded that agricultural emissions, especially increases in livestock inventories and rice cultivation, were the most likely drivers of observed global methane increases from 2006 to 2014.⁷³¹ These results stand in contrast to other contemporaneous and recent studies that have supplied evidence for the role of oil and gas extraction in the recent upsurge in atmospheric methane.⁷³² (See entry for February 16, 2016 below.)
- February 16, 2016 – A Harvard-led team used both satellite retrievals and surface observations to estimate that methane emissions in the United States increased by more than 30 percent over the past twelve years. These findings, which contradict the 10 percent decline reported by the EPA, suggest that the United States could be responsible for 30-60 percent of the recent global spike in atmospheric methane.^{733, 734} Since 2015, research on atmospheric methane has frequently relied on an “inverse method” to optimize emission estimates by combining “bottom-up” and “top-down” data, yet data from different sources have not yielded consistent estimates of methane emissions and levels. Three major sources (Wecht et al. [2014], Miller et al. [2013], and Turner et al. [2015]) all found maximum emissions in the South Central United States, with spatial overlaps that made separating livestock sources from oil and gas sources difficult. Taking into account the time period investigated by differing studies reveals an increasing trend in methane emissions, with an increase of 38 percent from 2004 to 2011, a period of greatly increasing drilling activity. This trend is confirmed by analyzing temporal trends in satellite data. While this account still differs from the EPA’s inventory in 2014 showing a 3 percent decrease in oil and gas emissions over that same time period, the

⁷³⁰ McKenna, P. (2016, April 8). Researchers find no shortcuts for spotting wells that leak the most methane. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/07042016/big-methane-leaks-superemitters-oil-gas-production-climate-change-edf>

⁷³¹ Schaefer, H., Fletcher, S. E. M., Veidt, C., Lassey, K. R., Brailsford, G. W., Bromley, T. M., . . . White, J. W. C. (2016, March 10). A 21st century shift from fossil-fuel to biogenic methane emissions indicated by ¹³CH₄. *Science*. doi: 10.1126/science.aad2705

⁷³² McKenna, P. (2016, March 10). The mystery of the global methane rise: Asian agriculture or U.S. fracking? *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/10032016/mysterious-global-methane-rise-asian-agriculture-or-us-fracking>

⁷³³ Turner, A. J., Jacob, D. J., Benmergui, J., Wofsy, S. C., Maasackers, J. D., Butz, A., . . . Biraud, S. C. (2016). A large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations. *Geophysical Research Letters*, 43. doi: 10.1002/2016GL067987

⁷³⁴ Magill, B. (2016, February, 16). Study ties U.S. to spike in global methane emissions. *Climate Central*. Retrieved from <http://www.climatecentral.org/news/us-60-percent-of-global-methane-growth-20037>

EPA's data presumed better control of measured leaks, which may not correlate with better control of overall emissions.

- January 29, 2016 – Working in the Marcellus Shale Basin, a Carnegie Mellon research team compared methane emissions from older conventional gas wells (those that were vertically drilled) and newer, unconventional gas wells (those that combined fracking with horizontal drilling). Measured by facility, the mean emission rate for unconventional wells was 23 times higher than that of conventional wells. This difference, in part, was attributed to the larger size of unconventional well pads, which, typically, have multiple wells per pad, more ancillary equipment, and produce more gas. When corrected for production, the conventional wells leaked more—that is to say, they lost a comparably larger fraction of methane per unit of production—likely due to “unresolved equipment maintenance issues.” All together, the authors concluded, these new emissions data show that the recently instituted Pennsylvania Department of Environmental Protection’s (PA DEP) methane emissions inventory substantially underestimates facility-level methane emissions. Five unconventional well sites included in this study leaked 10-37 times more methane than estimated in the state inventory.⁷³⁵
- January 25, 2016 – Cornell University scientists introduced an innovative methodology for assessing potential climate impacts of alternative choices and used it to demonstrate that emissions of the two most important greenhouse gases (carbon dioxide and methane), calculated as time-integrated radiative forcing, are lower with heat pump water heaters than any other means of heating water. Further, their calculations showed that heat pump water heaters powered by coal-generated electricity achieve greater net climatic benefit than heaters powered by natural gas, while even greater benefits may be achieved by combining heat pump water heaters with electricity generated by renewable sources. The authors proposed and justified a methane emission rate of 3.8 percent for conventional shale gas, which is therefore offered as a lower bound for future, tightly controlled methane emissions from unconventional gas activities. The authors also made their web-based tool for evaluating the greenhouse gas footprint of reference and alternative technologies and its source code available to the public (at <http://www.eeb.cornell.edu/howarth/methane/tool.htm>).⁷³⁶
- December 22, 2015 – To reconcile troubling divergences in published estimates of methane emissions, in which “top-down” estimates, based on atmospheric or satellite sampling, often exceed “bottom-up” estimates, based on ground-level sampling or individual source reports, researchers used a combination of repeated mass balance measurements plus ethane fingerprinting to improve top-down estimates and incorporated a more complete and detailed count of facilities to improve bottom-up estimates.⁷³⁷ The

⁷³⁵ Omara, M., Sullivan, M. R., Li, X., Subramanian, R., Robinson, A. L., & Presto, A. A. (2016). Methane emissions from conventional and unconventional natural gas production sites in the Marcellus Shale Basin. *Environmental Science & Technology*, 50. doi: 10.1021/acs.est.5b05503

⁷³⁶ Hong, B. & Howarth, R. W. (2016). Greenhouse gas emissions from domestic hot water: Heat pumps compared to most commonly used systems. *Energy Science & Engineering*, 4(2), 123-133. doi: 10.1002/ese3.112

⁷³⁷ Zavala-Araiza, D., Lyon, D. R., Alvarez, R. A., Davis, K. J., Harriss, R. Herndon, S. C., . . . Hamburg, S. P. (2015). Reconciling divergent estimates of oil and gas methane emissions. *Proceedings of the National Academies of Science*, 112(51), 15597-15602. doi: 10.1073/pnas.1522126112

results, as demonstrated in the Barnett Shale oil and gas-producing region of Texas, revealed a convergence of estimates to within 10 percent for fossil methane and 0.1 percent for total methane, with predicted methane emissions 90 percent larger than those estimated by the EPA's Greenhouse Gas Inventory. Exclusion of additional problematic studies might have resulted in even greater convergence and higher estimates.⁷³⁸ The agreement between top-down and bottom-up estimates demonstrates that well-designed surveys using either approach can be useful, with spatially resolved bottom-up estimates pointing toward production sites as the source of 53 percent of emissions, compressor stations 31 percent of emissions, and processing plants 13 percent of emissions. The Barnett shale emission rate of 1.5 percent calculated in this study is low enough (less than 3 percent) to suggest that gas fired electricity production in this region causes less climate forcing than coal-fired electricity, but it is high enough (greater than 1 percent) to argue against the conversion of diesel powered freight trucks to compressed natural gas. Gas production practices and heavier activity in other basins may lead to higher emission rates, as may the storage and long-distance or very long-distance transmission of natural gas.

- December 22, 2015 – Writing for *Environment & Energy Publishing*, journalist Gayathri Valdyanathan reported on efforts by climate scientists to convince the United Nations to stop expressing the heat-trapping potential of methane over a 100-year time frame and instead use a twenty-year time frame when generating global warming potential, the conversion factor that allows policymakers to compare methane's ability to trap heat with that of carbon dioxide. Methane is a far more potent heat-trapping gas than is carbon dioxide, but it is also shorter lived. By convention, policymakers have used a 100-year time frame when calculating global warming potentials. However, there is no scientific reason to do so, and many scientific critics argue that choosing this time scale veils the true climate impacts of natural gas and “makes the gas appear more benign than it is.”⁷³⁹
- November 25, 2015 – Using reports from countries and companies with proved reserves of recoverable oil, natural gas, and coal, an analysis published in *Global Environmental Change* shows that full production of these resources would use up 160 percent of the world's estimated remaining carbon budget (designed to restrict anthropogenic climate change to equal to or less than 2° C). While 76 percent of reserves are owned by states or state entities, the relatively smaller amount of reserves owned by investors poses the greater immediate threat, since those companies are more likely poised to produce, refine, and deliver fossil fuels to global markets in the near term. However, exploitation of existing proved reserves controlled by the private sector alone does not lead to warming above the 2° limit, if it is not accompanied by exploration for and development of new reserves. Future considerations of fossil fuel use should focus not only on reducing private sector contributions but also on reducing contributions from countries that have

⁷³⁸ Song, L. (2015, December 7). Texas fracking zone emits 90% more methane than EPA estimated. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/07122015/methane-emissions-texas-fracking-zone-90-higher-epa-estimate>

⁷³⁹ Vaidyanathan, G. (2015, December 22). Recalculation of leaking methane impacts may affect natural gas market. *E&E Publishing, LLC*. Retrieved from <http://www.eenews.net/stories/1060029873>

historically dominated or currently dominate emissions, and especially nation-states with large undeveloped reserves.⁷⁴⁰

- November 9, 2015 – Including data available through 2014, the World Meteorological Organization (WMO) reported that globally averaged levels of carbon dioxide, methane, and nitrous oxide reached new highs in 2014, with values, respectively, “143%, 254% and 121% of pre-industrial (1750) levels.”^{741, 742} While the atmospheric increase in carbon dioxide has slowed, methane and nitrous oxide levels continue to increase. Measurements from the WMO’s Global Watch Programme point to wetlands in the tropics and anthropogenic sources at mid-latitudes of the northern hemisphere as the sources of increased methane over the past decade.
- October 8, 2015 – As a foundation for policy recommendations, Cornell University biogeochemist Robert Howarth summarized and analyzed the evidence documenting the magnitude of methane emissions related to oil and gas development in the United States since 2007. With estimated emission rates ranging from 3.8-12 percent, the high radiative forcing of methane over a twenty-year period prevents natural gas from serving as a bridge fuel. Instead of further investments in natural gas, Howarth proposes a rapid transition to electric powered vehicles for transportation, high-efficiency heat pumps for space and water heating, and imposition of a methane tax that is roughly 86 times higher than currently proposed carbon taxes, which typically address only carbon dioxide.⁷⁴³ Howarth also noted that the EPA “has seriously underestimated the importance of methane emissions in general—and from shale gas in particular.”⁷⁴⁴
- August 4, 2015 – A developer of high flow sampling technology determined that a commonly used instrument to quantify methane leakage has unreliable sensors and malfunctions in ways that vastly underreport emissions by factors of three to five. More than 40 percent of the compiled national methane inventory may be affected by this measurement failure, according to the author of this study.⁷⁴⁵ The implications of this discovery for our understanding of system-wide methane leakage rates from drilling and fracking operations are not known, but they do call into question the results of at least one major study of methane emissions that relied on this device for collecting data. This

⁷⁴⁰ Heede, R. & Oreskes, N. (2015). Potential emissions of CO₂ and methane from proved reserves of fossil fuels: An alternative analysis. *Global Environmental Change*, 36. Advance online publication. Retrieved from <http://dx.doi.org/10.1016/j.gloenvcha.2015.10.005>

⁷⁴¹ World Meteorological Organization. (2015, November 9). The state of greenhouse gases in the atmosphere based on global observations through 2014. *Greenhouse Gas Bulletin*, 11. Retrieved from http://scifun.chem.wisc.edu/news/ghg-bulletin_2015.pdf?id=8495

⁷⁴² Miles, T. (2015, November 9). CO₂ levels hit record high for 30th year in a row. *Scientific American*. Retrieved from <https://www.scientificamerican.com/article/co2-levels-hit-record-high-for-30th-year-in-a-row/>

⁷⁴³ Howarth, R. W. (2015). Methane emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy. *Energy and Emission Control Technologies*, 3, 45-54. doi: <https://dx.doi.org/10.2147/EECT.S61539>

⁷⁴⁴ Hauser, A. (2015, October 21). Two studies highlight risks of fracking-released methane. *Weather.com*. Retrieved from <https://weather.com/science/environment/news/studies-highlight-risks-of-methane-from-fracking>

⁷⁴⁵ Howard, T. (2015). University of Texas study underestimates national methane emissions at natural gas production sites due to instrument sensor failure. *Energy Science & Engineering*. Advance online publication. doi: 10.1002/ese3.81

is the second of two studies that finds that the primary tool approved by the U.S. EPA for measuring and reporting emissions of methane fails to function properly when used as directed by the manufacturer. (See also entry below dated March 24, 2015.)

- July 21, 2015 – An international team of researchers investigated the claim that the fracking boom, which has dramatically increased supplies of natural gas in the United States, is the main driver of the modest decline in carbon dioxide emissions since 2007. Conventional wisdom, as expressed by the Third National Climate Assessment of the U.S. Global Change Research Program, attributes the drop in emissions to a shift away from carbon dioxide-intensive coal and toward natural gas in power plants. But this team analyzed the sources of change in carbon dioxide emissions and, using a tool called input-output structural decomposition analysis, documented that the economic downturn, not fuel switching in the power sector, was the explanation for declining carbon dioxide emissions since 2007. The single biggest impact on U.S. emissions was changes in the volume of goods and services consumed. Between 2007 and 2013, driven by a huge drop in the volume of capital investment, emissions associated with capital formation decreased by almost 25 percent. During the same period, emissions related to household consumption decreased by 11 percent.⁷⁴⁶
- July 7, 2015 – A scientific opinion piece by Environmental Defense Fund researchers involved in a group of 11 studies on methane emissions in Texas’ Barnett Shale provided an overview and orientation to new research that either measured or estimated methane emissions from oil and gas operations. Research from both top-down estimates (based on measuring atmospheric methane or related compounds at regional or larger scales) and bottom-up measurements (made directly from components or at ground level near studied sites) demonstrated that methane emissions from oil and gas operations in the Barnett Shale region exceeded the emissions expected from the EPA’s greenhouse gas inventory, which relies on industry self-reporting and excludes many compressor stations. The new research detailed the importance of addressing high-emitting landfills and natural gas facilities (“super-emitters”) and malfunctioning equipment in efforts to control ongoing methane emissions.⁷⁴⁷
- May 28, 2015 – A comprehensive working paper from the New Climate Economy initiative of the Global Commission on the Economy and Climate at Stockholm Environment Institute found that the experience in the United States of substituting natural gas for oil was unlikely to be replicated around the globe and probably will not provide climate benefits unless coupled with strict controls on methane leakage, limits on total energy use, and policies to prevent the displacement of non-fossil fuel energy by methane. Citing multiple studies of the net climate impact of “more abundant, cheaper natural gas supplies,” the Commission concluded that “both globally and for the United States, the increase in emissions from the scale effect [from increased energy

⁷⁴⁶ Feng, K., Davis, S. J., Sun, L., & Hubacek, K. (2015). Drivers of the US CO₂ emissions 1997-2013. *Nature Communications*, 6. doi: 10.1038/ncomms8714

⁷⁴⁷ Harriss, R., Alvarez, R.A., Lyon, D., Zavala-Araiza, D., Nelson, D. & Hamburg, S.P. (2015). Using multi-scale measurements to improve methane emission estimates from oil and gas operations in the Barnett Shale Region, Texas. *Environmental Science & Technology*, 49, 7524-7526. doi: 10.1021/acs.est.5b02305

consumption boosted by cheap natural gas and loss of potentially more expensive lower carbon approaches] fully offsets the emission benefits from the substitution effect, net of methane leakage.”^{748, 749}

- March 24, 2015 – A University of Cincinnati researcher and independent engineers documented that the Bacharach Hi-Flow Sampler (BHFS)—one of the only tools approved by the EPA for measuring and reporting emissions of methane from natural gas transmission, storage, and processing facilities—failed to function properly when used as indicated by the manufacturer. The BHFS, unless recalibrated daily and running revised software (or taking measurements in a nearly pure methane environment, which is exceedingly rare in the field), misreported high levels of natural gas by as much as an order of magnitude lower than actual concentration. A reanalysis of 2011 results from the City of Fort Worth Air Quality Study revealed at least seven instances for which the BHFS indicated sample concentrations at or below 5 percent when more reliable canister methane readings indicated concentrations that ranged from 6.1 percent to 90.4 percent. Inaccurate measurements like these can contribute to the discrepancy between “top-down” and “bottom-up” measurements of methane, with ground-level measurements from the BHFS potentially producing reports of falsely low emissions.⁷⁵⁰ This study was followed by another that further documented malfunctions in the BHFS device and called into question the results of a landmark 2013 survey of methane emissions at 190 drilling and fracking sites across the United States. That 2013 survey, from the University of Texas, relied on the BHFS device for collecting data and found very low leakage rates.⁷⁵¹ (See also entry above dated August 4, 2015.)
- March 20, 2015 – A team led by Bruno Franco from the University of Liege in Belgium discovered an abrupt uptick in ethane levels at a mountaintop station in the Swiss Alps that is far removed from local pollution sources.⁷⁵² In a later comment about this discovery, Franco said, “Since 2009, we observed increases of 5% per year here—it was completely unexpected.”⁷⁵³ The team attributed the trend reversal to the natural gas boom

⁷⁴⁸ Lazarus, M., Tempest, K., Klevnäs, P., & Korsbakken, J. I. (2015) Natural gas: Guardrails for a potential climate bridge. Stockholm Environment Institute. Retrieved from <http://www.sei-international.org/mediamanager/documents/Publications/Climate/NCE-SEI-2015-Natural-gas-guardrails-climate-bridge.pdf>

⁷⁴⁹ Evans, S. (2015, June 2). The climate benefits of a gas bridge are unlikely to be significant. *Climate Spectator*. Retrieved from <http://www.businessspectator.com.au/article/2015/6/2/policy-politics/climate-benefits-gas-bridge-are-unlikely-be-significant>

⁷⁵⁰ Howard, T., Ferrara, T., & Townsend-Small, A. (2015). Sensor transition failure in the high flow sampler: Implications for methane emission inventories of natural gas infrastructure. *Journal of the Air & Waste Management Association*, 65(7), 856-862. doi: 10.1080/10962247.2015.1025925

⁷⁵¹ Allen, D. T., Torres, V. M., Thomas, J., Sullivan, D.W., Harrison, M., Hendler, A., . . . Seinfeld, J. H. (2013). Measurements of methane emissions at natural gas production sites in the United States. *Proceedings of the National Academy of Sciences*, 110,17768–17773. doi: 10.1073/pnas.1304880110

⁷⁵² Franco, B., Bader, W., Toon, G. C., Bray, C., Perrin, A., Fischer, E. V., . . . & Mahieu, E. (2015). Retrieval of ethane from ground-based FTIR solar spectra using improved spectroscopy: recent burden increase above Jungfrauoch. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 160, 36-49. <http://dx.doi.org/10.1016/j.jqsrt.2015.03.017>

⁷⁵³ Environmental Research Web. (2016, May 23). Ethane emissions back on the rise. Retrieved from <http://environmentalresearchweb.org/cws/article/news/65093>

in North America. Ethane is released together with methane from drilling and fracking operations and serves as a proxy for it. (See also the entry above for April 7, 2016.)

- March 9, 2015 – With specialized equipment in a mobile van, University of Colorado, the National Oceanic and Atmospheric Administration (NOAA), Environmental Defense Fund, and independent researchers continuously measured methane and ethane from public roads at sites downwind of potential emission sources, such as natural gas production wellheads, processing plants, and compressor stations. The sampling method and modeling allowed capture of multiple “accidental” plumes, acquired during long drives across the study region between planned measurements near large facilities. Sampling was not random but documented a large number of facilities with low methane emission rates (equal to or less than 10 kg/hr), with a smaller yet important number of facilities showing much higher emissions. Although the largest measured emission in this study (1,360 kg/hr) corresponded to approximately \$1.2 million in lost revenue per year, the authors noted that, in this industry, the “leak fraction” or “proportional loss” levels they documented would generally translate into only a small proportion of lost revenue, probably not sufficient to prompt strong energy-sector self-regulation.⁷⁵⁴
- March 1, 2015 – Using a simulation model, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, writing for Germany’s Federal Environmental Agency, found that shale gas was not a cheap option to reduce global greenhouse gas emissions. Multiple comparison simulations found that shale gas availability, especially in the short-term, tends to lead to higher emissions due to lower energy prices inducing higher use. The net result is higher costs to achieve compliance with climate targets. In this model, shale gas was also found to compete in an unhelpful way with renewable energy sources, resulting in reduced use of renewable energy sources and reduced investment in energy efficiency measures.⁷⁵⁵
- January 8, 2015 – Using a single integrated modeling program that incorporates detailed estimates of the world’s reserves of oil, gas, and coal and is consistent with a wide variety of prior modeling approaches, University College London researchers demonstrated that, around the world, “a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050” in order to meet a target of less than or equal to a 2 degree Celsius rise in global temperature. In addition, “development of resources in the Arctic and any increase in unconventional oil production are incommensurate with efforts to limit average global warming” below the 2 degree threshold. Calling for a “stark transformation” of our understanding of fossil fuel availability, the authors noted that, in a climate-constrained world, fears of scarcity of

⁷⁵⁴ Yacovitch, T. I., Herndon, S. C., Pétron, G., Kofler, J., Lyon, D., Zahniser, M. S., & Kolb, C. E. (2015). Mobile laboratory observations of methane emissions in the Barnett Shale Region. *Environmental Science & Technology*, 49, 7889–7895. doi: 10.1021/es506352j

⁷⁵⁵ Kersting, J., Duscha, V., Schleich, J., & Keramidas, K. (2015). The impact of shale gas on the costs of climate policy. Environmental Research of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. Retrieved from https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_03_2015_the_impact_of_shale_gas_1.pdf

fossil fuels must be superseded by a commitment to preventing overuse of existing resources and reserves.⁷⁵⁶

- November 26, 2014 – Stanford University and independent researchers compared coal and natural gas for power generation and concluded that the question of “whether natural gas plants are better than coal plants cannot be answered in the general case.” During the period of plant operation, “natural gas plants can produce greater near-term warming than coal plants, with the same power output.” They found that over time, natural gas plants can produce some reduction in near-term warming, but only if life cycle methane leakage rates are low and power plant efficiency is high. Relative to coal, there is the potential that “deployment of natural gas power plants could both produce excess near-term warming (if methane leakage rates are high) and produce excess long-term warming (if the deployment of natural gas plants today delays the transition to near-zero emission technologies).”⁷⁵⁷
- October 23, 2014 – Adding to the debate about natural gas and climate change, a multi-center, international research team used a sophisticated, integrated approach to the global energy-economy-climate systems question and found no climate benefit to natural gas over other fossil fuels. As summarized by the editor of *Nature*,

The development of hydraulic fracturing technologies has led to rapid growth in the use of natural gas as an energy source. Some evidence has suggested that this growing adoption of natural gas might lead a reduced greenhouse gas burden and consequent mitigation of climate change. This collaboration between five energy–climate modelling teams show that instead—under a scenario of abundant natural gas availability—increased consumption will have little or no impact on climate change.” The authors concluded, “although market penetration of globally abundant gas may substantially change the future energy system, it is not necessarily an effective substitute for climate change mitigation policy.”⁷⁵⁸

- October 6, 2014 – Utilizing satellite data for the Bakken and Eagle Ford formations, scientists from Germany, the United Kingdom, and the University of Maryland confirmed that higher “top-down” estimates of fugitive methane leaks from oil and gas fields (which are obtained via tall tower flask samples, aircraft measurements, and road surveys) are more accurate than lower “bottom-up” estimates (which are obtained by summing emissions from different types of known sources at sites provided by participating utility companies). According to “bottom-up” estimates, the average U.S. leakage rate ranges from 1.2-2.0 percent. But satellite data show much higher leakage rates: 10.1 percent (± 7.3 percent) and 9.1 percent (± 6.2 percent), for the Bakken and Eagle Ford formations, respectively. These higher estimates indicate that current

⁷⁵⁶ McGlade, C., & Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2°C. *Nature*, 517, 187-190. doi: 10.1038/nature14016

⁷⁵⁷ Zhang, X., Myhrvold, N. P., & Caldeira, K. (2014). Key factors for assessing climate benefits of natural gas versus coal electricity generation. *Environmental Research Letters*, 9. doi: 10.1088/1748-9326/9/11/114022

⁷⁵⁸ McJeon, H., Edmonds, J., Bauer, N., Clarke, L., Fisher, B., Flannery, B., . . . Tavoni, M. (2013). Limited impact on decadal-scale climate change from increased use of natural gas. *Nature*, 514, 482–485. doi: 10.1038/nature13837

inventories likely underestimate fugitive emissions and call into question any immediate climate benefit from switching from coal to natural gas. Similar results were seen for the Marcellus shale region, but as a result of technical and geographical limitations, the authors declined to quantify their results, pending future studies with enhanced equipment.⁷⁵⁹

- September 24, 2014 – According to a paper published by scientists from the University of California and Stanford University, “... without strong limits on [greenhouse gas] emissions or policies that explicitly encourage renewable electricity, abundant natural gas may actually slow the process of decarbonization, primarily by delaying deployment of renewable energy technologies.” The study builds on previous research by examining natural gas in a range of supply curves, with a tested economic model, and across three different types and levels of climate policy. Researchers found that abundant natural gas, even with low rates of methane leakage, does little to reduce—and may increase—greenhouse gases. They conclude that delaying deployment of renewable energy technologies “may actually exacerbate the climate change problem in the long term.”⁷⁶⁰
- September 2, 2014 – Analyzing the level of greenhouse gas emissions attributable to electricity from natural-gas-fired power plants and coal-fired power plants, economist Chris Busch and physicist Eric Gimon conclude that, over short time frames and at high rates of leakage, natural gas offers little benefit compared to coal and could exacerbate global warming. Although Busch and Gimon acknowledge that natural gas offers some reductions in greenhouse gas emissions over longer time frames, they point out that such reductions are not large enough for natural gas to play an expanded role in efforts to manage emissions. They conclude that under the best of circumstances, natural gas-fired electric power offers a modest benefit toward abating climate change, while if poorly developed (i.e., with extensive methane leaks, estimated by these authors to be on the order of 4 percent or higher), or if used to displace energy efficiency or renewable energy, natural gas could seriously contribute to increased greenhouse gas emissions.⁷⁶¹
- August 5, 2014 – Reporting in *Scientific American*, the science news organization Climate Central outlined the natural gas-related factors that threaten any ability to achieve climate goals through the proposed Clean Power Plan. “No one has any idea how much methane is leaking from our sprawling and growing natural gas system. This is a major problem, because without a precise understanding of the leak rate natural gas could actually make climate change worse.” Referring to an interactive Climate Central tool that runs various methane leakage scenarios, the article notes that, even given modest leak rates and an aggressive transition, “we could still end up with little or no climate

⁷⁵⁹ Schneising, O., Burrows, J. P., Dickerson, R. R., Buchwitz, M., Reuter, M., & Bovensmann, H. (2014). Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations. *Earth's Future*, 2(10), 548–558. doi: 10.1002/2014EF000265

⁷⁶⁰ Shearer, C., Bistline, J., Inman, M., & Davis, S. J. (2014). The effect of natural gas supply on US renewable energy and CO2 emissions. *Environmental Research Letters*, 9. doi: 10.1088/1748-9326/9/9/094008

⁷⁶¹ Busch, C. & Gimon, E. (2014). Natural gas versus coal: Is natural gas better for the climate. *The Electricity Journal*, 27(7), 97-111.

benefits by 2030 after an enormous financial and political investment in natural gas.”⁷⁶²

- July 25, 2014 –EPA’s Office of Inspector General reports that the agency “has placed little focus and attention on reducing methane emissions from pipelines in the natural gas distribution sector.” According to this report, the EPA acknowledged in 2012 that leaks from natural gas pipelines “accounted for more than 13 million metric tons of carbon dioxide equivalent emissions,” are almost 100 percent methane, and represent more than 10 percent of total methane emissions from natural gas systems in the United States. Nevertheless, as report went on to note, the EPA does not have the partnerships in place to begin controlling methane leaks, such as with the Pipeline and Hazardous Materials Safety Administration, nor has it conducted a comprehensive analysis of emissions factors, relying instead on a 1996 study with a “high level of uncertainty.”⁷⁶³
- May 15, 2014 – A recent review of existing data on life cycle emissions of methane from natural gas systems concluded that, as a strategy for addressing climate change, natural gas is a “bridge to nowhere.” The review found that, over a 20-year time frame, natural gas is as bad as or worse than coal and oil as a driver of climate change.⁷⁶⁴ Referencing this review and other recent studies, *Bloomberg Business News* reported that the EPA has underestimated the impact of methane leakage resulting from the production, transmission, and distribution of natural gas and is using outdated estimates of methane’s potency compared to more recent estimates from the Intergovernmental Panel on Climate Change (IPCC).⁷⁶⁵
- April 25, 2014 – A reassessment of the heat-trapping potential of greenhouse gases revealed that current methods of accounting underestimate the climate-damaging impact of methane pollution from all sources, including drilling and fracking operations.⁷⁶⁶
- April 14, 2014 – A study from researchers at Purdue University, NOAA, Cornell University, University of Colorado at Boulder, and Pennsylvania State University, published in *Proceedings of the National Academy of Sciences* found very high levels of methane emissions above many wells being drilled at fracking sites in Pennsylvania.

⁷⁶² Climate Central. (2014, August 5). Methane leak rate proves key to climate change goals. *Scientific American*. Retrieved from <http://www.scientificamerican.com/article/methane-leak-rate-proves-key-to-climate-change-goals/>

⁷⁶³ U.S. Environmental Protection Agency Office of Inspector General. (2014, July 25). *Improvements needed in EPA efforts to address methane emissions from natural gas distribution pipelines*. Report No. 14-P-0324. Retrieved from <http://www.epa.gov/oig/reports/2014/20140725-14-P-0324.pdf>

⁷⁶⁴ Howarth, R. W. (2014). A bridge to nowhere: Methane emissions and the greenhouse gas footprint of natural gas [Abstract]. *Energy Science & Engineering*. doi: 10.1002/ese3.35

⁷⁶⁵ Childers, A. (2014, May 9). EPA underestimates fracking's impact on climate change. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2014-05-09/epa-underestimates-fracking-s-impact-on-climate-change.html>

⁷⁶⁶ Edwards, M. R. & Trancik, J. E. (2014). Climate impacts of energy technologies depend on emissions timing. *Nature Climate Change*, 4, 348-352. doi: 10.1038/NCLIMATE2204

Levels were 100-1,000 times above the estimates of federal regulators, who have always assumed very low methane emissions as wells are drilled.^{767, 768}

- February 26, 2014 – The United Nations’ top environmental official, Achim Steiner, argued that the shale gas rush is “a liability” in efforts to slow climate change and that a switch from coal to natural gas is delaying critical energy transition to renewables.⁷⁶⁹
- February 13, 2014 – A major study in *Science* by Stanford University, Massachusetts Institute of Technology, and the U.S. Department of Energy found that methane leaks negate any climate benefits of natural gas as a fuel for vehicles, and that the EPA is significantly underestimating methane in the atmosphere.⁷⁷⁰ Lead author Adam R. Brandt told the *New York Times*, “Switching from diesel to natural gas, that’s not a good policy from a climate perspective.”⁷⁷¹ This study also concluded that the national methane leakage rate is likely between 3.6 and 7.2 percent of production.
- January 15, 2014 – As reported by the *Guardian*, a new study by BP concluded that shale gas “...will not cause a decline in greenhouse gases” and will do little to cut carbon emissions.⁷⁷²
- December 30, 2013 – An analysis of fracking-related truck transportation in the Susquehanna River Basin in Pennsylvania found that greenhouse gas emissions from frack water and waste hauling operations were 70-157 metric tons of CO₂ equivalent per gas well.⁷⁷³
- November 11, 2013 – In a letter to California Governor Jerry Brown, twenty of the nation’s top climate scientists warned that pro-fracking policies will worsen climate disruption and harm California’s efforts to be a leader in reducing greenhouse gas

⁷⁶⁷ Caulton, D. R., Shepson, P. B., Santoro, R. L., Sparks, J. P., Howarth, R. W., Ingraffea, A. R., . . . Miller, B. R. (2014). Toward a better understanding and quantification of methane emissions from shale gas development. *Proceedings of the National Academy of Sciences of the United States of America*. doi: 10.1073/pnas.1316546111

⁷⁶⁸ Banjeree, N. (2014, April 14). EPA drastically underestimates methane released at drilling sites. *Los Angeles Times*. Retrieved from <http://www.latimes.com/science/sciencenow/la-sci-sn-methane-emissions-natural-gas-fracking-20140414,0,2417418.story>

⁷⁶⁹ Goldenberg, S. (2014, February 26). Achim Steiner: Shale gas rush “a liability” in efforts slow climate change. *Guardian*. Retrieved from <http://www.theguardian.com/environment/2014/feb/26/achim-steiner-shale-gas-rush-climate-change-energy>

⁷⁷⁰ Brandt, A. R., Heath, G. A., Kort, E. A., O’Sullivan, F., Petron, G., Jordaan, S. M., . . . Harriss, R. (2014). Methane leaks from North American natural gas systems. *Energy and Environment*, 343(6172), 733-735. doi: 10.1126/science.1247045

⁷⁷¹ Davenport, C. (2014, February 13). Study finds methane leaks negate benefits of natural gas as a fuel for vehicles. *The New York Times*. Retrieved from <http://www.nytimes.com/2014/02/14/us/study-finds-methane-leaks-negate-climate-benefits-of-natural-gas.html?smid=tw-share>

⁷⁷² Harvey, F., & Macalister, T. (2014, January 16). BP study predicts greenhouse emissions will rise by almost a third in 20 years. *The Guardian*. Retrieved from http://www.theguardian.com/business/2014/jan/15/bp-predicts-greenhouse-emissions-rise-third?CMP=tw_t_gu

⁷⁷³ Gilmore, K. R., Hupp, R. L., & Glathar, J. (2014). Transport of Hydraulic Fracturing Water and Wastes in the Susquehanna River Basin, Pennsylvania. *Journal of Environmental Engineering*, 140. doi: 10.1061/(ASCE)EE.1943-7870.0000810

emissions. The letter called on Governor Brown to place a moratorium on fracking.⁷⁷⁴ On November 21, 2013, a group of Governor Brown's former policy and campaign advisors made a similar request in light of concerns about the effects of fracking on climate change and water pollution.⁷⁷⁵

- October 18, 2013 – A team of researchers from multiple institutions including Harvard, the University of Michigan, and NOAA reported that methane emissions due to drilling activities in the south-central U.S. may be almost five times greater than reported by the world's most comprehensive methane inventory. "These results cast doubt on the US EPA's recent decision to downscale its estimate of national natural gas emissions by 25-30 percent," the authors wrote.⁷⁷⁶ As the *New York Times* reported, "The analysis also said that methane discharges in Texas and Oklahoma, where oil and gas production was concentrated at the time, were 2.7 times greater than conventional estimates. Emissions from oil and gas activity alone could be five times greater than the prevailing estimate."⁷⁷⁷
- October 18, 2013 – A major study spearheaded by Stanford University's Energy Modeling Forum concluded that fracking and the shale gas revolution will have no long-term climate benefit. The study brought together a working group of about 50 experts and advisors from companies, government agencies, and universities, and modeling teams from 14 organizations. The study also found that build-out of infrastructure for fracking and natural gas will discourage efforts to conserve energy and boost efficiency. The study did not examine methane leaks in order to weigh in on the short-term climate impacts of natural gas.⁷⁷⁸
- October 11, 2013 – As reported in the *Guardian*, key climate scientists argued that the growth in fracking across the United States is hurting the United States' credibility on climate change.⁷⁷⁹
- October 2, 2013 – Updated measurements from the IPCC determined that methane is even worse for the climate than previously thought. The IPCC determined that methane is

⁷⁷⁴ Rogers, P. (2013, November 12). Top climate scientists call for fracking ban in letter to Gov. Jerry Brown. *San Jose Mercury News*. Retrieved from http://www.mercurynews.com/ci_24509392/top-climate-scientists-call-fracking-ban-letter-gov

⁷⁷⁵ McNary, S. (2013, November 21). Former advisors to Gov. Brown request fracking ban. *Southern California Public Radio*. Retrieved from <http://www.scpr.org/blogs/politics/2013/11/21/15248/former-advisors-to-gov-brown-request-fracking-ban/>

⁷⁷⁶ Miller, S. M., Wofsy, S. C., Michalak, A. M., Kort, E. A., Andrews, A. E., Biraud, S. C., . . . Sweeney, C. (2013). Anthropogenic emissions of methane in the United States. *Proceedings of the National Academy of Sciences*, *110*(50), 20018-20022. doi: 10.1073/pnas.1314392110

⁷⁷⁷ Wines, M. (2013, November 25). Emissions of methane in U.S. exceed estimates, study finds. *The New York Times*. Retrieved from http://www.nytimes.com/2013/11/26/us/emissions-of-methane-in-us-exceed-estimates-study-finds.html?_r=0

⁷⁷⁸ Huntington, H. (2013). Changing the game? Emissions and market implications of new natural gas supplies. *Energy Modeling Forum*, *1*. Retrieved from <https://emf.stanford.edu/publications/emf-26-changing-game-emissions-and-market-implications-new-natural-gas-supplies>

⁷⁷⁹ Magill, B. (2013, October 11). Fracking hurts US climate change credibility, say scientists. *Guardian*. Retrieved from <http://www.theguardian.com/environment/2013/oct/11/fracking-us-climate-credibility-shale-gas>

34 times more potent as a greenhouse gas in the atmosphere than CO₂ over a 100-year timeframe, and 86 times more potent over a 20-year timeframe.⁷⁸⁰

- September 27, 2013 – The IPCC formally embraced an upper limit on greenhouse gases for the first time, warning that the world will exceed those levels and face irreversible climatic changes in a matter of decades unless steps are taken soon to reduce emissions. The IPCC reported that humanity faces a “carbon budget”—a limit on the amount of greenhouse gases that can be produced by industrial activity before irreversible, damaging consequences—of burning about a trillion metric tons of carbon. The world is on track to hit that by around 2040 at the current rate of energy consumption.⁷⁸¹
- August 12, 2013 – A *New Scientist* review of the science on fracking and global warming concluded that fracking could accelerate climate change rather than slow it.⁷⁸²
- May 28, 2013 – A research team led by Jeff Peischl, an associate scientist at NOAA and the Cooperative Institute for Research in Environmental Sciences, estimated that methane leakage from Los Angeles-area oil and gas operations was about 17 percent.^{783, 784}
- May 2013 – A group of scientists and journalists studying climate change, led by energy systems analyst Eric Larson of Princeton University and the news organization Climate Central, reported that the often-purported 50 percent climate advantage of natural gas over coal is unlikely to be achieved over the next three to four decades given methane leaks and other factors.⁷⁸⁵ The 50 percent claim is based on the fact that natural gas produces half as much carbon dioxide when burned than coal, but it ignores the significant greenhouse gas impacts of methane leakage that occurs throughout the life cycle of natural gas production, transmission, and distribution.
- January 2, 2013 – A NOAA study found methane emissions from oil and gas fields in Utah to be as high as nine percent of production. These levels are considered extremely damaging to the climate.⁷⁸⁶

⁷⁸⁰ IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P. M. Midgley (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. doi: 10.1017/CBO9781107415324.

⁷⁸¹ Gillis, J. (2013, September 27). U.N. climate panel endorses ceiling on global emissions. *The New York Times*. Retrieved from <http://www.nytimes.com/2013/09/28/science/global-climate-change-report.html?pagewanted=all>

⁷⁸² Pearce, F. (2013, August 12). Fracking could accelerate global warming. *New Scientist*. Retrieved from <http://www.newscientist.com/article/dn24029-fracking-could-accelerate-global-warming.html#.UpEWqsQ3uSo>

⁷⁸³ Peischl, J., Ryerson, T. B., Brioude, J., Aikin, K. C., Andrews, A. E., Atlas, E., . . . Parrish, D. D. (2013). Quantifying sources of methane using light alkanes in the Los Angeles basin, California. *Journal of Geophysical Research: Atmospheres*, 118(10), 4974-4990. doi: 10.1002/jgrd.50413

⁷⁸⁴ Ogburn, S. (2014, May 15). Solving the Case of California's Extra Methane. *Scientific American Global RSS*. Retrieved from <http://www.scientificamerican.com/article/solving-the-case-of-californias-extra-machine/>

⁷⁸⁵ Larson, E. D. (2013). Natural gas & climate change. *Climate Central*. Retrieved from <http://assets.climatecentral.org/pdfs/NaturalGas-and-ClimateChange.pdf>

⁷⁸⁶ Tollefson, J. (2013). Methane leaks erode green credentials of natural gas. *Nature*, 493(7430), 12-12. doi: 10.1038/493012a

- November 2012 – A review by the United Nations Environment Programme found that emissions from fracking, as well as other unconventional natural gas extraction methods, could increase global warming in the short-term and be comparable to coal over a 100-year timeframe.⁷⁸⁷
- November 2012 – The International Energy Agency (IEA) found that a large natural gas boom—even with improvements in place to reduce leakage—would eventually lead to greenhouse gas concentrations of 650 parts per million and a global temperature rise of 3.5 degrees Celsius, far exceeding the 2 degree Celsius limit which is critical to avoid the most severe effects of climate change.⁷⁸⁸
- May 29, 2012 – The *Guardian* summarized a special report on natural gas by the IEA: “A ‘golden age of gas’ spurred by a tripling of shale gas from fracking and other sources of unconventional gas by 2035 will stop renewable energy in its tracks if governments do not take action.”⁷⁸⁹
- February 2012 – A study published in *Environmental Research Letters* found that the carbon dioxide emitted from the burning of natural gas—even neglecting the impacts of methane leakage—contributes significantly to greenhouse gas emissions that are driving climate change.⁷⁹⁰
- February 7, 2012 – A NOAA study of Colorado gas fields measured methane emissions of about four percent, a significant percentage that could be very damaging to the climate.⁷⁹¹
- December 29, 2011 – As reported by the *New York Times*, levels of methane in the atmosphere have been steadily rising since 2007—coinciding with the onset of the fracking boom and posing a serious threat to the Earth’s climate.⁷⁹²
- October 2011 – A study from the National Center for Atmospheric Research concluded that substituting the use of natural gas for coal will increase, rather than decrease, the rate of global warming for many decades.⁷⁹³

⁷⁸⁷ Global Environmental Alert Service. (2012). Gas fracking: Can we safely squeeze the rocks? United Nations Environmental Programme. Retrieved from http://www.unep.org/pdf/UNEP-GEAS_NOV_2012.pdf

⁷⁸⁸ World Energy Outlook 2012, (November 2012). *Golden Rules for a Golden Age of Natural Gas—World Energy Outlook Special Report on Unconventional Gas*, International Energy Agency. Retrieved from <http://www.iea.org/publications/freepublications/publication/name,27408,en.html>

⁷⁸⁹ Harvey, F. (2012, May 29). 'Golden age of gas' threatens renewable energy, IEA warns. *Guardian*. Retrieved from <http://www.theguardian.com/environment/2012/may/29/gas-boom-renewables-agency-warns>

⁷⁹⁰ Myhrvold, N. P., & Caldeira, K. (2012). Greenhouse gases, climate change and the transition from coal to low-carbon electricity. *Environmental Research Letters*, 7(1). doi: 10.1088/1748-9326/7/1/014019

⁷⁹¹ Tollefson, J. (2012, February 7). Air sampling reveals high emissions from gas field. *Nature*. Retrieved from <http://www.nature.com/news/air-sampling-reveals-high-emissions-from-gas-field-1.9982>

⁷⁹² Gillis, J. (2011, December 29). The puzzle of rising methane. *The New York Times*. Retrieved from <http://green.blogs.nytimes.com/2011/12/29/the-puzzle-of-rising-methane/>

⁷⁹³ Wigley, T. M. (2011). Coal to gas: The influence of methane leakage. *Climatic Change*, 108(3), 601-608. doi: 10.1007/s10584-011-0217-3

- July 6, 2011 – According to the U.S. Energy Information Administration and other research, significant amounts of methane are leaking from aging gas pipelines and infrastructure.⁷⁹⁴
- April 2011 – A comprehensive analysis of the greenhouse gas footprint of natural gas from shale formations found that between 3.6 percent to 7.9 percent of the methane from natural gas production wells escapes into the atmosphere, rather than being combusted, thereby undermining any climate benefits of gas over coal as a source of energy.^{795, 796}

Threats from fracking infrastructure

The infrastructure for drilling and fracking operations is complex, widespread, and poses its own risks to public health and the climate. Beginning where silica sand is mined and processed and ending where gas is burned or liquefied for export, infrastructure includes pipelines, compressor stations, dehydrators, processing plants, rail tankers, flare stacks, and storage depots through which oil or gas is moved, filtered, pressurized, warehoused, refined, and vented. It also includes injection wells and recycling facilities that dispose and treat the prodigious amounts of liquid waste that fracking generates. Air pollution is produced at every stage of the process.

In the Upper Midwest, the boom in silica sand mining threatens both air and water quality. It has transformed rural areas into industrialized zones and introduced complex public health risks that are not well understood. Wisconsin alone provides more than half the sand used in fracking operations in the United States. Silica dust is a well-known cause of both lung cancer and silicosis. Precise exposures to downwind communities are unknown at this writing.

Compressor stations and pipelines are major sources of air pollutants, including benzene and formaldehyde, constituting potential health risks to those living nearby while offering no offsetting economic benefits. Instead, they are associated with loss of tax revenue and economic development for the communities where they are sited and traverse. The Medical Society of the State of New York and the American Medical Association have each called for comprehensive health impact assessments regarding the health and safety risks associated with natural gas pipelines, which include fires, explosions, and leaks.

Gas storage facilities include not only manmade holding tanks but also geological formations, most notably, abandoned salt caverns and depleted oil fields left over from mining and drilling operations. These unlined cavities were not created with the intent to store pressurized hydrocarbon gases, nor are they engineered for this purpose. The 3,600-acre Aliso Canyon gas

⁷⁹⁴ McKenna, P. (2011, July 6). Thousands of gas leaks under Boston and San Francisco. *New Scientist*. Retrieved from <http://www.newscientist.com/article/mg21128203.800-thousands-of-gas-leaks-under-boston-and-san-francisco.html#UpEbbMQ3uSp>

⁷⁹⁵ Howarth, R. W., Santoro, R., & Ingraffea, A. (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. *Climatic Change*, 106(4), 679-690. doi: 10.1007/s10584-011-0061-5

⁷⁹⁶ Howarth, R. W., Santoro, R., & Ingraffea, A. (2012). Venting and leaking of methane from shale gas development: Response to Cathles et al. *Climatic Change*, 113(2), 537-549. doi: 10.1007/s10584-012-0401-0

storage facility, located in a depleted oil field in southern California, released more than 100,000 metric tons of methane into the air of the San Fernando Valley over a four-month period beginning in October 2015 before it was finally contained in February 2016. This massive methane leak—the largest in U.S. history—is the greenhouse gas equivalent of a half million cars driving for a year. The plume itself was visible from space. More than 8,000 families in the nearby community of Porter Ranch were evacuated and relocated, thousands were sickened, and two public schools closed. The immediate cause of the Aliso Canyon blowout was a cracked well casing and lack of a shut-off valve. Federal standards to regulate underground gas storage were drafted in response to the Aliso Canyon leak. However, the current administration has delayed their implementation.

Liquefied natural gas (LNG) facilities consist of liquefaction plants, import/export terminals, tanker ships, regasification terminals, and inland storage equipment. All together, this capital-intensive equipment transforms methane vapor into liquid form through a cryogenic process that lowers the temperature of the gas to its condensation point (– 259° F) and then transports it to distant locations not serviced by pipelines. Chilling natural gas to its liquid state shrinks its volume by a factor of 600, allowing LNG to be exported overseas on massive tanker ships. LNG is sometimes used as vehicle fuel in, for example, long-haul trucks. LNG facilities encourage fracking by creating storage for the glut of gas that fracking has created, by enabling its export, and by driving up prices and profit margins.

LNG liquefaction requires immense energy in order to achieve the ultra-low temperatures required for condensation. An LNG facility typically requires its own power plant. Because they rely on evaporative cooling to maintain the liquid at super-chilled temperatures and prevent explosions, LNG tanks are leaky by design: vaporized gas is vented from storage tanks directly into the atmosphere. Larger tanks are engineered to capture boiled-off gas, but this process is not leak-proof. Before it is used or sent down a pipeline, LNG must be regasified via an energy-intensive process that requires massive infrastructure of its own, including periodic flaring to control pressure. Refrigeration, venting, leaks, flaring, and shipping make LNG more energy intensive than conventional natural gas. A new analysis shows that exporting large quantities of LNG from the United States will likely cause global greenhouse gas emissions to rise not only because of its energy penalty but also because LNG exports add more fossil fuels to the global market and extend the lifespan of U.S. coal-fired plants.

LNG creates acute public safety risks. LNG explodes when spilled into water and, if spilled on the ground, can turn into rapidly expanding, odorless clouds that can flash-freeze human flesh and asphyxiate by displacing oxygen. If ignited at the source, LNG vapors can become flaming “pool fires” that burn hotter than other fuels and cannot be extinguished. LNG fires burn hot enough to cause second-degree burns on exposed skin up to a mile away. LNG facilities pose significant risks to nearby population centers, and have been identified as potential terrorist targets.

Sand mining and processing

- November 25, 2017 – In Minnesota, a district judge upheld Winona County’s ban on the mining, processing, and loading of frack sand. In her decision, the judge referenced public health and safety threats, fragility of the water quality in the area, and evidence for

harm from sand mines in other areas. Winona is the first county in the United States to pass a countywide ban on frack sand extraction. Efforts to replicate the ban are now ongoing in neighboring counties.^{797, 798}

- July 5, 2016 – The Wisconsin Department of Natural Resources (DNR) released a *Strategic Analysis for Public Review* of the state’s industrial sand mining industry that downplayed environmental health effects from air pollution. There are 128 industrial sand mine facilities in Wisconsin, including the mines themselves and processing and rail loading facilities. The DNR identified airborne particulate matter as a primary concern for industrial sand mining facilities and said that air quality monitors in western Wisconsin have not detected a problem.⁷⁹⁹ Researchers, organizations, and the native community involved in monitoring impacts of the frack sand industry challenged these findings, pointing to lack of data collection on the most dangerous kind of particulate matter called PM2.5, which represents fine particles that are less than 2.5 microns in width. These critics noted that the U.S. Environmental Protection Agency (EPA) had previously expressed concerns about the DNR’s approach to regulating PM2.5.⁸⁰⁰ Regarding groundwater, the report described elevated levels of several metals in wastewater holding ponds at the sand mines, presenting a risk to groundwater quality.
- March 25, 2016 – The Occupational Safety and Health Administration (OSHA) amended its existing standards for occupational exposure to respirable crystalline silica, “having determined that employees exposed to respirable crystalline silica at the previous permissible exposure limits face a significant risk of material impairment to their health.”⁸⁰¹ Key provisions include the reduction of the permissible exposure limit to 50 micrograms per cubic meter of air, averaged over an 8-hour shift. The standards cover many industries with some having two years to comply; the hydraulic fracturing industry is allowed an additional five-year extension for engineering controls, until June 23, 2021.⁸⁰² The *New York Times* reported that safety experts have advocated for a tightening of silica exposure standards for the past forty years but that “progress was stymied for decades by resistance from affected companies and regulatory inaction.” The article reported that many oil and gas companies in particular were not meeting the current silica

⁷⁹⁷ McKinney, M. (2017, November 25). Judge’s ruling on Winona County ban of frac sand mining stirs interest. *Minneapolis Star-Tribune*. Retrieved from <http://www.startribune.com/judge-s-ruling-on-winona-county-frac-sand-ban-stirs-interest/459974433/>

⁷⁹⁸ Rogers, C. (2017, November 22). District court upholds county frac sand ban. *Winona Post*. Retrieved from <http://www.winonapost.com/Article/ArticleID/57056/District-court-upholds-county-frac-sand-ban>

⁷⁹⁹ Wisconsin Department of Natural Resources. (2016). *Industrial sand mining in Wisconsin: Strategic analysis for public review*. Retrieved from <http://dnr.wi.gov/topic/EIA/documents/ISMSA/ISMSA.pdf>

⁸⁰⁰ Hubbuch, C. (2016, July 6). DNR releases frac sand analysis to immediate criticism from environmental group. *LaCrosse Tribune*. Retrieved from http://lacrossetribune.com/news/local/dnr-releases-frac-sand-analysis-to-immediate-criticism-from-environmental/article_bce8ea56-fff1-52ae-97cb-c67cfb120a1f.html

⁸⁰¹ Occupational Safety and Health Administration. (2016, March 25). Occupational exposure to respirable crystalline silica. *Federal Register*. Retrieved from <https://www.federalregister.gov/articles/2016/03/25/2016-04800/occupational-exposure-to-respirable-crystalline-silica>

⁸⁰² Occupational Safety and Health Administration. (2016, March 25). OSHA’s Final Rule to protect workers from exposure to respirable crystalline silica. United States Department of Labor, Washington, DC. Retrieved from <https://www.osha.gov/silica/>

exposure standard. The new rules, when fully in effect, are estimated to save 600 lives and prevent 900 new cases of silicosis per year.⁸⁰³

- March 1, 2016 – University of Wisconsin anthropologist Thomas Pearson conducted in-depth interviews examining the impact of frack sand mining on sense of community, quality of life, and place in nearby residents. His findings indicated that the sudden influx of this heavy extractive industry has eroded residents’ sense of place and belonging and that these experiences are rarely taken into account by policymakers. Residents report “significant anxiety and stress from truck traffic, noise, light pollution, and uncertainty about environmental health impacts,” and distress caused by drastic changes to long-familiar landscapes over which they have no control. Pearson concluded that policymakers should pay closer attention to the uneven distribution of benefits and costs and “recognize that the costs go beyond quantifiable economic or environmental impacts.”⁸⁰⁴
- January 29, 2016 – The Institute for Wisconsin’s Health, Inc. released its Health Impact Assessment (HIA) on frack sand mining operations in western Wisconsin, prepared with the participation of 15 local and tribal health departments. According to the report, the HIA was a collaborative effort. The scope of the report was limited to the potential for community-level health effects of industrial sand mining in western Wisconsin. Regarding air quality, the report concluded that health effects from the impact of industrial sand mining on community-level air quality related to particulate matter are unlikely, and that it was also unlikely that community members would be exposed to respirable crystalline silica from industrial sand mining as currently regulated. Regarding water quality, the report concluded that contamination is possible; however, health effects were unlikely. Quality of life effects were likely, but variable.⁸⁰⁵ Though it was a “Level 1 Partner” for the report, the Ho-Chunk Nation responded to the HIA with criticism, writing, “we are disappointed with the conclusions drawn in the report, particularly in the section on air quality impacts, and we believe a more robust assessment of the air quality impacts is required before such conclusions can be drawn.” They wrote that the HIA failed to provide an accurate and complete analysis of the health threats posed by this industry because of the limited scope, and “minimal discussion about fine particulate matter (or PM2.5), which likely presents the biggest threat from industrial sand mining operations.”⁸⁰⁶ As reported by Rochester, Minnesota’s *Post-Bulletin*, Crispin Pierce, director of University of Wisconsin-Eau Claire’s environmental public health program, “believes the study ignored important air quality data collected by university students at

⁸⁰³ Meier, B. (2016, March 24). New rules aim to reduce silica exposure at work sites. *The New York Times*. Retrieved from http://www.nytimes.com/2016/03/24/business/new-rules-aim-to-reduce-silica-exposure-at-work-sites.html?_r=1

⁸⁰⁴ Pearson, T. (2016). Frac sand mining and the disruption of place, landscape, and community in Wisconsin. *Human Organization*, 75(1), 47-58. doi: <http://dx.doi.org/10.17730/0018-7259-75.1.47>

⁸⁰⁵ Boerner, A., Young, N., & Young, D. (2016). *Health impact assessment of industrial sand mining in western Wisconsin*. Institute for Wisconsin’s Health, Inc., Madison, WI. Retrieved from http://www.instituteforwihealth.org/uploads/1/2/7/8/12783470/iwhi_industrial_sand_w_covers.pdf

⁸⁰⁶ Ho-Chunk Nation. (2016, March 9). *Concerns about air quality impacts and human health remain after release of industrial sand mining Health Impact Assessment* [Press release]. Retrieved from <http://midwestadvocates.org/assets/resources/Frac%20Sand%20Mining/20160309HoChunkHIARelease.pdf>

sand mining sites at Bloomer, New Auburn and Augusta during the past 18 months,” which he described as “the only work that looked at these fine particles.”⁸⁰⁷

- November 6, 2015 – According to findings from a pilot study led by Crispin Pierce (see entry above), levels of fine particulate matter (PM2.5) are not being adequately measured near frack sand operations. Air monitors set up by Pierce and his team consistently showed higher readings than detections measured by Wisconsin’s DNR.⁸⁰⁸ In some instances, PM2.5 levels exceeded the EPA guideline of 12 micrograms per cubic meter of air. In an accompanying news story, Pierce noted that the state’s air quality data largely comes from industry itself. “‘The DNR so far has continued to shy away from doing their own monitoring,’ he said. ‘The monitoring I’ve seen so far is inadequate. People aren’t looking at PM2.5, and they really should be—from unbiased sources.’”⁸⁰⁹
- October 15, 2015 – *InsideClimate News* reported on the response of nearby communities to the “bust” cycle of the frack sand industry in Wisconsin and Minnesota. Reactions reported included ongoing concerns that the industry does not provide permanent economic prosperity. Municipalities and community organizations are using the lull to advance protections in advance of a possible upturn: “‘Towns in the region are also trying to strengthening their local zoning ordinances, such as adding rules to limit industrial noise and light pollution. In other cases, communities are trying to oust pro-sand advocates from office.’”⁸¹⁰
- June 30, 2015 – Because the amount of sand used per fracking well has increased, demand for silica sand by the oil and gas industry is still growing even though new drilling activity has taken a downturn. A global investment bank reported that fracking operations now require an average of 4.2 million pounds of sand per well. A few years ago, silica sand comprised 9.5 percent of fracking fluid but now is closer to 20 percent. Further “rising intensity” of sand use is expected.⁸¹¹
- June 15, 2015 – An investigative report by *EnergyWire* documented self-reported health impacts among residents of southwestern Wisconsin who live near silica sand mining operations that service the fracking industry. Exposure to silica dust is a proven cause of silicosis and lung cancer. [See further entries on silica sand exposure among workers in the section, “Occupational Health and Safety Hazards.”] Residents near frack sand mine

⁸⁰⁷ Lindquist, E. (2016, February 4). Report downplays frac sand link to health troubles. *Post-Bulletin*. Retrieved from http://www.postbulletin.com/news/local/report-downplays-frac-sand-link-to-health-troubles/article_b3023c6c-fe74-5028-a7a4-6238fa035eaa.html

⁸⁰⁸ Pierce, C., Walters, K., Jacobson, J., & Kroening, Z. (2015.) PM2.5 Airborne Particulates near frac sand operations. *Journal of Environmental Health* 78, 8-12.

⁸⁰⁹ Schuessler, R. (2015, November 6). Wisconsin locals fear dust from mines for fracking sand even as boom wanes. *Aljazeera America*. Retrieved from <http://america.aljazeera.com/articles/2015/11/6/wisconsin-locals-fear-frac-sand-mining.html>

⁸¹⁰ Hirji, Z. (2015, October 15). In fracking downturn, sand mining opponents not slowing down. *InsideClimate News*. Retrieved from <http://insideclimatenews.org/news/14102015/fracking-struggles-sand-mining-opponents-momentum-Minnesota-Wisconsin>

⁸¹¹ Chapa, S. (2015, June 30). Demand for sand: frac sand use per well goes up amid low oil prices. *San Antonio Business Journal*. Retrieved from <http://www.bizjournals.com/sanantonio/blog/eagle-ford-shale-insight/2015/06/demand-for-sand-frac-sand-use-per-well-goes-up.html>

operations reported exposure to dust pollution and respiratory problems. Air monitoring data from the Wisconsin DNR showed that none of the state's 63 active sand mines were in violation for particulate matter, but, as the author noted, the state measured particles only 10 micrometers in diameter or larger.⁸¹² Below this diameter, crystalline silica particles are small enough to bypass the body's natural clearance mechanisms and are likely to lodge deep in the lungs where they can initiate scarring, autoimmune reactions, and tumor formation.⁸¹³

Wastewater treatment facilities

- March 31, 2015 – University of Wyoming researchers identified a wastewater treatment and recycling facility as an important contributor to high winter ozone levels in Wyoming's Green River Basin. The facility released a signature mixture of volatile hydrocarbons, including toluene and xylene, which are ozone precursors.⁸¹⁴ This study documented that recycling activities can transfer volatile pollutants from water into air when fracking wastewater is cleaned up for reuse and that water treatment emissions can serve as an important point source of air pollutants.⁸¹⁵

Pipelines and compressor stations

- October 12, 2017 – Researchers at University of Albany's Institute for Health and the Environment prepared a 300-page technical report on the health effects of the emissions from 18 natural gas compressor stations in New York State. The team found that, collectively, these sites released 40 million pounds of 70 different contaminants over a seven-year period, making natural gas compressor stations the seventh largest point source of air pollution in the state. By volume, the largest emissions were nitrogen oxides, carbon monoxide, volatile organic compounds (VOCs), formaldehyde, and particulate matter. Exposure to these chemicals is linked to cancer, as well as cardiovascular, neurological, and developmental disorders. The authors noted, "The potential health impacts of the large volumes of pollutants generated by natural gas compressor stations have not been addressed, let alone answered, by those arguing for their construction and expansion."⁸¹⁶

⁸¹² King, P. (2015, June 15). Frac sand towns question whether rules protect them against silica pollution. *EnergyWire*. Retrieved from <http://www.eenews.net/stories/1060020192>

⁸¹³ U.S. Department of Labor, Occupational Safety and Health Administration. (n.d.) Dust and its control. Retrieved from https://www.osha.gov/dsg/topics/silicacrystalline/dust/chapter_1.html

⁸¹⁴ Field, R. A., Soltis, J., McCarthy, M. C., Murphy, S., & Montague, D. C. (2015). Influence of oil and gas field operations on spatial and temporal distributions of atmospheric non-methane hydrocarbons and their effect on ozone formation in winter. *Atmospheric Chemistry and Physics*, 15, 3527-3542. doi: 10.5194/acp-15-3527-2015

⁸¹⁵ Peterka, A. (2015, April 2). Study links Wyo. winter ozone to drillers' wastewater plant. *Greenwire*. Retrieved from <http://www.eenews.net/stories/1060016205>

⁸¹⁶ Russo, P. N., & Carpenter, D. O. (2017, October 12). *Health effects associated with stack chemical emissions from NYS natural gas compressor stations, 2008-2014*. Retrieved from https://www.albany.edu/about/assets/Complete_report.pdf

- October 11, 2017 – A study of airborne methane emissions from assorted components of natural gas infrastructure in California, including compressor stations and storage facilities, confirmed earlier studies in finding widely variable leakages. The results suggested that a significant fraction of the methane emitted from storage facilities may, in fact, be escaping from their associated compressor stations.⁸¹⁷
- July 17, 2017 – A comprehensive investigation of the pipeline approval process by the Center for Public Integrity, *StateImpact Pennsylvania*, and National Public Radio found that the Federal Energy Regulatory Commission (FERC), which is charged with ensuring the public’s interest, routinely assesses need based on company filings and functions as an agency captured by industry interests, concluding, “at every turn, the agency’s process favors the pipeline companies.” The result, according to this analysis of more than 500 pipeline cases, is that the financial interests of the gas industry, and not market demand or public necessity, is driving the ongoing pipeline build-out. In some cases, utility companies have complex financial ties to the pipeline companies that service them.⁸¹⁸ Continuing this investigation, *InsideClimate News* then reviewed several large, new pipeline proposals in the Marcellus and Utica Shale regions, focusing on joint ventures and interlocking financial relationships between customers (state-regulated utilities) and suppliers (pipeline companies). Affiliate agreements that allow parent companies of utilities to seek federal certificates for interstate pipelines—which typically allow a 14 percent return on equity—contribute to the ongoing frenzy of pipeline construction even when natural gas demand is flat. Existing pipelines, the investigation noted, run at only slightly more than half capacity.⁸¹⁹
- July 12, 2017 – A Canadian study found that oil and gas infrastructure, including compressor stations, contributes to habitat fragmentation and increases parasitism by cowbirds on Savannah sparrow nests in the Northern Great Plains. Populations of North American grassland songs birds, including the Savannah sparrow, are declining precipitously, mostly due to habitat loss and degradation. These results suggest that “brood parasitism associated with oil and natural gas infrastructure may result in additional pressures that reduce the productivity of this declining grassland songbird.”⁸²⁰
- May 16, 2017 – An analysis of records from state agencies revealed that low-pressure flow lines at oil and gas well sites are responsible for more than 7,000 spills, leaks, and accidents since 2009. Flow lines carry oil, gas, or wastewater from scattered pieces of

⁸¹⁷ Mehrotra, S., Faloona, I., Suard, M., Conley, S., & Fischer, M. L. (2017). Airborne methane emission measurements for selected oil and gas facilities across California. *Environmental Science & Technology* 51(21), 12981–12987. doi: 10.1021/acs.est.7b03254

⁸¹⁸ Lombardi, K., & Hopkins, J. S. (2017, July 17). Natural gas building boom fuels climate worries, enrages landowners. *NPR.org*. Retrieved from <http://www.npr.org/2017/07/17/536708576/natural-gas-building-boom-fuels-climate-worries-enrages-landowners>

⁸¹⁹ McKenna, P. (2007, August 3). Pipeline payday: how builders win big, whether more gas is needed or not. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/02082017/natural-gas-pipeline-boom-corporate-profit-bubble-limited-demand-climate-emissions>

⁸²⁰ Bernath-Plaisted, J., Nenner, H., & Koper, N. (2017). Conventional oil and natural gas infrastructure increases brown-headed cowbird (*Molothrus ater*) relative abundance and parasitism in mixed-grass prairie. *Royal Society Open Science*, 4(7), 170036. doi: 10.1098/rsos.170036

equipment within a production site. Other than in New Mexico, operators are not required to report gas leaks from flow lines. A fatal explosion in April 2017 in a Firestone, Colorado home built on top of an oil field was triggered when an abandoned flow line seeped gas into a basement where it ignited. Two people were killed and one was badly injured. Soon after, Colorado Governor John Hickenlooper ordered a statewide review of all oil and gas lines located near occupied buildings. Preliminary data showed that 16,000 wells across Colorado have flow lines that lie within 1,000 feet of homes. Corrosion is a leading cause of flow line failures.^{821, 822}

- February 15, 2017 – A team of researchers from University of Texas investigated emissions from natural gas compressor stations throughout Pennsylvania and New York. They found that compressors emitted highly variable plumes of methane that spread downwind and were measurable a full mile away at levels that could expose nearby residents, especially during temperature inversions. The researchers concluded, “Our data indicate that compressor stations are likely sources of methane emissions and presumably co-emitted air contaminants, and can sporadically/episodically emit methane at relatively high levels...if such facilities are to be permitted to release specified amounts of contaminants, those amounts should be actively measured and verified. Without measurement there can be no assurance that permit conditions are being met.”⁸²³
- November 30, 2016 – A CityLab investigation used data from the Pipeline and Hazardous Materials Safety Administration to map all significant U.S. pipeline accidents between 1986 and 2016 and concluded, “wherever pipelines are extended, deadly accidents will follow.” Pipeline accidents over the past 30 years have resulted in 548 deaths, more than 2,500 injuries, and over \$8.5 billion in damages. Accidents are particularly common in Texas and Louisiana.⁸²⁴
- July 5, 2016 – The National Energy Board, Canada’s pipeline watchdog, gave two of Canada’s largest pipeline companies six months to fix severe deficiencies in pipelines, ultimately issuing an emergency safety order in February 2016. Newly released federal documents showed that Texas-based Kinder Morgan and Alberta-based Enbridge were both looking into the use of defective parts purchased from Thailand-based Canadoil Asia that recently went bankrupt. U.S. regulators warned of these deficiencies eight years prior. At least one Canadian pipeline with defective materials exploded during that period.⁸²⁵

⁸²¹ Soraghan, M. (2017, May 16). Flow lines cited in more than 7K spills. *E&E News*. Retrieved from <https://www.eenews.net/stories/1060054568>

⁸²² Lee, M. (2017, June 12). Fatal explosion threatens more upheaval over drilling in Colo. *E&E News*. Retrieved from <https://www.eenews.net/stories/1060055846>

⁸²³ Payne, B. F., Ackley, R., Wickler, A. P., Hildenbrand, Z., Carlton, Jr., D. D., & Schug, K. A. (2017). Characterization of methane plumes downwind of natural gas compressor stations in Pennsylvania and New York. *Science of the Total Environment*, 580, 1214-21. doi: 10.1016/j.scitotenv.2016.12.082

⁸²⁴ Joseph, G. (2016, November 30). 30 years of oil and gas pipeline accidents, mapped. *CityLab*. Retrieved from <https://www.citylab.com/environment/2016/11/30-years-of-pipeline-accidents-mapped/509066/>

⁸²⁵ De Souza, M. (2016, July 5). How Canada’s pipeline watchdog secretly discusses ‘ticking time bombs’ with industry. *National Observer*. Retrieved from <http://www.nationalobserver.com/2016/07/05/news/how-canada%E2%80%99s-pipeline-watchdog-secretly-discusses-ticking-time-bombs-industry>

- June 10, 2016 – EPA Region 2 submitted comments to FERC on Docket Nos. PFI6-3, Eastern System Upgrade Project, which includes new natural gas compressor stations in Hancock and Highland, New York. The EPA submission suggested an analysis of whether this project was needed; clarification of what is meant by a loop system; evaluation of alternatives; a comprehensive analysis of cumulative, indirect, and secondary impacts; information on greenhouse gas emissions and climate change impacts; a Health Impact Assessment; the inclusion of all pollution prevention practices; and a consideration of environmental justice concerns.⁸²⁶ The company agreed to provide funding toward a health study but wished to retain the ability to determine the study parameters.⁸²⁷ Skeptical of the health study’s funding and parameters, residents and potentially impacted towns objected to the company’s dismissal of the towns’ laws prohibiting the construction and operation of heavy industrial use facilities. The Deputy Supervisor of one of the affected towns “said he was encouraged by the federal Environmental Protection Agency’s comments on the project’s preliminary federal application. He said the EPA concerns were ‘the same as ours.’”⁸²⁸
- April 27, 2016 – In its report on two natural gas pipeline expansion projects in Appalachia, the Institute for Energy Economics and Financial Analysis demonstrated that the Atlantic Coast and Mountain Valley pipelines are “emblematic of the risks that such expansion creates for ratepayers, investors and landowners.” The report concluded that pipelines out of the Marcellus and Utica region are being overbuilt, putting ratepayers at risk of paying for excess capacity, landowners at risk of losing their property to unnecessary projects, and investors at risk of loss. The report stated that FERC facilitates this building of excess pipeline capacity and its approach for assessing need is insufficient.⁸²⁹
- April 22, 2016 – The federal Agency for Toxic Substances and Disease Registry (ATSDR) released a report on air quality near a natural gas compressor station in Brooklyn Township, Susquehanna County, Pennsylvania, finding levels of fine particulate matter (PM2.5) at levels that can damage human health in those with long-term exposure. Evaluating data from an 18-day EPA field air monitoring event, the report found that the average ambient 24-hour PM2.5 concentration observed at one residence (19 µg/m³) was higher than the nearest regional National Ambient Air Quality Standards (NAAQS) monitoring station (12.3 µg/m³) in Scranton, PA, over the same period. ATSDR concluded that there was evidence that long-term exposure to PM2.5 at the levels found can cause an increase in mortality, respiratory problems, hospitalizations, preterm births, and low birth weight. The agency said that in the short term, exposure

⁸²⁶ EPA Region 2. (2016, June 10). Docket Nos. PFI6-3, Eastern System Upgrade Project (comments). Retrieved from https://elibrary.ferc.gov/idmws/file_list.asp?document_id=14468753

⁸²⁷ Mayer, F. (2016, April 27). Millennium to pay for health study. *River Reporter*. Retrieved from <http://www.riverreporter.com/news/4302/2016/04/27/millennium-pay-health-study>

⁸²⁸ Julse, D. (2016, June 22). Highland concerned about study underfunding. *River Reporter*. Retrieved from <http://www.riverreporter.com/news/4302/2016/06/22/highland-concerned-about-study-underfunding>

⁸²⁹ Kunkel, C., & Sanzillo, T. (2016). *Risks associated with natural gas pipeline expansion in Appalachia*. The Institute for Energy Economics and Financial Analysis. Retrieved from http://ieefa.org/wp-content/uploads/2016/04/Risks-Associated-With-Natural-Gas-Pipeline-Expansion-in-Appalachia-_April-2016.pdf

could be harmful to sensitive populations, such as those with respiratory problems or heart disease. The agency recommended that sensitive individuals monitor air quality and limit activity accordingly, and that the PA DEP work to reduce other sources of PM and its precursors.⁸³⁰

- April 3, 2016 – The Southwest Pennsylvania Environmental Health Project issued a *Technical Report* in response to the January 29, 2016 federal ATSDR report on the Brigich compressor station in Chartiers Township, Washington County, Pennsylvania. ATSDR detected chemicals that had been reported at gas sites previously, and this confirmation of their presence provided “an important acknowledgement that neighbors of such facilities are being exposed (often at very close range) to chemicals that bring with them the possibility of short- and long-term health effects.” The report stated that, in conjunction with the monitoring work of the EPA, ATSDR “provided a solid set of data.” However, due to the limitations of the methodologies available to them, the authors were “concerned that there was, in the end, an underestimate of risk to community members.”⁸³¹
- April 1, 2016 – Kinder Morgan, the largest energy infrastructure company in North America, suspended construction of a \$1 billion pipeline project that would have carried gasoline and diesel fuel across the southeastern United States. Construction was suspended after landowners protested the seizure of their property, a Georgia Superior Court judge upheld a decision denying a certificate that would have allowed the company to use eminent domain, and the state legislature passed legislation to block the property seizure.⁸³²
- March 26, 2016 – According to a Boston University-led study, fugitive emissions from urban natural gas pipeline systems were the largest anthropogenic source of the greenhouse gas methane in the United States and contribute to the risk of explosions in urban environments, with 15 percent of leaks qualifying as potentially explosive.⁸³³ “All leaks must be addressed, as even small leaks cannot be disregarded as ‘safely leaking,’” concluded the report authors. In an interview with *InsideClimate News*, the lead author said that in addition to weighing the safety risks from gas leaks, regulators and utility

⁸³⁰ Agency for Toxic Substances and Disease Registry. (2016, April 22). *Health Consultation: Brooklyn Township PM2.5, Brooklyn Township, Susquehanna County, Pennsylvania*. U.S. Department of Health and Human Services, Atlanta, GA. Retrieved from http://www.atsdr.cdc.gov/HAC/pha/BrooklynTownship/BrooklynTwnsp_pm2-5_HC_Final_04-22-2016_508.pdf

⁸³¹ Southwest Pennsylvania Environmental Health Project. (2016, April 3). ATSDR releases investigation of Pennsylvania compressor station. *Response to Governmental Action and Publication, 1*. Retrieved from <http://www.environmentalhealthproject.org/resources/research-factsheets>

⁸³² McKenna, P. (2016, April 1). Property rights outcry stops billion-dollar pipeline project in Georgia. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/01042016/palmetto-pipeline-kinder-morgan-georgia-eminent-domain-oil-gas-republicans>

⁸³³ Hendrick, M. F., Ackley, R., Sanaie-Movahed, B., Tang, X., & Phillips, N.G. (2016). Fugitive methane emissions from leak-prone natural gas distribution infrastructure in urban environments. *Environmental Pollution, 213*, 710–716. [doi:10.1016/j.envpol.2016.01.094](https://doi.org/10.1016/j.envpol.2016.01.094)

companies must also consider the climate impact of leaks when determining priorities for repairing and replacing pipes.⁸³⁴

- March 7, 2016 – A lawsuit filed against FERC in U.S. District Court in Washington, D.C. challenged the agency’s relationship with industry, reported *Penn Live*: “The suit accuses the commission of regulatory capture, a situation in which corporations control regulators.” FERC receives all of its funding from the energy companies that it regulates and had never rejected a pipeline plan, which, according to the complainant, demonstrates “clear bias and corruption.”⁸³⁵
- February 26, 2016 – Congressman Chris Gibson (NY-19), in response to citizen concerns, sent a letter to FERC regarding the proposed 41,000-horsepower compressor station in southern Rensselaer County, New York, part of the Northeast Energy Direct (NED) pipeline project. He discussed the inadequacy of federal exposure standards with regard to exposures at compressor sites and lack of medical expertise in these decisions. He requested public health expertise on all Environmental Assessment and Environmental Impact Statement teams, an independent panel to review the federal exposure standards around compressor stations, and “a transparent and effective review process.”⁸³⁶ His call was supported by other elected officials, as well as public health researcher David O. Carpenter, MD, who has studied compressor station pollutants.⁸³⁷
- January 29, 2016 – ATSDR, in collaboration with the EPA Region 3 Air Protection Division, conducted an exposure investigation to evaluate exposures of residents living near the Brigich natural gas compressor station in Chartiers Township, Washington County, Pennsylvania. ATSDR concluded that, although exposure to the levels of chemicals detected in the ambient air was not expected to harm the health of the general population, “some sensitive subpopulations (e.g., asthmatics, elderly) may experience harmful effects from exposures to hydrogen sulfide and PM 2.5 [and] [s]ome individuals may also be sensitive to aldehyde exposures, including glutaraldehyde.” According to ATSDR, one of the study’s limitations was that the sampling “may not have adequately captured uncommon but significant incidents when peak emissions (e.g. unscheduled facility incidents, blowdowns or flaring events) coincide with unfavorable meteorological conditions (e.g. air inversion).” ATSDR recommendations included reducing exposures to the chemicals of concern to protect sensitive populations, continued collection of

⁸³⁴ McKenna, P. (2016, March 31). Methane hazard lurks in Boston's aging, leaking gas pipes, study says. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/30032016/boston-natural-gas-pipelines-leaking-methane-climate-change-explosion>

⁸³⁵ Pynes, M. (2016, March 7). Federal agency funded by energy industry has never rejected a pipeline plan. *PennLive.com*. Retrieved from http://www.pennlive.com/news/2016/03/pipeline_fights_raise_big_ques.html#incart_article_small

⁸³⁶ Gibson, C. (2016, February 26). Compressor station needs review. *Sullivan County Democrat*. Retrieved from <http://scdemocratonline.com/webpages/letterdetail.aspx?id=9f047d33-ba32-4027-883b-ff2e457ebb7a>

⁸³⁷ Nearing, B. (2016, March 31). Gibson: Federal natural gas air pollution safety standards may be obsolete. *Albany Times Union*. Retrieved from <http://www.timesunion.com/business/article/Gibson-Federal-natural-gas-air-pollution-safety-7221271.php>

emissions data for long-term and peak exposures, and air modeling to better understand ambient air quality.⁸³⁸

- December 8, 2015 – The Niagara County Legislature, following the recommendations of the Medical Society of the State of New York, called for a Health Impact Assessment (HIA) on natural gas infrastructure, including compressor stations, and co-hosted a conference in Albany on the Medical Society’s health findings. A compressor station with twin compressors, part of the “2016 Northern Access Plan” to transfer gas from Pennsylvania to Canada, is proposed for the county.⁸³⁹
- November 9, 2015 – Following the 2010 heavy oil spill in Michigan’s Kalamazoo River, Congress ordered an audit that spotlighted the industry’s poor record of spotting leaks. *Politico* reported on the 2015 regulatory structure ultimately unveiled in response, determining the proposal “fails to patch that hole in the nation’s pipeline safety net.” “While the agency’s proposed rule expands the number of pipelines that must have a leak-detection system in place, it sets no basic standards for how well that technology should work. Instead, safety advocates say, it lets pipeline operators decide for themselves whether they are adequately prepared.”⁸⁴⁰
- October 16, 2015 – The EPA urged FERC to consider “whether the Northeast Energy Direct pipeline could be combined with other projects, rather than constructing a new system that would have a host of environmental impacts,” reported Oneonta, New York’s *Daily Star*. The EPA also advised “that the gas demand addressed by NED’s application could be met by renewable forms of energy such as solar and wind power...”⁸⁴¹ (Note: Kinder Morgan withdrew its NED pipeline application in April 2016.)
- September 17, 2015 – At a shale gas conference, industry representatives espoused the construction of new pipelines as necessary to re-invigorate the gas industry in the Marcellus. Speakers noted that FERC approval can be expected to now take longer, by about six months, blaming environmental groups for the delays.⁸⁴²
- September 9, 2015 – New pipelines are failing at a rate on par with gas transmission lines installed before the 1940s, according to an analysis of federal data by the Pipeline Safety

⁸³⁸ Agency for Toxic Substances and Disease Registry. (2016, January 29). *Health Consultation: Exposure Investigation, Natural Gas Ambient Air Quality Monitoring Initiative Brigich Compressor Station, Chartiers Township, Washington County, Pennsylvania*. Retrieved from http://www.atsdr.cdc.gov/HAC/pha/Brigich_Compressor_Station/Brigich_Compressor_Station_EI_HC_01-29-2016_508.pdf

⁸³⁹ Staff. (2015, December 8). County lawmakers call for study on compressor health risks. *Lockport Union-Sun & Journal*. Retrieved from http://www.lockportjournal.com/news/local_news/county-lawmakers-call-for-study-on-compressor-health-risks/article_932989cd-058a-594f-9ef2-e52827db85a6.html

⁸⁴⁰ Schor, E. (2015, November 9). The hole in Obama’s pipeline safety plan. *Politico*. Retrieved from <http://www.politico.com/story/2015/11/obama-pipeline-safety-plan-oil-215617>

⁸⁴¹ Mahoney, J. (2015, October 16). EPA: Can local pipeline plans merge? *Daily Star*. Retrieved from http://www.thedailystar.com/news/local_news/epa-can-local-pipeline-plans-merge/article_f2836510-a96b-5c2d-9892-755b94b1f640.html?mode=jqm

⁸⁴² Packel, D. (2015, September 17). Energy honchos lament FERC pipeline approval delays. *Law 360*. Retrieved from <http://www.law360.com/publicpolicy/articles/697120/energy-honchos-lament-ferc-pipeline-approval-delays>

Trust, reported by *S&P Global Market Intelligence*. “The gas transmission lines installed in the 2010s had an annual average incident rate of 6.64 per 10,000 miles over the time frame considered, even exceeding that of the pre-1940s pipes. Those installed prior to 1940 or at unknown dates had an incident rate of 6.08 per 10,000 miles.” The director of the National Transportation Safety Board's Office of Railroad, Pipeline and Hazardous Materials Investigations “agreed that the rapid construction of pipelines in the U.S. is likely a contributing factor.”⁸⁴³

- August 18, 2015 – Houston Advanced Research Center (HARC) scientists addressed “the commonly acknowledged sources of uncertainty which are the lack of sustained monitoring of ambient concentrations of pollutants associated with gas mining, poor quantification of their emissions, and inability to correlate health symptoms with specific emission events.” They concluded that “more contemporary monitoring and data analysis techniques should take the place of older methods to better protect the health of nearby residents and maintain the integrity of the surrounding environment.” “Real-time mobile monitoring, microscale modeling and source attribution, and real-time broadcasting of air quality and human health data over the World Wide Web” have been demonstrated, they wrote, by past, current, and planned future monitoring studies in the Barnett and Eagle Ford shale regions.⁸⁴⁴ Founded as a technology incubator in 1982 by Houston oilman George P. Mitchell, HARC later re-aligned to focus on sustainable development.
- August 14, 2015 – HARC scientists found that port operations involving petrochemicals may significantly increase emissions of air toxics, including peaks of carcinogenic benzene of up to 37 ppb. The scientists matched the benzene spikes with pipeline systems. The spikes were at levels much higher than those reported in the EPA’s 2011 National Emissions Inventory. The authors recommended the use of updated methods for ambient monitoring.⁸⁴⁵ Lead scientist Jay Olaguer said in a related interview that “government regulators should wake up to the reality of the situation, that their methods of tracking air pollution need to be updated so that the samples are taken in real time and can catch it when toxic vapors of this magnitude are released.”⁸⁴⁶
- July 15, 2015 – Rensselaer County lawmakers passed a resolution asking the state of New York to freeze the approval process for the Northeast Energy Direct pipeline—

⁸⁴³ Smith, S. (2015, September 9). As US rushes to build gas lines, failure rate of new pipes has spiked. *SNL Financial*. Retrieved from <https://www.snl.com/InteractiveX/Article.aspx?cdid=A-33791090-11060>

⁸⁴⁴ Olaguer, E. P., Erickson, M., Wijesinghe, A., Neish, B., Williams, J., & Colvin, J. (2015). Updated methods for assessing the impacts of nearby gas drilling and production on neighborhood air quality and human health. *Journal of the Air & Waste Management Association*, 66, (2), 173-183. doi: 10.1080/10962247.2015.1083914

⁸⁴⁵ Olaguer, E. P., Erickson, M. H., Wijesinghe, A., & Neish, B. S. (2015). Source attribution and quantification of benzene event emissions in a Houston ship channel community based on real-time mobile monitoring of ambient air. *Journal of the Air & Waste Management Association*, 66, (2), 164-172. doi: 10.1080/10962247.2015.1081652

⁸⁴⁶ Wray, D. (2016, February 23). Scientists discover pipelines belching benzene in East Houston. *Houston Press*. Retrieved from <http://www.houstonpress.com/news/scientists-discover-pipelines-belching-benzene-in-east-houston-8181569>

which would carry fracked gas from Pennsylvania to Boston—until it conducts a comprehensive health impact assessment for natural gas pipelines.⁸⁴⁷

- July 8, 2015 – Researchers from West Virginia University completed leak and loss audits for methane emissions at three natural gas compressor stations and two natural gas storage facilities, with a “leak” defined as an unintended release of natural gas due to malfunction of a component, and a “loss” defined as an intended release of natural gas. In terms of frequency, most emissions were leaks, but on a mass basis, losses were the dominant source of methane emissions (88 percent). The top loss emitters were engine exhausts (accounting for nearly half), packing vents, and slop tanks. Emissions from compressor blowdowns were not included.⁸⁴⁸ A related study by a University of Houston team found that emission rates from compressor stations in Texas’ Barnett Shale were far higher than from well pads.^{849, 850}
- July 7, 2015 – Seeking a method to bridge the gap between bottom-up and top-down methods of measuring methane emissions, Purdue University, University of Houston, the National Oceanic and Atmospheric Administration (NOAA), Environmental Defense Fund, and independent researchers surveyed eight high-emitting point sources in the Barnett Shale using an aircraft-based “mass balance” approach. Results from four gas processing plants and one compressor station highlighted the importance of addressing methane “super-emitters” and confirmed that self-reports from the Greenhouse Gas Reporting Program underestimated actual emission rates by a factor of 3.8 or higher, due to “underestimated facility emissions, temporal variability of emissions, and the exclusion of nonreporting facility emissions.”⁸⁵¹
- July 7, 2015 – Using relatively easy-to-acquire and inexpensive stable isotopic and alkane ratio tracers, researchers are now able to distinguish methane arising from natural gas production and transport from agricultural and urban methane sources, and, in addition, to distinguish between methane released from shale gas as opposed to conventional wells. Initial research from the University of Cincinnati, University of California at Irvine, and the Environmental Defense Fund found that methane in the Barnett Shale hydraulic fracturing region near Fort Worth, Texas, represents a complex mixture of these sources. This new approach, used for ground-level measurements, can complement and extend top-down approaches, allowing for more accurate inventories

⁸⁴⁷ Nearing, B. (2015, July 15). County: Put study before any permit. *Albany Times-Union*. Retrieved from <http://www.timesunion.com/news/article/County-Put-study-before-any-permit-6387404.php>

⁸⁴⁸ Johnson, D. R., Covington, A. N., & Clark, N. N. (2015). Methane emissions from leak and loss audits of natural gas compressor stations and storage facilities. *Environmental Science & Technology*, 49, 8132-8138. doi: 10.1021/es506163m

⁸⁴⁹ Lan, X., Talbot, R., Laine, P., & Torres, A. (2015). Characterizing fugitive methane emissions in the Barnett Shale area using a mobile laboratory. *Environmental Science & Technology*, 49, 8139-8146. doi: 10.1021/es5063055

⁸⁵⁰ Song, L., & Hirji, Z. (2015, July 8). Methane emissions in Texas fracking region 50 percent higher than EPA estimates. *InsideClimate News*. Retrieved from <http://insideclimatenews.org/news/08072015/methane-emissions-texas-fracking-region-50-higher-epa-estimates-oil-gas-drilling-barnett-shale-environmental-defense-fund>

⁸⁵¹ Lavoie, T. N., Shepson, P. B., Cambaliza, M. O. L., Stirm, B. H., Karion, A., Sweeney, C., . . . Lyon, D. (2015). Aircraft-based measurements of point source methane emissions in the Barnett Shale Basin. *Environmental Science & Technology*, 49, 7904-7913. doi: 10.1021/acs.est.5b00410

of thermogenic and biogenic sources of methane emissions.⁸⁵²

- July 1, 2015 – In New York State, Schoharie County supervisors and medical professionals demanded comprehensive health impact assessments as a precondition for permitting natural gas pipelines and compressor stations.⁸⁵³
- June 12, 2015 – The Agency for Toxic Substances and Disease Registry investigated the health effects of ruptured gas pipelines in an analysis of data in a database on acute petroleum-related releases to which seven states contribute (Louisiana, New York, North Carolina, Oregon, Tennessee, Utah, and Wisconsin). From 2010 to 2012, there were 1,369 such incidents, which resulted in 259 injuries. More than three-quarters of these incidents were related to natural gas distribution. Equipment failure accounted for half of all incidents; human error accounted for 40 percent. The report noted the “continuing occurrence” of petroleum release incidents—including from natural gas pipeline ruptures—which have “the potential to cause mass casualties and environmental contamination.”⁸⁵⁴
- June 9, 2015 – The American Medical Association (AMA) adopted a resolution, “Protecting Public Health from Natural Gas Infrastructure,” that was based on a resolution adopted by the Medical Society of the State of New York. (See below.) The resolution states, “Our AMA recognizes the potential impact on human health associated with natural gas infrastructure and supports legislation that would require a comprehensive Health Impact Assessment regarding the health risks that may be associated with natural gas pipelines.”⁸⁵⁵
- May 2, 2015 – The Medical Society of the State of New York adopted a resolution, “Protecting Public Health from Natural Gas Infrastructure,” that recognizes the potential impact to human health and the environment of natural gas pipelines and calls for a governmental assessment of these risks.⁸⁵⁶
- March 3, 2015 – Researchers with the Southwest Pennsylvania Environmental Health Project measured ambient levels of particulate and volatile air pollutants from fracking-related operations and calculated expected human exposures in Washington County, Pennsylvania. Extremely high exposures peaked at night when air was still. These

⁸⁵² Townsend-Small, A., Marrero, J. E., Lyon, D. R., Simpson, I. J., Meinardi, S., & Blake, D.R. (2015). Integrating source apportionment tracers into a bottom-up inventory of methane emissions in the Barnett Shale hydraulic fracturing region. *Environmental Science & Technology*, 49, 8175–8182. doi: 10.1021/acs.est.5b00057

⁸⁵³ Adams, K. (2015, July 1). Schoharie County officials ask new studies on gas lines: Report say dangers are equivalent to fracking. *Daily Gazette*, Retrieved from http://www.dailygazette.com/news/2015/jul/01/0701_gasline/?print

⁸⁵⁴ Anderson, A. R. (2015, June 12). Health effects of cut gas lines and other petroleum product release incidents—seven states. *Morbidity and Mortality Weekly Report*, 64, 601-605.

⁸⁵⁵ American Medical Association. (2015). H-135.930 Protecting public health from natural gas infrastructure, Resolution 519, A-15. Retrieved from <https://www.ama-assn.org/sites/default/files/media-browser/public/hod/a15-hod-resolutions.pdf>

⁸⁵⁶ Medical Society of the State of New York. (2015). 2015 House of Delegates Actions: Public Health and Education. Retrieved from <http://www.mssny.org/Documents/HOD/Actions/ActionPHE.pdf>

fluctuating exposure events mimic, in frequency and intensity, the episodic nature of health complaints among residents. Over a one-year period, compressor stations were responsible for more extreme exposure events (118) than well pads or gas processing plants.⁸⁵⁷

- February 24, 2015 – As part of a literature review on the health impacts of compressor stations, the Southwest Pennsylvania Environmental Health Project reported that peak emissions of fine particles tended to occur during construction time, that day-to-day emissions during operational time can fluctuate greatly, and that a compressor blowdown typically represented the single largest emission event during operations. Hence, documentation of these fluctuations cannot be captured by calculating yearly averages. A blowdown is an intentional or accidental release of gas through the blowdown valve that creates a 30- to 60-meter-high gas plume. Blowdowns, which are used to control pressure, can last as long as three hours. The authors noted that blowdowns result in times of high levels of contaminant release and that anecdotal accounts associate blowdowns with burning eyes and throat, skin irritation, and headache.⁸⁵⁸ There is neither a national or state inventory of compressor station accidents nor a body of peer-reviewed research on the public health impacts of compressor stations.
- February 17, 2015 – A Boston study found that emissions from residential, end-use natural gas infrastructure was a significant source of atmospheric methane—two to three times larger than previously presumed—and accounted for 60 to 100 percent of methane, depending on the season. Of all the natural gas in the downstream component of the natural gas system, 2.7 percent was lost to the atmosphere.⁸⁵⁹
- February 10, 2015 – A team of engineers from Pennsylvania and Colorado examined methane emissions from natural gas compressor stations and found that vents, valves, engine exhaust, and equipment leaks were also major emissions sources. There was considerable variation in emissions among the 45 compressor stations measured. Surprisingly, substantial emissions were found even when compressors were not operating.⁸⁶⁰
- December 27, 2014 – A *Pittsburgh Tribune-Review* investigation found that the vast majority of natural gas “gathering lines”—pipelines that take natural gas from rural well

⁸⁵⁷ Brown, D. R., Lewis, C., & Weinberger, B. I. (2015). Human exposure to unconventional natural gas development: a public health demonstration of periodic high exposure to chemical mixtures in ambient air. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, 50, 460-72. doi: 10.1080/10934529.2015.992663

⁸⁵⁸ Southwest Pennsylvania Environmental Health Project (2015, February 24). Summary on compressor stations and health impacts. Retrieved from <http://www.environmentalhealthproject.org/wp-content/uploads/2012/03/Compressor-station-emissions-and-health-impacts-02.24.2015.pdf>

⁸⁵⁹ McKain, K., Down, A., Raciti, S. M., Budney, J., Hutyra, L. R., Floerchinger, C., . . . Wofsy, S.C. (2015). Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts. *Proceedings of the National Academy of Sciences*, 112, 1941-46. doi: 10.1073/pnas.1416261112

⁸⁶⁰ Subramanian, R., Williams, L. L., Vaughn, T. L., Zimmerle, D., Roscioli, J. R., Herndon, S. C., . . . Robinson, A.L. (2015). Methane emissions from natural gas compressor stations in the transmission and storage sector: measurements and comparisons with the EPA Greenhouse Gas Reporting Program protocol. *Environmental Science & Technology*, 49, 3252-61. doi: 10.1021/es5060258

pads to processing plants—were regulated by neither federal nor state pipeline safety laws. The United States has nearly 230,000 miles of natural gas gathering lines that are unregulated, operating without safety standards or inspection. These pipelines are among the largest and highest-pressure pipes in use and carry gas at nearly three times the pressure of transmission lines, which transport the gas from the processing plants to urban distribution networks.⁸⁶¹

- November 11, 2014 – An analysis by a Carnegie Mellon University research team of 40,000 pipeline accidents from 1968 to 2009 found that comparatively few accidents accounted for a large share of total property damage, whereas a large share of fatalities and injuries were caused by numerous, small-scale accidents. There are 2.4 million miles of natural gas pipeline in the United States and 175,000 miles of hazardous liquid pipeline (which includes crude oil).⁸⁶²
- October 30, 2014 – A research team led by David O. Carpenter at University at Albany found high levels of formaldehyde near 14 compressor stations in three states. In Arkansas, Pennsylvania, and Wyoming, formaldehyde levels near compressor stations exceeded health-based risk levels. The authors noted that compressor stations can produce formaldehyde through at least two routes: it is created as an incomplete combustion byproduct from the gas-fired engines used in compressor stations. It is also created when fugitive methane, which escapes from compressor stations, is in the presence of sunlight. Formaldehyde is a known human carcinogen. Other hazardous air pollutants detected near compressor stations in this study were benzene and hexane. One air sample collected near a compressor station in Arkansas contained 17 different volatile compounds. (See entry for October 30, 2014 in Air Pollution.)
- October 15, 2014 – In comments to FERC, New York’s Madison County Health Department reviewed the literature on compressor station emissions and expressed concerns about associated health impacts, including documented correlations between health problems and residential proximity to compressor stations. It also reviewed health outcomes associated with exposures to chemicals known to be released from compressor stations, including VOCs, carbonyls and aldehydes, aromatics, and particulate matter. In addition, gas from fracking operations transiting through compressor stations may carry gaseous radon. The Health Department noted a troubling lack of information on the intensity, frequency, and duration of emission peaks that occur during the blowdowns and large venting episodes that are a normal part of compressor operations.⁸⁶³

⁸⁶¹ Wereschlagin, M. (2015, December 27). Rural gas gathering pipelines kindle concerns about safety laws. *Pittsburgh Review-Tribune*. Retrieved from <http://triblive.com/news/editorspicks/7362085-74/lines-gas-safety#axzz3NAHfzYF8>

⁸⁶² Siler-Evans, K., Hanson, A., Sunday, C., Leonard, N., & Tumminello, M. (2014). Analysis of pipeline accidents in the United States from 1968 to 2009. *International Journal of Critical Infrastructure Protection*, 7, 257-69. doi: 10.1016/j.ijcip.2014.09.002

⁸⁶³ New York State Madison County Health Department (2014, October 15). Comments to the Federal Energy Regulatory Committee concerning docket no. CP14-497-000, Dominion Transmission, Inc. Retrieved from https://www.madisoncounty.ny.gov/sites/default/files/publicinformation/madison_county_doh_comments_-_docket_no._cp14-497-000.pdf

- September 16, 2014 – Noting the proximity of a proposed high-pressure pipeline to Indian Point Nuclear Facility, as well as the evidence linking compressor station emissions to negative health impacts, New York’s Rockland County legislature adopted a resolution calling for a comprehensive Health Impact Assessment in regards to Spectra Energy’s planned Algonquin Incremental Market (AIM) natural gas pipeline, compressor, and metering stations expansion project.⁸⁶⁴ This resolution follows on the heels of similar resolutions expressing health concerns about the AIM project from both Westchester and Putnam County legislatures.^{865, 866}
- January 24, 2013 – A report prepared for the Clean Air Council by an independent consulting firm to evaluate air quality impacts from the Barto Compressor Station in Penn Township, Lycoming County, Pennsylvania predicted “large exceedances” of the nitrogen dioxide (NO₂) 1-hour NAAQS. Researchers used allowable emissions in the PA DEP permit, the 2006-2010 meteorological data and the latest EPA modeling guidance for the model’s prediction. Three techniques were used, and for two of the techniques, NAAQS exceedances occurred within a mile of the plant. The report concluded, “NO₂ impacts from the Barto plant alone are very significant since its emissions cause large exceedances of the 1-hour NAAQS.”⁸⁶⁷
- July 13, 2011 – A Fort Worth air quality study assessed the impact of drilling and fracking operations, and ancillary infrastructure, on concentrations of toxic air pollutants in the city of Fort Worth, Texas. The study found that compressor stations were a significant source of fracking-related air pollution. The compressor engines were responsible for over 99 percent of the hazardous air pollutants emitted from compressor stations, of which 67 percent was formaldehyde.⁸⁶⁸

⁸⁶⁴ Rockland County Legislature. (2014, September 16). *Resolution No. 404 of 2014 urging that health, safety and planning concerns be addressed and mitigated in the Environmental Review and all other review processes before project permissions be granted for Spectra Energy’s Algonquin Incremental Market (AIM) Natural Gas Pipeline, Compressor and Metering Stations Expansion Project*. Retrieved from

<https://sape2016.files.wordpress.com/2014/05/rockland-aim-resolution.pdf>

⁸⁶⁵ Board of Legislators County of Westchester, State of New York. (2014, July 21). *Resolution RES-2014-80*

Algonquin Incremental Marketing Project resolution. Retrieved from

<https://sape2016.files.wordpress.com/2014/05/080414-wcbol-resolution-no-80-2014-requesting-due-diligence-on-environment-p.pdf>

⁸⁶⁶ Putnam County Legislature. (2014, May 9). *Resolution #104, Resolution regarding the Algonquin Incremental*

Market (AIM) Project. Retrieved from <https://sape2016.files.wordpress.com/2014/05/putnam-county-resolutions-104-163-and-182-1.pdf>

⁸⁶⁷ Tran, K. T. (2013, January 24). *AERMOD modeling of NO₂ impacts of the Barto Compressor Station: Final*

report. Prepared for the Clean Air Council, Philadelphia, PA. Retrieved from

http://www.pennfuture.org/UserFiles/File/MineDrill/Marcellus/CAC_EmissionsNO2_CompressorBarto_20130124.pdf

⁸⁶⁸ Eastern Research Group. (2011, July 13). City of Forth Worth natural gas air quality study, final report. Retrieved from

<http://www.shaledigest.com/documents/2011/Air%20Quality%20Studies/Ft%20Worth%20Natural%20Gas%20Air%20Quality%20Study%20Final%20Report%20ERG%20Research%207-13-2011r.pdf>. See also Energy Research

Group. (2011, July 19). Forth Worth natural gas air quality study final report, pubic meeting presentation. Retrieved from http://fortworthtexas.gov/uploadedFiles/Gas_Wells/110719_ERG.pdf?v=110725

Gas storage: The Aliso Canyon leak

- November 22, 2017 – The U.S. Government Accountability Office (GAO) reported that, two years after the Aliso Canyon blow-out, the Pipeline and Hazardous Materials Safety Administration is failing to inspect natural gas storage sites in a timely manner, as called for by the Department of Transportation’s interim standards. Until 2016, states set the standards for 211 of the nation’s 415 gas storage sites, while the 204 sites that were connected to interstate pipelines had no standards at all. Collectively, these 415 natural gas storage sites contain about 17,000 wells that inject or withdraw natural gas from the underground formations below, which include depleted oil and gas reservoirs, abandoned mines, depleted aquifers, and hard rock caverns. The GAO noted that more than 300 cities and towns are located near natural gas storage sites.⁸⁶⁹
- June 21, 2017 – In response to requests from the oil and natural gas industry, the White House announced that it will delay implementation of a rule that would have set national standards for underground natural gas storage. Prompted by the 2015 disaster at Aliso Canyon and developed under the previous administration, this federal interim rule had called for phasing out single-point-of-failure, single-containment designs of the type that made impossible the task of swiftly shutting off the impaired Aliso Canyon well once it began leaking.⁸⁷⁰
- May 24, 2017 – A national assessment of thousands of underground gas storage wells by a Harvard School of Public Health team found that more than 20 percent are similar in design to the well that failed at Aliso Canyon. These obsolete wells, with single failure points and a median age of 74 years, operate in 19 states and represent more than half of the working capacity for U.S. natural gas. More than 2,700 of these wells were not originally designed to hold gas and, as at Aliso Canyon, have been repurposed to do so. An estimated 210 of these repurposed wells (located in Pennsylvania, Ohio, New York, and West Virginia) are more than 100 years old and entirely lack cement zonal isolation methods. Study author Jonathan Buonocore said, “Partly because no federal safety regulations apply to natural gas storage wells or their operations (now pending), very little aggregate information was available. . . . After we identified this data gap, we realized we needed to build our own database to begin to assess this previously

⁸⁶⁹ U.S. Government Accountability Office. (2017, November 22). *Natural gas storage: Department of Transportation could take additional steps to improve safety enforcement planning*. GAO-18-89. Retrieved from <https://www.gao.gov/assets/690/688553.pdf>.

⁸⁷⁰ Nemec, R. (2017, June 21). PHMSA pauses stricter natural gas storage rules for clarification. *Natural Gas Intel*. Retrieved from <http://www.naturalgasintel.com/articles/110856-phmsa-pauses-stricter-natural-gas-storage-rules-for-clarification>

inapparent hazard.” With the 50 percent increase in domestic natural gas production over the last ten years, natural gas storage is at an all time high and in demand.^{871, 872}

- October 21, 2016 – The California Air Resources Board determined that the Aliso Canyon gas storage facility released 100,000 tons of methane, becoming the largest ever natural gas leak in U.S. history.⁸⁷³
- October 18, 2016 – A federal task force issued a report with 44 recommendations intended to prevent another Aliso Canyon-style disaster. Chief among them is a phase-out of “single-point of failure” designs.⁸⁷⁴
- July 13, 2016 – As reported by the *Los Angeles Daily News*, Los Angeles County health officials were prepared to go to court to ensure that the Southern California Gas Company complies with an order to pay for professional comprehensive cleaning in the homes of residents who were relocated due to the Aliso Canyon gas leak. The company had filed legal papers asking that the order “to remove dust and oily mist from up to 35,000 homes be nullified,” after their report of having cleaned 1,700 homes to date. The Los Angeles County Health Department said the company had done a poor job on these and did not follow protocol to remove the metal particles, including barium, manganese, vanadium, aluminum, and iron previously identified in household surface dust.⁸⁷⁵
- July 9, 2016 – California’s South Coast Air Quality Management District and Southern California Gas Company were still at an impasse seven months after the company was given an abatement order that included a community health study on the potential impacts of exposures from the massive Aliso Canyon leak. The company was ordered to commit to paying “reasonable costs” for the study.⁸⁷⁶

⁸⁷¹ Michanowicz, D. R., Buonocore, J. J., Rowland, S. T., Konschnik, K. E., Goho, S. A., & Bernstein, A.S. (2017). A national assessment of underground gas storage identifying wells with designs likely vulnerable to a single-point-of-failure. *Environmental Research Letters*, 12(6). doi: 10.1088/1748-9326/aa7030

⁸⁷² Institute of Physics. (2017, May 24). Study uncovers widespread leak risk for US underground natural gas storage wells. *Phys.Org*. Retrieved from <https://phys.org/news/2017-05-uncovers-widespread-leak-underground-natural.html>

⁸⁷³ California Air Resources Board (2016, October 21). Determination of total methane emissions from Aliso Canyon natural gas leak incident. Retrieved from https://www.arb.ca.gov/research/aliso_canyon/aliso_canyon_methane_emissions-arb_final.pdf

⁸⁷⁴ U.S. Department of Energy and U.S. Department of Transportation’s Pipeline and Hazardous Materials Safety Administration. (2016, October 18). Ensuring safe and reliable underground natural gas storage: Final report of the interagency task force on natural gas storage safety. Retrieved from <https://energy.gov/sites/prod/files/2016/10/f33/Ensuring%20Safe%20and%20Reliable%20Underground%20Natural%20Gas%20Storage%20-%20Final%20Report.pdf>

⁸⁷⁵ Abram, S. (2016, July 13). SoCalGas slammed for poor cleanup of Porter Ranch homes. *Los Angeles Daily News*. Retrieved from <http://www.dailynews.com/health/20160713/socalgas-slammed-for-poor-cleanup-of-porter-ranch-homes>

⁸⁷⁶ Bartholomew, D. (2016, July 9). Gas Company, pollution agency at odds over cost of Porter Ranch health study. *Los Angeles Daily News*. Retrieved from <http://www.dailynews.com/government-and-politics/20160709/gas-company-pollution-agency-at-odds-over-cost-of-porter-ranch-health-study>

- June 22, 2016 – The first federal legislation of gas storage facilities was signed into law. The Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016 includes a provision in response to the Aliso Canyon gas leak requiring the Pipeline and Hazardous Materials Safety Administration to develop regulations for the construction and operation of underground natural gas storage facilities.⁸⁷⁷ (See entry below, of February 8, 2016, for analysis of the likely shortcomings of these first federal regulations and their inability to prevent a leak such as that at Aliso Canyon.)
- June 20, 2016 – As reported in *Geophysical Research Letters*, an airborne instrument onboard a NASA satellite was able to detect and quantify the size and shape of the methane plume from the Aliso Canyon gas leak as the event occurred.⁸⁷⁸ This is the first time a natural gas leak has been visible from space, according to the authors of the study.⁸⁷⁹
- May 4, 2016 – Southern California Gas Company said that costs related to the Aliso Canyon natural gas storage facility leak reached an estimated \$665 million. The utility company let the Securities and Exchange Commission know they carry policies with a combined limit available “in excess of \$1 billion,” but according to the *Los Angeles Times*, legal experts and lawyers said that \$1 billion in insurance might not be enough for what they ultimately need.⁸⁸⁰
- April 12, 2016 – California energy agencies issued a report indicating the threat of widespread summer power outages if no gas can be withdrawn from Aliso Canyon. The report was met with criticism. “Consumer groups and utility critics contend that the blackout warnings are an irresponsible scare tactic to ensure that Southern California Gas Company is allowed to keep storing gas at the facility and that ratepayers will pay for upgrades to store even more fuel there.”⁸⁸¹
- April 6, 2016 – The *Los Angeles Times* reported that, though prices for homes in Porter Ranch adjacent to the Aliso Canyon gas storage leak held up, sales declined. After the leak that began October 23, 2015, sales from December 2015 to February 2016 declined 20 percent from the year before. Disclosures for homes in the area “now include a mention of the community's proximity to the gas field and the recent problems.”⁸⁸²

⁸⁷⁷ Cama, T. (2016, June 22). Obama signs pipeline safety bill. *The Hill*. Retrieved from <http://thehill.com/policy/energy-environment/284479-obama-signs-pipeline-safety-bill>

⁸⁷⁸ Thompson, D. R., Thorpe, A. K., Frankenberg, C., Green, R. O., Duren, R., Guanter, L., ...Ungar, S. (2016). Space-based remote imaging spectroscopy of the Aliso Canyon CH₄ superemitter. *Geophysical Research Letters* 43(12). doi: 10.1002/2016GL069079

⁸⁷⁹ Mooney, C. (2016 June 15). This gas leak was so massive that NASA saw it from space. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/energy-environment/wp/2016/06/15/this-gas-leak-was-so-massive-that-nasa-saw-it-from-space/?utm_term=.1e66d8da1423

⁸⁸⁰ Penn, I. (2016, May 4). Costs related to Aliso Canyon leak reach an estimated \$665 million. *Los Angeles Times*. Retrieved from <http://www.latimes.com/business/la-fi-aliso-canyon-costs-20160504-snap-story.html>

⁸⁸¹ Penn, I. (2016, April 12). 'This is a threat. This is not a report.' Critics call blackout warnings a scare tactic to keep Aliso Canyon open. *Los Angeles Times*. Retrieved from <http://www.latimes.com/business/la-fi-gas-field-20160412-story.html>

⁸⁸² Khouri, A. (2016, April 6). Gas leak disrupts Porter Ranch housing market. *Los Angeles Times*. Retrieved from <http://www.latimes.com/business/realestate/la-fi-porter-ranch-sales-20160406-story.html>

- March 18, 2016 – The California State Oil and Gas Division of the Department of Conservation issued penalties totaling \$75,000 for three separate violations after finding incidents of intentional venting of gas at the Aliso Canyon gas field and malicious concealment of those acts. Both are violations of the state gas regulations.⁸⁸³ Following the Aliso Canyon gas storage leak, the California State Public Utilities Commission ordered a statewide survey of California’s 12 natural gas storage fields and found 229 faulty valves, flanges and leaky wellheads and a 230th leak at an abandoned well; eight were deemed hazardous.⁸⁸⁴
- March 14, 2016 – Methane and ethane emissions were measured to determine spatial patterns and source attribution of urban methane in the Los Angeles Basin. The surveys demonstrated the prevalence of fugitive methane emissions across the Los Angeles urban landscape and that fossil fuel sources accounted for 58–65 percent of methane emissions.⁸⁸⁵
- February 25, 2016 – Measurements of methane and other chemicals were taken by aerial equipment following the October gas release from a faulty well in the Aliso Canyon storage field. The data demonstrated that the blowout of this single well created the largest known anthropogenic point source of methane in the United States. The leak lasted 112 days and released a total of 97,100 tons of methane and 7,300 tons of ethane into the atmosphere. This was equal to 24 percent of the methane and 56 percent of the ethane emitted each year from all other sources in the Los Angeles Basin combined.⁸⁸⁶ Aliso Canyon was already a major pollution source before the massive leak.⁸⁸⁷ As determined by the study and reported by major news outlets, the recent methane leak is officially the worst in U.S. history.^{888, 889}
- February 18, 2016 – Stanford and UCLA scientists reported to *InsideClimate News* that the lack of measurement data for the entire 100+ days of community exposures to the

⁸⁸³ California Department of Conservation. (2016, March 18). State oil & gas division issues \$75,000 fine to operator for illegally venting natural gas. NR#2016-06. Retrieved from [http://www.conservation.ca.gov/index/Documents/2016-06%20DOC%20fines%20oil%20operator%20\\$75,000.pdf](http://www.conservation.ca.gov/index/Documents/2016-06%20DOC%20fines%20oil%20operator%20$75,000.pdf)

⁸⁸⁴ St. John, P. (2016, March 23). 229 leaks found in state's underground gas storage facilities, most considered minor. *Los Angeles Times*. Retrieved from

<http://www.latimes.com/local/lanow/la-me-ln-gas-leaks-storage-wells-20160322-story.html>

⁸⁸⁵ Hopkins, F. M., Kort, E. A., Bush, S. E., Ehleringer, J. R., Lai, C.-T., Blake, D. R., & Randerson, J. T. (2016). Spatial patterns and source attribution of urban methane in the Los Angeles Basin. *Journal of Geophysical Research: Atmospheres*, 121(5), 2490–2507. doi: 10.1002/2015JD024429

⁸⁸⁶ Conley, S., Franco, G., Faloona, I., Blake, D. R., Peischl, J. & Ryerson, T. B. (2016). Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA. *Science*. Advance online publication. doi: 10.1126/science.aaf2348

⁸⁸⁷ Lobet, I. & Reicher, M. (2016, February 14). *inewssource.org*. Retrieved from <http://inewssource.org/2016/02/14/aliso-canyon-major-pollution/>

⁸⁸⁸ Akpan, N. (2016, February 25). Los Angeles methane leak was officially the worst in U.S. history, study says. *PBS Newshour*. Retrieved from <http://www.pbs.org/newshour/rundown/los-angeles-methane-leak-is-officially-the-worst-in-u-s-history/>

⁸⁸⁹ Khan, A. (2016, February 25). Porter Ranch leak declared largest methane leak in U.S. history. *Los Angeles Times*. Retrieved from <http://www.latimes.com/science/sciencenow/la-sci-sn-porter-ranch-methane-20160225-story.html>

Aliso Canyon methane leak, combined with gaps in the science about many of the chemicals, hinders the ability to understand the health impacts of the leak. “The first week is when we would expect the highest gas concentrations to reach the neighborhood because the pressures in the storage field were the highest,” said Robert Jackson, an earth system science professor at Stanford University who measured methane concentrations in nearby communities during the leak. “And yet we don't have any information or data for that first week at least.” Jackson noted that even after monitoring was initiated, it was intermittent rather than continuous.⁸⁹⁰

- February 18, 2016 – Independent regional experts from USC and UCLA interviewed by Southern California Public Radio expressed skepticism that an industry-funded study ordered by the South Coast Air Quality Management District following the Aliso Canyon methane leak would be rigorously designed to answer specific questions about sub-chronic, cumulative exposures, including hydrogen sulfide, which was measured in the nearby Porter Ranch community at levels far greater than the average across American cities.⁸⁹¹
- February 13, 2016 – The Los Angeles County Department of Health prepared a *Supplemental Report* for its Expanded Air Monitoring Plan concerning the Southern California Gas Company’s Aliso Canyon storage facility long-term gas leak. The report addressed “chemicals of health concern” including toluene, ethylbenzene, xylene, hydrocarbons, VOCs, metals, and radon and concluded, “all results suggest that chemical exposures experienced by residents as a result of the gas leak are below the levels of concern that have been established by various regulatory agencies.”⁸⁹² Remaining challenges named by the report itself included possible gaps in data collection, other chemicals present for which no sampling occurred, and further study of the symptoms reported by the public. Many independent scientists did not concur with the Department of Health’s ongoing statements that chemical exposures were below levels of concern. Issues raised included monitoring not initiated until a week after the leak began, lack of continuous monitoring, and reliance on “grab samples.” Speaking to *InsideClimate News*, John Bosch, a retired air-monitoring expert with more than 30 years’ experience at the EPA said, “Grab samples may be OK as a first-tier guestimate of what the problem is, but you really have to have continuous monitoring.”⁸⁹³

⁸⁹⁰ McKenna, P. (2016, February 18). What will be the health impact of 100+ days of exposure to California's methane leak? *InsideClimate News*. Retrieved from <http://insideclimatenews.org/news/17022016/health-impacts-aliso-canyon-porter-ranch-methane-leak-california-socal-gas>

⁸⁹¹ O’Neill, S. (2016, February 18). Did the Porter Ranch gas leak cause long-term health damage? 89.33 *KPCC*. Retrieved from <http://www.scpr.org/news/2016/02/18/57666/did-the-porter-ranch-gas-leak-cause-long-term-health/>

⁸⁹² Los Angeles County Department of Health. (2016, February 13). ALISO CANYON GAS LEAK Results of Air Monitoring and Assessments of Health, SUPPLEMENTAL REPORT: Updated Results and Expanded Chemical Testing. Retrieved from <http://www.publichealth.lacounty.gov/media/docs/SUPPLEMENTAL%20-Aliso%20Canyon%20Gas%20Leak-%20Results%20of%20Air%20Monitoring%20and%20Assessments%20of%20Health%20-%202013-16.pdf>

⁸⁹³ McKenna, P. (2016, February 18). What will be the health impact of 100+ days of exposure to California's methane leak? *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/17022016/health-impacts-aliso-canyon-porter-ranch-methane-leak-california-socal-gas>

- February 8, 2016 – The Pipeline and Hazardous Materials Safety Administration (PHMSA) announced that it might issue its first federal safety regulations for gas storage sites such as Aliso Canyon, while also suggesting site operators voluntarily follow guidelines that the proposed rules (which would likely take years to issue) will likely mirror. According to a report in *InsideClimate News*, these guidelines would not require systems to stop the flow of gas in an emergency or mandate redundancies to prevent methane from leaking into the environment.” If PHMSA proceeds to adopt industry guidelines, the resulting rules “may not address two key issues that turned Aliso Canyon into a disaster: emergency shutoff valves and a safer configuration of pipes.” Further, even with new regulations, storage units would most likely remain under state jurisdiction, “though state authorities may adopt any new federal rules.”⁸⁹⁴ A subsequent story reported on members of Congress pressing PHMSA to create the first federal standards for the 418 underground gas storage facilities for which it has authority to set regulations. In the hearing before a subcommittee of the House Committee on Transportation and Infrastructure, California representatives “spoke about their efforts to speed up PHMSA’s rulemaking for underground gas storage.”⁸⁹⁵
- February 5, 2016 – As part of the Expanded Air Monitoring Plan, Los Angeles County Department of Health provided results for the primary chemicals of concern to assess health effects in residents, pets, and other animals in the community during the Southern California Gas Aliso Canyon storage facility leak. Those chemicals included methane, odorants, and benzene. The maximum level of methane detected was 4,340 ppm and the maximum level of benzene was 30.6 ppb. Early on, average weekly benzene levels that were close to the 1 ppb chronic exposure limit/ health protective level. “Methane levels have remained above normal, but have decreased substantially over time,” the report summarized. It also stated that odorants “... remained below instrument detection limits throughout the entire period, including immediately after the leak, even at locations near the leaking well,” and that “[b]enzene and other chemicals were originally detectable at levels above normal from within community sampling sites, but peak levels remained below acute exposure thresholds.”⁸⁹⁶ While the Los Angeles County Department of Health concluded that “health effects resulting from the on-going leak should be limited to short-term effects resulting from exposure to the odorants,” independent scientists, noting data gaps, have challenged these conclusions.
- January 25, 2016 – Some health experts and residents of Porter Ranch, California, adjacent to the Aliso Canyon gas field leak, expressed concern about long-term exposure to the odorous component of the gas, mercaptans, to which regulators attributed several symptoms of residents. Mercaptans are sulfurous chemicals that are added to natural gas to aid in the detection of leaks. Though California regulators have said the health

⁸⁹⁴ McKenna, P. (2016, February 8). New federal gas storage regulations likely to mimic industry's guidelines. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/08022016/federal-gas-storage-regulations-likely-mimic-industry-guidelines-aliso-canyon-phmsa-api>

⁸⁹⁵ Song, L. (2016, February 26). *InsideClimate News*. U.S. pipeline agency pressed to regulate underground gas storage. Retrieved from <https://insideclimatenews.org/news/26022016/phmsa-pipeline-regulator-pressed-regulate-underground-natural-gas-storage-aliso-canyon-methane>

⁸⁹⁶ Los Angeles County Department of Health. (2016, February 5). Aliso Canyon gas leak: Results of air monitoring and assessments of health. Retrieved from <http://www.publichealth.lacounty.gov/media/docs/AlisoAir.pdf>

problems, such as headaches, vomiting, and nosebleeds are temporary and will not lead to long-term damage, medical researchers described data gaps to *InsideClimate News*. There is “virtually no research on prolonged exposure to mercaptans.” Further, some researchers suggest the health problems may have been caused by different chemicals in the gas, and that “regulators have downplayed the significance of other contaminants that are also present in the leak.”⁸⁹⁷

- January 19, 2016 – Peter Richman, MD, president of the Los Angeles County Medical Association told the *Los Angeles Daily News* that, at nearly three months after the Aliso Canyon methane leak began, physicians had yet to receive a formal statement from the Los Angeles County Department of Public Health about airborne chemical pollutants related to the gas leak or guidelines on how to answer questions from patients about long-term health effects. Richman expressed special concern about prolonged exposure to methane and trace chemicals known to be carcinogenic. Another area physician reported that, as of the interview date, his urgent care practice had seen a hundred patients whose symptoms were consistent with exposure to leak-related pollutants.⁸⁹⁸
- January 14, 2016 – Boston University researcher Nathan Phillips and Bob Ackley of Gas Safety USA drove a high precision GIS-enabled gas analyzer through roads throughout California’s San Fernando Valley adjacent to the Aliso Canyon gas leak in early January 2016. Early results showed methane levels elevated 2-67 times the background level.⁸⁹⁹
- January 13, 2016 – Investigations into the possible cause of the gas leak in Aliso Canyon included the consideration that nearby fracking may have contributed to casing failure. In an email to the *Los Angeles Daily News*, California Department of Conservation Chief Deputy Jason Marshall said that their investigation will examine well records, including those pertaining to “well stimulation operations.”⁹⁰⁰ According to a 2015 report prepared for the California Council on Science and Technology, hydraulic fracturing is used about twice yearly to enhance storage “mostly in one facility serving southern California (Aliso Canyon).”⁹⁰¹

⁸⁹⁷ Song, L. (2016, January 25). Mercaptans in methane leak make Porter Ranch residents sick, and fearful. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/22012016/porter-ranch-residents-health-effects-methane-leak-aliso-canyon-california>

⁸⁹⁸ Abram, S. (2016, January 19). Doctors treating Porter Ranch residents want more gas-leak guidance. *Los Angeles Daily News*. Retrieved from <http://www.dailynews.com/health/20160119/doctors-treating-porter-ranch-residents-want-more-gas-leak-guidance>

⁸⁹⁹ Bartholomew, D. (2016, January 14). ‘Plume chaser’ researchers fan out across San Fernando Valley to map reach of Porter Ranch gas leak. *Los Angeles Daily News*. Retrieved from <http://www.dailynews.com/environment-and-nature/20160114/plume-chaser-researchers-fan-out-across-san-fernando-valley-to-map-reach-of-porter-ranch-gas-leak>

⁹⁰⁰ Wilcox, G. J. (2016, January 13). Regulators probing whether fracking was connected to Aliso Canyon gas well leak. *Los Angeles Daily News*. Retrieved from <http://www.dailynews.com/environment-and-nature/20160113/regulators-probing-whether-fracking-was-connected-to-aliso-canyon-gas-well-leak>

⁹⁰¹ Long, J. C. S., Feinstein, L. C., Birkholzer, J., Jordan, P., Houseworth, J., Dobson, P. F., . . . Gautier, D. L. (2015). *An independent scientific assessment of well stimulation in California, Volume I: Well stimulation technologies and their past, present, and potential future use in California*. California Council on Science and Technology, Sacramento, CA. Retrieved from <https://ccst.us/publications/2015/2015SB4-v1.pdf>

- January 13, 2016 – “Aliso Canyon is a wake-up call,” according to a *Rocky Mountain PBS News* investigative report on the state of U.S. natural gas infrastructure. Natural gas is no longer a cleaner fuel than coal when methane leakage rates exceeds 2-4 percent, but the vast size of the nation’s interconnected natural gas storage and pipeline systems makes difficult the task of tallying all the micro-leaks spread across the entire network and answering fundamental questions about exactly how much methane is being lost. The PBS report also expressed concern about the age of many of the system’s component parts. According to the piece, nearly half (46 percent) of the nation’s transmission pipelines, designed to carry high-pressure gas over long distances, were built in the 50s and 60s and are now more than a half century old.⁹⁰²
- December 30, 2015 – According to the *Los Angeles Daily News*, which unearthed November 2014 state regulatory filing documents, the Southern California Gas Company knew about the corrosion and potential for leakage at Aliso Canyon prior to the massive blow-out. “In written testimony to the California Public Utilities Commission, [SoCalGas Director of Storage Operations Phillip] Baker described a reactive maintenance process that hinted at major leakage problems underground.”⁹⁰³
- November 20, 2015 – California state agencies collaborated with Aviation Scientific to measure methane emission rates at two early November dates, finding rates of 44,000±5,000 kilograms of methane per hour and 50,000±16,000 kilograms of methane per hour. The results indicated that the Aliso Canyon gas leak would have contributed about a quarter of California’s methane emissions for the time period studied.⁹⁰⁴
- November 20, 2015 – According to the *Los Angeles Times*, one month into the Aliso Canyon ongoing gas leak, Southern California Gas warned that it “might need several months” to plug the leak. An order from California’s Division of Oil, Gas and Geothermal Resources, “stated that an ‘uncontrolled flow of fluids’ and gas was escaping and the operator had failed to fully inform state officials about the well’s status. Steve Bohlen, the state oil and gas supervisor, also directed the company to submit a schedule for remediation work or for drilling a relief well.”⁹⁰⁵
- October 19, 2015 – *Houston Public Media* reported on the 125 caverns carved out of salt storing natural gas liquids (NGLs), thousands of feet under the city of Mont Belvieu, Texas, east of Houston. “There have been fiery accidents here. But nothing like what

⁹⁰² Wirfs-Brock, J. (2016, January 13). Vast California methane leak is dire but not unique in aging infrastructure. *Rocky Mountain PBS News*. Retrieved from <http://inewsnetwork.org/2016/01/13/vast-california-methane-leak-is-dire-but-not-unique-in-aging-infrastructure/>

⁹⁰³ Reicher, M. (2015, December 30). SoCalGas knew of corrosion at Porter Ranch gas facility, doc shows. *Los Angeles Daily News*. Retrieved from <http://www.dailynews.com/general-news/20151230/socalgas-knew-of-corrosion-at-porter-ranch-gas-facility-doc-shows>

⁹⁰⁴ California Air Resources Board. (2015, November 20). Report on greenhouse gas emissions from Aliso Canyon leak. *Los Angeles Times*. Retrieved from <http://documents.latimes.com/report-greenhouse-gas-emissions-aliso-canyon-leak/>

⁹⁰⁵ Barboza, T. (2015, November 20). Natural gas leak that's sickening Valley residents could take months to fix. *Los Angeles Times*. Retrieved from <http://www.latimes.com/local/california/la-me-1121-gas-leak-20151121-story.html>

happened 23 years ago at a different [NGL] storage site 100 miles to the west. ‘A bomb-like blast literally blew residents in this small community out of their beds this morning, said a reporter for Dallas’s Channel 8 as he did a live report just outside the city of Brenham.’ That blast, which killed three and injured 21, was reportedly caused by the lack of an emergency shut-off valve. There are no federal standards in place for such requirements. Twenty-three years later, a month prior to the *Houston Public Media* report, “at a hearing held by the U.S. Senate Committee on Commerce, Science, & Transportation, Donald Santa, head of the Interstate Natural Gas Association of America, told the senators that it was only in recent weeks that the industry approved standards for storing natural gas.” Texas did enact legislation a year after the deadly blast “and now requires emergency shutoff valves and inspections for leaks every five years.”⁹⁰⁶

- October 5, 2011 – The federal district court in Topeka struck down Kansas gas-safety laws in 2010, and 11 underground storage sites with a capacity of more than 270 billion cubic feet of gas have gone uninspected, leaving thousands of Kansans to live on and around uninspected gas-storage fields.⁹⁰⁷
- 2008 – When considering the possibility of storing natural gas in a variety of underground gas storage facilities, the UK government commissioned the British Geological Survey to identify the main types of facilities currently in operation worldwide along with any documented or reported failures and incidents which have led to release of stored product. The researchers found that California had the most incidents, but concluded that many of these problems and geological factors would not necessarily be applicable to the UK. The incidents most relevant to gas storage in the UK resulted from a failure of either the man-made infrastructure (well casings, cement, pipes, valves, flanges, compressors etc.), or human error, which has included overfilling of caverns and inadvertent intrusion. Extreme natural events, including earthquakes, also played a role. The researchers looked closely at incidents in salt caverns that had been repurposed to store gas. They reported that “early salt cavern storage in the US was done in brine wells that had been solution mined [in which salt deposits are melted away with hot water or steam] without consideration for subsequent storage in the depleted caverns. This practice sometimes resulted in later problems for storage operations in retrofitted brine caverns.” The authors conclude that the rate for a geological failure of the storage cavity in an underground gas storage facility is of the order of 10^{-5} failures per well year.⁹⁰⁸

⁹⁰⁶ Fehling, D. (2015, October 19). On edge of Houston, underground caverns store huge quantities of natural gas liquids. *Houston Public Media*. Retrieved from <http://www.houstonpublicmedia.org/articles/news/2015/10/19/124674/on-edge-of-houston-underground-caverns-store-huge-quantities-of-natural-gas-liquids/>

⁹⁰⁷ Lefler, D. (2011, October 5). Lawsuit leaves large gas storage fields in Kansas unregulated. *Wichita Eagle*. Retrieved from <http://www.kansas.com/news/article1071558.html>

⁹⁰⁸ Keeley, D. (Health and Safety Laboratory). 2008. *Failure rates for underground gas storage: Significance for land use planning assessments*. Health and Safety Laboratory for the Health and Safety Executive, Derbyshire, UK. Retrieved from <http://www.hse.gov.uk/research/rpdf/rr671.pdf>

Liquefied natural gas (LNG) facilities

- November 20, 2017 – Using a hybrid lifecycle and energy strategy analysis, a team of energy researchers investigated the potential climate impacts of U.S. LNG exports to Asia. They found that gas emissions were widely variable, dependent on the specific destination and the ultimate purpose for which the gas is used. Despite this range, under a scenario in which U.S. LNG exports continue to rise, “emissions are not likely to decrease and may increase significantly” because of additional energy demand, higher U.S. emissions, and increased methane leakage. The study also predicted that increased LNG exports could actually prolong the lifespans of coal-fired plants within the United States. All together, these factors, “have the very real potential to undermine any prospective climate benefit in the long run.” Going forward, policymakers must consider “the complete climate ramifications of LNG exports.”⁹⁰⁹ *E&E News*, reporting on the study, quoted one of the authors as saying, “The implications of our paper are that the greenhouse gas impacts from exporting U.S. natural gas...here at home and abroad, can be very, very bad.”⁹¹⁰
- July 25, 2017 – Citing volatile market conditions, Malaysia’s energy giant Petronas cancelled plans for a massive LNG export terminal at the mouth of the Skeena River on British Columbia’s remote northwest coast in Canada. As reported extensively by *The Tyee*, the project was the target of intense protest by First Nations people and the subject of many lawsuits, as it threatened public health and would industrialize pristine salmon habitat. “At one time as many as twenty LNG projects were proposed for coastal communities, but not one has been built. The majority of largely Asian-backed proponents have now cancelled or deferred their projects. A 50 percent drop in global oil prices combined with a 70 percent drop in global LNG prices forced Petronas to...scuttle a number of projects over the last two years.”⁹¹¹
- July 10, 2017 – Using a lifecycle assessment and optimization analysis to forecast the environmental impacts of LNG, researchers modeled three usage scenarios: hydrogen production; electricity generation; and vehicle fuel. The model assumed LNG transport by pipeline only, and not by tanker. The highest environmental impact in each case was global warming potential (GWP), and the highest GWP occurred when LNG was used as vehicle fuel.⁹¹²
- March 30, 2017 – Transportation researchers identified and assessed potential risks to public safety from LNG transport on inland waterways and as a fuel for vessels and

⁹⁰⁹ Gilbert, A. Q., & Sovacool, B. K. (2017). US liquefied natural gas (LNG) exports: Boom or bust for the global climate? *Energy*, 141, 1671-1680. doi: 0.1016/j.energy.2017.11.098

⁹¹⁰ Gilmer, E. M., & Mandel, J. (2017, December 15). Increased LNG exports would spell trouble for climate – study. *E&E News*. Retrieved from <https://www.eenews.net/stories/1060069129>

⁹¹¹ Nikiforuk, A. (2017, July 25). ‘Basic economics’ kill \$11-billion LNG project on BC’s coast. *The Tyee*. Retrieved from https://thetyee.ca/News/2017/07/25/LNG-Project-BC-Coast-Killed/?utm_source=facebook&utm_medium=social&utm_content=072517-4&utm_campaign=editorial-0717

⁹¹² Zhang, Y., Jiang, H., Li, J., Shao, S., Hou, H., Qi, Y., & Zhang, S. (2017). Life cycle assessment and optimization analysis of different LNG usage scenarios. *International Journal of Life Cycle Assessment*. Advance online publication. doi: 10.1007/s11367-017-1347-2

ferries. The hazards included the possibility of collision with other ships or with stationary objects such as bridges, as well as the threats of vapor release, flash and jet fires, boiling liquid expanding vapor explosion, and rapid phase transition. Firefighting strategies for different scenarios were proposed.⁹¹³

- March 9, 2017 – Liquefaction, LNG transport, and LNG evaporation determined more than 50 percent of LNG’s global warming potential (GWP) in a “cradle to gate” life cycle analysis of LNG imported to the UK from Qatar. The analysis confirmed the dangerous effect of fugitive methane emissions on the total GWP of the supply chain. Other important parameters affecting GWP included the shipping distance and the tank volume.⁹¹⁴
- December 22, 2016 – Methane emissions from the heavy-duty transportation sector have climate change implications, according to a “pump-to-wheels” evaluation of natural gas powered vehicles and the compressed natural gas and LNG stations that fuel them. While fueling stations themselves leak methane, tailpipe and crankcase emissions were the highest sources.⁹¹⁵
- May 2, 2016 –The potential economic and greenhouse gas (GHG) impacts of importing LNG to Hawaii for electricity generation was modeled. Methane is a potent GHG, and although the use of LNG would decrease the local GHG output of Hawaii’s electrical sector, lifecycle (global) GHG emissions would likely increase. This study did not examine other potential environmental impacts of LNG. Currently, the majority of Hawaii’s electricity is provided by oil-fired generation.⁹¹⁶
- November 12, 2015 – New York Governor Andrew Cuomo rejected a heavily contested proposal to construct an LNG terminal 19 miles off the coast of Long Island. From his letter to the Maritime Administration: “The security and economic risks far outweigh any potential benefits. . . .The potential for disaster with this project during extreme weather or amid other security risks is simply unacceptable.” The governor also noted the risks posed to scallop and squid fisheries as well as the project’s conflict with a proposed large-scale, offshore wind farm.⁹¹⁷
- September 30, 2015 – Measurements of the gaseous and particulate emissions of a cruise ferry on the Baltic Sea using a dual-fuel engine showed that LNG is not a clean fuel for

⁹¹³ Galieriková, A., Kalina, T., & Sosedová, J. (2017). Threats and risks during transportation of LNG on European inland waterways. *Transport Problems*, 12(1), 73-81. doi: 10.20858/tp.2017.12.1.7

⁹¹⁴ Tagliaferri, C., Clift, R., Lettieri, P., & Chapman, C. (2017). Liquefied natural gas for the UK: A life cycle assessment. *International Journal of Life Cycle Assessment*, 22, 1944–1956. doi: 10.1007/s11367-017-1285-z

⁹¹⁵ Clark, N. N., McKain, D. L., Johnson, D. R., Wayne, W. S., Li, H., Akkerman, V., . . . Ugarte, O. J. (2017). Pump-to-wheels methane emissions from the heavy-duty transportation sector. *Environmental Science & Technology*, 51(2), 968-976. doi: 10.1021/acs.est.5b06059

⁹¹⁶ Coffman, M., Bernstein, P., Wee, S., & Schafer, C. (2017). Economic and GHG impacts of natural gas for Hawaii. *Environmental Economics and Policy Studies*, 19, 519–536. doi: 10.1007/s10018-016-0157-2

⁹¹⁷ Santora, M. (2015, November 12). Cuomo rejects natural gas port proposed off Long Island. *The New York Times*. Retrieved from https://www.nytimes.com/2015/11/13/nyregion/cuomo-rejects-natural-gas-port-proposed-off-long-island.html?_r=0

ships. Methane made up about 85 percent of the vessel's hydrocarbon emissions. Particulate emissions showed a huge amount of volatile and nonvolatile particles, both of which are hazardous to human health.⁹¹⁸

- September 26, 2014 – The GAO issued a report of the federal process for reviewing applications to export LNG. As part of the process, the Department of Energy (DOE) and FERC consider public comment. Numerous environmental concerns include the risk that exports will increase hydro-fracking for natural gas, along with its associated environmental effects and greenhouse gas emissions. Under the National Environmental Policy Act, the DOE must consider the environmental effects of its decisions.⁹¹⁹
- April 23, 2014 –The dynamics and hazards from a LNG spill are not well understood and require further research, according to a comprehensive review of research into the LNG production chain from Australia that examined vapor production, vapor dispersion, and mechanisms of combustion. Noting the “intrinsic process safety issues” of LNG as well as potential attraction as a terrorist target, authors described various threats to human safety, including pool fires, jet fires, and vapor cloud explosions.⁹²⁰
- December 14, 2009 – Certain LNG hazards are not “understood well enough to support a terminal siting approval,” according to a Congressional Research Service (CRS) report that summarizes LNG hazards in the context of federal rules related to where LNG terminals are located. Potential risks include pool fires and flammable vapor clouds, as well as the possibility of terrorist attacks. The analysis points out the need for additional LNG safety research.⁹²¹
- July 7, 2009 – Because LNG projects are among the most expensive energy projects, the reserves of gas to justify the investment need to be large enough to guarantee about 30 years of production, according to a report by the Joint Research Centre of the European Union.⁹²²
- May 13, 2008 – LNG infrastructure is “inherently hazardous and it is potentially attractive to terrorists,” according to a CRS study that was prepared at a time when the United States was a net importer of LNG. Security of tankers, import terminals, and inland storage plants were identified as issues of concern. Serious risks include pool fires with intense heat, which can occur when LNG spills near an ignition source; flammable vapor clouds that can drift until reaching an ignition source; and a rapid phase transition

⁹¹⁸ Anderson, M., Salo, K., & Fridell, E. (2015). Particle- and gaseous emissions from an LNG powered ship. *Environmental Science & Technology*, 49, 12568–12575. doi: 10.1021/acs.est.5b02678

⁹¹⁹ U.S. Government Accountability Office. (2014, September). *Federal approval process for liquefied natural gas exports*. GAO-14-762. Retrieved from <https://www.gao.gov/assets/670/666177.pdf>

⁹²⁰ Ikealumba, W. C., & Wu, H. Some recent advances in liquefied natural gas (LNG) production, spill, dispersion, and safety. *Energy & Fuels*, 28(6), 3556–3586. doi: 10.1021/ef500626u

⁹²¹ [Name redacted]. (2009, December). *Liquefied natural gas (LNG) import terminals: Siting, safety, and regulation*. Congressional Research Service. RL32205. Retrieved from https://www.everycrsreport.com/files/20091214_RL32205_e95cb50c88dbd56a2c8f706b2d521ef7ae81ee00.pdf

⁹²² Kavalov, B., Petric, H., & Georgakaki, A. (2009). *Liquefied natural gas for Europe—some important issues for consideration*. European Commission Joint Research Centre, Reference Report. doi: 10.2790/1045.

that can generate a flameless explosion. As per this report, there have been 13 serious accidents at onshore LNG terminals since 1944.⁹²³

- February 22, 2007 – The GAO examined the results of studies on the consequences of an LNG spill and discussed expert opinion about the consequences of a terrorist attack on an LNG tanker. The studies indicate that 30 seconds of exposure to the heat of an LNG fire could cause burns up to a distance of about one mile. The experts concluded that this would be the most likely public safety hazard, with the risk of explosion less likely. Recommendations were made for further studies, including evaluating the possibility of “cascading failure,” where multiple LNG tanks on a ship might fail in sequence.⁹²⁴
- September 9, 2003 – As part of a larger investigation of potential terrorist targets in wake of the 9/11 attacks, the CRS provided a background report to the U.S. Congress on the security of LNG terminals in the United States. At the time, the United States was a net importer of natural gas, and LNG was shipped from overseas to U.S. ports. CRS identified LNG tanker ships and storage infrastructure as “vulnerable to terrorism,” noting that tankers could be turned as weapons against coastal cities and that inland LNG facilities are typically located near large population centers. The CRS further noted that the public cost of security for LNG shipments, via Coast Guard escorts of tankers through coastal shipping channels, was considerable (\$40,000-\$80,000 per tanker).⁹²⁵
- August 1, 1995 – The U.S. Department of Transportation identified three important hazardous properties of LNG: flammability hazards (fire or explosion from ignition of leaks); toxicity hazards (asphyxiation from exposure to non-odorized fuel gas); cryogenic hazards (personal injury plus structural failure of equipment from prolonged exposure to extremely cold temperatures.)⁹²⁶

Inaccurate jobs claims, increased crime rates, threats to property values and mortgages, and local government burden

Experiences in various states and accompanying studies have shown that the oil and gas industry’s promises of job creation from drilling for natural gas have been greatly exaggerated. Many of the jobs are short-lived, have gone to out-of-area workers, and, increasingly, are lost to automation. With the arrival of drilling and fracking operations, communities have experienced steep increases in rates of crime, including assault, rape, larceny, and auto theft.

⁹²³ Parfomak, P. W. (2008, May). *Liquefied natural gas (LNG) infrastructure security: Issues for Congress*. Congressional Research Service. RL32073. Retrieved from <https://www.hsdl.org/?view&did=486464>

⁹²⁴ U.S. Government Accountability Office. (2007, February). *Public safety consequences of a terrorist attack on a tanker carrying liquefied natural gas need clarification*. GAO-07-316. Retrieved from <https://www.gao.gov/new.items/d07316.pdf>

⁹²⁵ Congressional Research Service. (2003, September 9). *Liquefied natural gas (LNG) infrastructure security: Background and issues for Congress*. Retrieved from http://www.energy.ca.gov/lng/documents/CRS_RPT_LNG_INFRA_SECURITY.PDF

⁹²⁶ U.S. Dept. of Transportation, Federal Transit Administration. (1995, August 1). *Summary of assessment of the safety, health, environmental and system risks of alternative fuel*. Retrieved from <https://rosap.ntl.bts.gov/view/dot/8403>

Crime rates have increased even with additional allocation of funds for public safety. Financial and other strains on municipal services include those on law enforcement, road maintenance, emergency services, and public school district administration. In Texas alone, road damage and other transportation impacts costs an estimated \$1.5-\$2 billion a year. In shale boom areas across the United States, school districts report heightened stress, regardless of whether student funding increased or decreased. Economists are increasingly quantifying community quality of life impacts and the unequal distribution of costs and benefits associated with drilling and fracking. Drilling and fracking pose an inherent conflict with mortgages and property insurance due to the hazardous materials used and the associated risks. The departure of drilling and fracking operations from communities eases some of these challenges but can also lead to additional economic harm such as by a sharp uptick in foreclosures, late car and mortgage payments, empty housing units, and failed or diminished local businesses.

- September 26, 2017 – The partial abandonment of the Eagle Ford Shale dramatically hurt small business owners, according to a report by *Bloomberg*. “As the shale drillers moved on to richer fields, the South Texas landscape became pockmarked with abandoned structures. This nimbleness—the ability to just pack up and leave at a moment’s notice—may give U.S. oil companies a competitive advantage against their more rigid state-run OPEC rivals, but there is a human cost to it all.” Concerning one tool and supply company in the region, the investigation found: “During the height of the Eagle Ford boom, R. Katz was supplying as many as 52 rigs and employing as many as 18 people in its office outside Cuero’s main strip. Today, it’s got 11 rig clients and three employees.”⁹²⁷
- August 10, 2017 – Researchers from the independent, nonpartisan economic research group Resources for the Future studied the impacts of unconventional oil and gas booms on public school districts in the oil- and gas-producing states Pennsylvania, Ohio, West Virginia, North Dakota, Montana, and Colorado between 2000 and 2013. Using quantitative data analysis as well as extensive interviewing with parents and students in the districts, the study addressed the effects of recent oil and gas booms on student enrollment, teachers, public education finances, and student achievement metrics. Though divergent trends were found between school districts in the eastern versus western U.S., “nearly all boom districts reported heightened stress from financial volatility.” Though some districts had a statistically positive increase in per student funding while others had a decline, “the study found that greater revenues do not always translate into increased educational outcomes.... One western Colorado school district had to operate on a four-day-a week schedule and cut academic programs because of increased economic volatility.”⁹²⁸ As reported in *U.S. News and World Report*, “the boom-and-bust cycle of the industry was found to create overwhelming stress on local

⁹²⁷ Murtaugh, D. (2017, September 26). The oil ghost towns of Texas. *Bloomberg*. Retrieved from <https://www.bloomberg.com/news/features/2017-09-26/the-oil-ghost-towns-of-texas>

⁹²⁸ Ratledge, N. & Zachary, L. (2017). *Impacts of unconventional oil and gas booms on public education: A mixed-methods analysis of six producing states*. Retrieved from <http://www.rff.org/research/publications/impacts-unconventional-oil-and-gas-booms-public-education-mixed-methods>

districts as students and teachers were moving in and out of a region to meet the economic demands of drilling.”⁹²⁹

- June 18, 2017 – A Shale Task Force of the Academy of Medicine, Engineering and Science of Texas (TAMEST) developed the report, *Environmental and Community Impacts of Shale Development in Texas*, a “first-of-its-kind, comprehensive review of scientific research and related findings regarding impacts of shale oil and gas production in Texas.” Transportation impacts included road damage costing Texas an estimated \$1.5 to \$2 billion a year, and rural crashes involving commercial vehicles increasing over 75 percent in some drilling regions. The number of fatal collisions in the Permian Basin doubled from 94 during 2006 to 2009, to 183 from 2010 to 2013. The report also noted that Texas is the only major oil and gas producing state without a “surface damage act” to protect landowners, who do not own the mineral rights on their land and have little control over oil and gas operations. The report, which also addressed topics such as seismicity, air, and water, noted that the various impacts of oil and gas development “can’t be studied or addressed in isolation.” Authors continued, “[t]hese connections are important and pervasive, but are not well-studied yet.” TAMEST includes all of the state’s Nobel Laureates, plus Texas-based members of the National Academies of Sciences, Engineering, and Medicine.⁹³⁰
- April 5, 2017 – Economists at Colorado State University quantified the “substantial environmental costs associated with hydraulic fracturing,” as part of an analysis of the market and non-market costs and benefits of fracking in 14 U.S. states. These costs were “dominated by \$27.2 billion (\$12.5–\$41.95 billion) health damages from air pollution.” They also found costs including “\$3.8 billion (\$1.15–\$5.89 billion) in greenhouse gas emissions, \$4 billion (\$3.5–\$4.45 billion) in wildlife habitat fragmentation, and \$1 billion (\$0.5–\$1.6 billion) in pollution of private drinking water wells.” Results also showed a disconnect between those reaping economic rewards from fracking and those paying the price: the “benefits” (mostly in the form of lower natural gas prices to residential, commercial, and industrial consumers) were geographically dispersed while the costs tended to concentrate in localized areas where drilling took place. Although the most comprehensive economic study to date, this analysis was not able to fully quantify all costs, including those related to water contamination (beyond surface-spill related costs for damage to private wells); diminishment of open spaces and aesthetics for community members; and seismic activity. The authors concluded that costs might well outweigh the benefits for suburban dwellers near fracking operations, as exemplified by Denton, Texas, where “nearly all the royalty money was flowing to mineral owners living elsewhere... rather than to adjacent homeowners.”⁹³¹

⁹²⁹ Englert, E. (2017, August 10). Fracking brings challenges to local school systems. *U.S. News and World Report*. Retrieved from <https://www.usnews.com/news/national-news/articles/2017-08-10/fracking-brings-challenges-to-local-school-systems>

⁹³⁰ The Academy of Medicine, Engineering and Science of Texas. (2017). *Environmental and Community Impacts of Shale Development in Texas*. Retrieved from <http://tamest.org/shale-task-force/>
doi: 10.25238/TAMESTstf.6.2017

⁹³¹ Loomis, J., & Haefele, M. (2017). Quantifying market and non-market benefits and costs of hydraulic fracturing in the United States: A summary of the literature. *Ecological Economics*, 138, 160-167. doi: 10.1016/j.ecolecon.2017.03.036

- February 19, 2017 – The *New York Times* reported on the oil and gas industry’s embrace of automation and its threat to preserving and bringing back jobs. Executives interviewed as part of the investigation were straightforward in their intentions to shrink their work forces. “‘We want to transform our work force to the point where we need to hire fewer people,’ said Joey Hall, Pioneer’s executive vice president for Permian Operations.” In 2016 Pioneer Natural Resources added 240 wells in West Texas without adding any new employees. A vice president at a Pennsylvania manufacturer of drilling rigs stated, “If it’s a repetitive task, it can be automated, and I don’t need someone to do that. I can get a computer to do that.”⁹³²
- February 1, 2017 – Stanford University earth science professor Robert Jackson and two professors of law assessed how a new type of “conservation easement,” an established kind of legal agreement, could enable landowners to restrict fracking on their properties. A mineral estate conservation easement (MECE) can serve as a private landowner response to the demonstrable threats of fracking to property and community: “Accompanying the rise of high-volume hydraulic fracturing has been a suite of environmental and social concerns, including potential water and air contamination, greenhouse gas emissions, health effects, and community disruptions.” “We support the exploration of MECEs as an additional tool for landowners to exercise their rights and responsibilities,” the team concluded.⁹³³
- January 26, 2017 – Automation is reducing the size of drilling crews and will lessen the number of jobs added nationally with any upturn in oil and gas operations, according to a piece on OilPrice.com. The author described predictions, including:

Automated drilling rigs may be able in the future to reduce the number of persons in a drilling crew by almost 40 percent, from 25 workers to 15 workers, *Houston Chronicle*’s Jordan Blum writes, quoting industry analysts.

Drilling company Nabors Industries expects that it may be able to reduce the size of the crew at each well site to around 5 people from 20 workers now if more automated drilling rigs are used, Bloomberg’s David Wethe says.⁹³⁴
- December 22, 2016 – Researchers with the Energy Policy Institute at the University of Chicago measured the costs and benefits of fracking in local communities across nine U.S. shale basins. They found that, despite contributions to local economies with the

⁹³² Krauss, C. (2017, February 19). Texas oil fields rebound from price lull, but jobs are left behind. *New York Times*. Retrieved from https://www.nytimes.com/2017/02/19/business/energy-environment/oil-jobs-technology.html?_r=0

⁹³³ Jackson, R. B., Owley, J., & Salzman, J. (2017). Mineral estate conservation easements: A new policy instrument to address hydraulic fracturing and resource extraction. *Environmental Law Reporter*, 47(2). 10112-10120. Retrieved from <https://elr.info/news-analysis/47/10112/mineral-estate-conservation-easements-new-policy-instrument-address-hydraulic-fracturing-and-resource-ext>

⁹³⁴ Paraskova, T. (2017, January 26). Robots over roughnecks: Next drilling boom might not add many jobs. *OilPrice.com*. Retrieved from <https://oilprice.com/Energy/General/Robots-Over-Roughnecks-Next-Drilling-Boom-Might-Not-Add-Many-Jobs.html>

arrival of fracking, residents experienced decreases in local quality of life. Spikes in crime were the most directly measurable of these effects. “Despite local governments’ efforts to improve public safety—allocating 20 percent more funding—the crime rates still marginally increased.” The study also found unequal distribution of benefits. Students, the elderly, and those who don’t own mineral rights did not benefit at all. Their analysis found an average gain of about \$1,300 to \$1,900 per household per year, but these gains were offset by a reduction in the typical household’s quality of life, which the authors computed at about \$1,000 to \$1,600 per year.⁹³⁵

- December 21, 2016 – Economists from the University of Anchorage and Montana State University studied the impact of regional shale energy booms on crime rates across U.S. counties from 2000 to 2013, documenting increased rates of many types of crime, including assault, rape, larceny, and auto theft. In 2013, they pegged the average monetary cost of these additional crimes at \$2 million per county. Researchers emphasized these results represented short-term costs only, as they could not predict how crime rates and attendant costs will accrue over longer periods of time, as, for example, if criminal behavior and labor migration facilitate a slow drain of human and physical capital from the region and propagate “a long-term resource curse.” The study also found “that registered sex offenders moved in disproportionate numbers to boom towns in North Dakota,” and “that income inequality increased as the shale boom progressed.”⁹³⁶
- May 24, 2016 – In 327 U.S. counties previously at the center of the fracking boom, overdue car loans approached their highest level in five years, and late mortgage payments also rose, according to a report by the *Financial Times* that examined data from the Federal Reserve Bank of New York. These trends stood in stark contrast to lowered overdue debt rates in the rest of the U.S. This surge in late car payments in intensely fracked areas of the United States has “exposed the damage done by the collapse in drilling activity and marred broadly positive trends for late debt payments by American consumers.”⁹³⁷
- May 8, 2016 – With the downturn in the fracking industry, Wisconsin’s sand mining sector, which provides silica sand for fracking operations, has also slumped and prompted significant layoffs and job losses in both 2015 and 2016, according to a report by Eau Claire’s *Leader-Telegram*. “This is what the bust part of the boom-and-bust cycle of the energy sector looks like, and it’s something west-central Wisconsin residents, who are mostly new to the industry, aren’t used to seeing.” Other companies that supply goods and services to sand mining operations in the region have also experienced a downturn.⁹³⁸

⁹³⁵ Bartik, A. W., Currie, J., Greenstone, M., & Knittel, C. R. (2016). *The local economic and welfare consequences of hydraulic fracturing*. Energy Policy Institute at the University of Chicago. Retrieved from <https://epic.uchicago.edu/research/publications/local-economic-and-welfare-consequences-hydraulic-fracturing>

⁹³⁶ James, A., & Smith, B. (2016). There will be blood: Crime rates in shale-rich U.S. counties. *Journal of Environmental Economics and Management*, 84, 125–152. doi: 10.1016/j.jeem.2016.12.004

⁹³⁷ Fleming, S. (2016, May 24). US fracking bust sparks surge in car debt. *Financial Times*. Retrieved from <http://www.ft.com/cms/s/0/a4cb1270-21c2-11e6-aa98-db1e01fab0c.html>

⁹³⁸ Lindquist, E. (2016, May 8). Silent sandbox: Once booming frac sand industry continues major downturn. *Leader-Telegram*. Retrieved from <http://www.leadertelegram.com/News/Front-Page/2016/05/08/Silentsandbox.html>

- March 8, 2016 – A DeWitt County, Texas judge estimated it will cost his county \$432 million to rebuild its roads, noting that if a road “leads to a rig site, it's bound to be a broken road.” The judge stated that ultimately the companies would pay a large share.⁹³⁹
- February 22, 2016 – *Inside Energy* investigated oil-industry related wage theft claims in the West, finding “a growing number of oil workers are turning to the courts, saying they weren’t paid fairly even when times were good.” Between 2010 and 2015, wage theft suits against oil and gas companies in Colorado increased by a factor of nine, and in Texas nearly ten times. The investigation found that oil and gas companies were consistently among the top violators of wage laws—especially in failure to pay overtime. A federal investigation of the industry led to the recovery of \$40 million dollars in unpaid wages. One of the officers involved in the investigations is quoted saying, “We have found cases where workers were not even paid the minimum wage, because they’re working so many hours.... So the idea that they’re being highly compensated, in some cases, they’re not.”⁹⁴⁰
- January 13, 2016 – A fire on a fracking site in Grady County, Oklahoma that consumed 22 oil tankers required the response of six regional fire departments.⁹⁴¹
- December 15, 2015 – The value of homes that rely on well water in Pennsylvania dropped an average of \$30,167 when fracking took place within 1.5 kilometers, according to a study by Duke University researchers published in the *American Economic Review*. For these groundwater-dependent homes, a fracking well located within one kilometer was linked to a 13.9 percent average decrease in values; homes with wells at least two kilometers away maintained their value. The study was based on home sales between 1995 and 2012 in 36 counties. Researchers stated that their figures may not fully reflect the total costs associated with groundwater contamination risk, as, for example, when homeowners purchase expensive home water filtration systems. Though their study does not incorporate data on actual contamination, concerns about contamination can significantly affect property values. Researchers found “strong evidence of localized costs borne particularly by groundwater-dependent homes.”⁹⁴²
- December 8, 2015 – Even as housing prices in shale gas-areas of Pennsylvania have dropped along with fracking activity, many seniors and people living on low incomes are still being priced out of the market, *StateImpact* reported. Pennsylvania still lacks a quarter million affordable rental homes for people in poverty despite a 2012 law

⁹³⁹ Callahan, C. (2016, March 8). Fracking fall-off leaves South Texas roads a mess. *KSAT.com*. Retrieved from <http://www.ksat.com/web/ksat/news/fracking-fall-off-leaves-south-texas-roads-a-mess>

⁹⁴⁰ Boyce, D. (2016, February 22). Wage theft claims surge as oil prices fall. *Inside Energy*. Retrieved from <http://insideenergy.org/2016/02/22/wage-theft-claims-surge-as-oil-prices-fall/>

⁹⁴¹ KFOR-TV, Querry, K., & Fultonberg, L. (2016, January 13). Firefighters extinguish damaging Grady Co. fracking fire. *KFOR.com*. Retrieved from <http://kfor.com/2016/01/13/all-lanes-of-traffic-shut-down-due-to-large-oil-rig-fire/>

⁹⁴² Muehlenbachs, L., Spiller, E., & Timmins, C. (2015). The housing market impacts of shale gas development. *American Economic Review*, 105(12), 3633–3659. doi: 10.1257/aer.20140079

requiring gas companies to pay well fees intended to offset the costs of affordable housing programs in communities where drilling is occurring.⁹⁴³

- December 2, 2015 – “The local economy is feeling the pinch” of the downturn of activity in Pennsylvania’s gas fields, according to a Reuters report. The late 2015 slump marked a turning point in Marcellus Shale fracking. Regional economic effects reported include empty hotel rooms and foreclosure notices in Lycoming County at their highest since data were first collected.⁹⁴⁴
- October 7, 2015 – Vehicular collisions and Texas fracking activity are closely linked, according to a report by the Texas A&M University Transportation Institute. Researchers analyzed the number of crashes and injuries across Texas during the period from 2006 to 2009, when drilling and fracking operations were intensive over the Barnett Shale, as well as from 2010 to 2013, when activity increased in the Permian Basin in West Texas and the Eagle Ford Shale in South Texas, and decreased in the Barnett. Collisions increased where shale gas activity increased and decreased where it slowed down.⁹⁴⁵ Quoted in the *Texas Tribune*, report co-author Cesar Quiroga said, “The two trends correlated so well, and they were perfectly aligned ... We could use this as a predictive model.”⁹⁴⁶ Further, the increase was greater in South Texas, the region that relies most heavily on horizontal, hydraulic fracking requiring millions of gallons of water and sand to be trucked in, compared to West Texas which does use fracking but also more simple, vertical wells. The comprehensive cost of these collisions was estimated to be about \$2 billion more from 2010 to 2013—in both the Eagle Ford and Permian Basin—compared to the previous period.
- September 30, 2015 – The North Dakota Bureau of Criminal Investigation was set to hire nine new agents, reported the *Billings Gazette*, “...allowing for more attention to cases of human trafficking and organized crime in western North Dakota ... as increased oil production resulted in growing populations.”⁹⁴⁷
- September 29, 2015 – “New residential units sit empty as gas production falls,” *HousingWire Magazine* wrote, following up on their earlier reporting describing the link between the drilling boom and the real estate boom in the Bakken shale region of North

⁹⁴³ Cusick, M. (2015, December 8). Despite drilling slowdown, rents still high in fracking boomtowns. *StateImpact*. Retrieved from <https://stateimpact.npr.org/pennsylvania/2015/12/08/despite-drilling-slowdown-rents-still-high-in-fracking-boomtowns/>

⁹⁴⁴ McAllister, E. (2015, December 2). America's biggest gas field finally succumbs to downturn. *Reuters.com*. Retrieved from <http://www.reuters.com/article/us-usa-marcellus-decline-insight-idUSKBN0TLCY20151202#W0DRBI8eM4MKscSV.97>

⁹⁴⁵ Quiroga, C. & Tsapakis, J. (2015). *Oil and gas energy developments and changes in crash trends in Texas*. Texas A&M Transportation Institute, PRC 15-35 F. Retrieved from <http://d2dtl5mnpfr0r.cloudfront.net/tti.tamu.edu/documents/PRC-15-35-F.pdf>

⁹⁴⁶ Malewitz, J. (2015, October 7). Report: Energy boom-related traffic crashes cost billions. *Texas Tribune*. Retrieved from <https://www.texastribune.org/2015/10/07/report-shows-huge-toll-energy-boom-traffic-crashes/>

⁹⁴⁷ McCleary, M. (2016, September 30). North Dakota to hire 9 more criminal investigation agents. *Billings Gazette*. Retrieved from http://billingsgazette.com/news/state-and-regional/montana/north-dakota-to-hire-more-criminal-investigation-agents/article_a4192344-c9b0-51cc-9693-5a4335f5be05.html

Dakota. Economic data indicate that Bakken drilling is not lasting long enough to sustain the building explosion.⁹⁴⁸

- September 9, 2015 – Most local governments in Western North Dakota and Eastern Montana’s Bakken region have experienced net negative fiscal effects, according to a Duke University analysis published by the National Bureau of Economic Research. These trends were also seen in municipalities in rural Colorado and Wyoming, which also struggled to manage fiscal impacts during recent oil and gas booms, but in these two states the fiscal impact eased as drilling activity slowed.⁹⁴⁹ Referencing the report, *McClatchyDC* wrote, “North Dakota cities and counties have been slammed.” Municipal challenges have included providing water and sewer infrastructure, substantial damage to roads, soaring housing prices, and strained emergency services.⁹⁵⁰
- August 27, 2015 – Fracking in or near public parks could cause tourists to stay away and lead to a decline in park use, according to a report published by a team of tourism, recreation, and sport management researchers from the University of Florida, North Carolina State University, and Florida State University. Using data collected from 225 self-identified park users from Pennsylvania, Ohio, West Virginia, Kentucky, and Tennessee, researchers reported that only one-third of participants were willing to participate in recreational activities near fracking operations, compared to 38 percent unwilling, and 29 percent neutral. Forty-six percent of respondents supported a ban on fracking on public lands, while 20 percent agreed with promoting fracking on public lands.⁹⁵¹
- July 1, 2015 – Britain’s Department for Environment, Food & Rural Affairs released previously redacted sections of a report on the impacts of drilling and fracking. The report found that housing prices near fracking wells would likely fall up to seven percent for houses within a mile of wells. Furthermore, properties within one to five miles of fracking sites could incur additional insurance costs. The report warned of environmental damages, including from leakage of fracking waste fluids, and found that public health could be affected indirectly through consumption of contaminated wildlife, livestock, or agricultural products. The report also found potential for some benefits, such as job growth.⁹⁵²

⁹⁴⁸ Lane, N. (2015, September 29). Is fracking about to bust housing in North Dakota? *HousingWire Magazine*. Retrieved from <http://www.housingwire.com/articles/35196-is-fracking-about-to-bust-housing-in-north-dakota>

⁹⁴⁹ Newell, R. G., & Raimi, D. (2015). *Shale public finance: Local government revenues and costs associated with oil and gas development*. The National Bureau of Economic Research, Working Paper No. 21542. doi: 10.3386/w21542

⁹⁵⁰ Cockerham, S. (2015, September 9). Oil boom a loser for North Dakota cities, counties, study finds. *McClatchyDC*. Retrieved from <http://www.mcclatchydc.com/news/nation-world/national/economy/article34552824.html>

⁹⁵¹ Kellison, T. B., Bunds, K. S., Casper, J. M., & Newman, J. I. (2015). Fracking & parkland: Understanding the impact of hydraulic fracturing on public park usage. Retrieved from http://plaza.ufl.edu/tkellison/_/Fracking.html

⁹⁵² Vaughan, A. & Mason, R. (2015, July 1). Fracking could hurt house prices, health and environment, official report says. *Guardian*. Retrieved from <http://www.theguardian.com/environment/2015/jul/01/fracking-could-hurt-house-prices-health-and-environment-official-report-says>

- July 2015 – A working paper by researchers with the National Bureau of Economic Research found that fracking resulted in an increase in male teen high school dropout rates. “Our estimates imply that, absent fracking, the male-female gap in high school dropout rates among 17- 18-year olds would have narrowed by about 11 percent between 2000 and 2013 instead of remaining unchanged.” The authors explained that by increasing the demand for low-skilled labor, fracking could slow growth in educational attainment. They noted that the relative wage boost from fracking may be only temporary. Indeed, by the end of the sample period, the benefits had started to wane as the labor demand from fracking appeared to no longer favor dropouts. Thus, the fracking boom may be inhibiting educational achievement among young men who “would already be near the bottom of the skill distribution, with possible implications for future productivity and the social safety net.”^{953, 954}
- March 20, 2015 – The U.S. Attorney for Western New York linked a rise in production of methamphetamine to use among workers in the fracking fields of northern and western Pennsylvania. Surging demand for the drug, which allows users to stay awake for 48 to 72 hours, may be related to the extremely long working hours that employees in the gas industry must endure.⁹⁵⁵
- January 4, 2015 – A documentary by Forum News Service, “Trafficked Report,” revealed that sex trafficking, including of children, in the Bakken oil fields of North Dakota was a significant problem.⁹⁵⁶ The dynamics of the oil boom, with an influx of out-of-state and primarily male workers far from their families, created an increase in demand for prostitution.⁹⁵⁷
- December 28, 2014 – The *New York Times* profiled the impacts of oil drilling and fracking on the Fort Berthold Indian Reservation in North Dakota, finding corruption, crime, and negative environmental impacts. Aside from a significant rise in jobs, which often go to transient workers, many residents “see deterioration rather than improvement in their standard of living. They endure intense truck traffic, degraded roads, increased crime, strained services and the pollution from spills, flares and illegal dumping.” According to the *Times*' calculation, the reservation had seen 850 oil-related

⁹⁵³ Cascio, F. U., & Narayan, A. (2015, July). Who Needs a Fracking Education? The Educational Response to Low-Skill Biased Technological Change. National Bureau of Economic Research. Retrieved from <http://www.nber.org/papers/w21359>

⁹⁵⁴ Chandra, S. (2015, July 14). Fracking jobs encouraged American teens to become high school dropouts. *Bloomberg Business*. Retrieved from: <http://www.bloomberg.com/news/articles/2015-07-14/fracking-jobs-encouraged-american-teens-to-become-high-school-dropouts>

⁹⁵⁵ Newberg, R. (2015, March 20). Meth use tied to fracking workers in Pennsylvania. *WIVB 4*. Retrieved from <http://wivb.com/2015/03/20/meth-use-tied-to-fracking-workers-in-pennsylvania/>

⁹⁵⁶ Dalrymple, A. & Lynn, K. (2015, January 4). Trafficked Report: Sex for sale in the Bakken. *Forum News Service*. Retrieved from <http://www.traffickedreport.com/?p=15>

⁹⁵⁷ Gaines, J. (2015, March 9). The oil boom in North Dakota now has a serious sex-trafficking problem. *Business Insider*. Retrieved from <http://www.businessinsider.com/north-dakota-sex-trafficking-prostitution-oil-boom-police-raid-2015-3>

environmental incidents from 2007 through mid-October 2014, which generally went unpunished.⁹⁵⁸

- December 26, 2014 – Examining Pennsylvania Department of Transportation data, Ohio’s *Star Beacon* newspaper found that fracking poses a safety threat on rural roads. The paper found that Pennsylvania’s five busiest drilling counties recorded 123 more heavy truck crashes in 2011 than before the gas boom began—a 107 percent increase. The paper noted the burden drilling and fracking placed on local communities and governments, including the strain on local emergency responders.⁹⁵⁹
- December 17, 2014 – Heavy drilling and fracking (defined as 400 or more wells drilled within a county over 5-8 years) was positively correlated with increased crime, sexually transmitted diseases, and traffic fatalities, according to a report by the Multi-State Shale Research Collaborative.⁹⁶⁰ The report looked at the impacts in Pennsylvania, Ohio, and West Virginia, primarily finding statistically significant impacts in six heavily drilled counties in Pennsylvania. In those six counties, violent crime increased 17.7 percent—corresponding to about 130 more violent crimes in those counties in 2012—compared to a decrease in violent crime rates in both urban and rural non-drilling communities. Property crime increased 10.8 percent in those six counties, drug abuse rates rose 48 percent, and drunk-driving offenses rose 65 percent compared to 42 percent in rural areas with no drilling. The report found a statistically significant increase of 24 percent to 27 percent in rates of sexually transmitted diseases across drilling counties in all three states. Motor vehicle fatalities increased 27.8 percent in Pennsylvania’s six high-drilling counties. The report found a modest increase in jobs, but noted that an influx of out-of-state workers at least partially explained the increases in traffic and crime.⁹⁶¹
- December 15, 2014 – A report written in French by Quebec’s Advisory Office of Environmental Hearings concluded that the environmental costs of fracking in the St. Lawrence Lowlands would outweigh the potential economic benefits. In a press release, the Advisory Office of Environmental Hearings concluded that fracking “would not be advantageous for Quebec because of the magnitude of the potential costs and externalities, compared to royalties that would be collected by Quebec. Other concerns

⁹⁵⁸ Sontag, D. & McDonald B. (2014, December 28). In North Dakota, a tale of oil, corruption and death. *The New York Times*. Retrieved from <http://www.nytimes.com/2014/12/29/us/in-north-dakota-where-oil-corruption-and-bodies-surface.html>

⁹⁵⁹ Finnerty, J. (2014, December 26). Fracking’s biggest safety threat is on rural roads. *Star Beacon*. Retrieved from http://www.starbeacon.com/news/fracking-s-biggest-safety-threat-is-on-rural-roads/article_bc48687a-8caf-11e4-b4d9-6382c924a6f9.html

⁹⁶⁰ Price, M., Herzenberg, S., Ward, S., Wazeter, E., & Basurto, L. E. (2014, December). *The Shale Tipping Point: The Relationship of Drilling to Crime, Traffic Fatalities, STDs, and Rents in Pennsylvania, West Virginia, and Ohio*. Retrieved from: <http://www.multistateshale.org/shale-tipping-point>

⁹⁶¹ McKelvey, W. (2014, December 17). Fracking brought spikes in crime, road deaths and STDs to Pa.: report. *Patriot News*. Retrieved from http://www.pennlive.com/midstate/index.ssf/2014/12/fracking_brought_spikes_in_vio.html

also remain, including plans of social acceptability, legislation, and a lack of knowledge, particularly with respect to water resources.”⁹⁶²

- October 30, 2014 – The *New York Times* profiled the profound impact heavy drilling has had on Glasscock County, Texas, including its farming community. Farmers described increases in trash, traffic accidents, clashes around farmers selling groundwater to drillers, and economic detriment. In many cases, acres of farmland around a drill site “will probably never be suitable for fertile farming again,” and farmers are “at the mercy” of what drillers want to pay for damages. The county itself receives revenue, but most of that additional money “is being used to repair roads damaged by oil field truck activity. Overall, the gains from drilling are not viewed as worth the drawbacks in a county long dominated by cotton farming.”⁹⁶³
- September 28, 2014 – A *Washington Post* investigation reported on heroin and methamphetamine addiction—and associated violent crime—among Native American communities located within the Bakken Shale oil fields. According to a chief judge for the Mandan, Hidatsa, and Arikara Nation, “The drug problem that the oil boom has brought is destroying our reservation.”⁹⁶⁴
- September 11, 2014 – An editor for the *Washington Post* examined jobs and manufacturing data in Youngstown, Ohio, to demonstrate that drilling and fracking are not resulting in a revitalization of the Rust Belt as some proponents and a prominent *New York Times* story asserted. The *Post* determined that in Youngstown, Ohio, the manufacturing sector has lost jobs by the tens of thousands in the last twenty years and the oil and gas industry has created approximately two thousand jobs since the recession ended. Six years prior, there were 13,000 more jobs in the Youngstown metro area than there were in summer 2014.⁹⁶⁵
- September 9, 2014 – A study by researchers at Colorado State University examined the political economy of harm and crime associated with the oil and gas industry in rural Colorado, particularly around the rise of fracking. The researchers looked at complaints that citizens filed with the state, and also conducted interviews and examined other data. They found 2,444 complaints between November 2001 and June 2013 covering a range of issues including water, environment, noise, air quality, land use, and more. They characterized citizen complaints as “extensive and complex” and concluded that,

⁹⁶² McCarthy, S. (2014, December 15). Fracking dealt another setback by Quebec report. *Globe and Mail*. Retrieved from <http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/bape-says-shale-gas-production-not-advantageous-for-quebec/article22096203/>

⁹⁶³ Batheja, A. (2014, October 30). A county resents oil drilling, despite the money it brings in. *The New York Times*. Retrieved from http://www.nytimes.com/2014/10/31/us/a-county-resents-oil-drilling-despite-the-money-it-brings-in.html?ref=earth&_r=1

⁹⁶⁴ Horwitz, S. (2014, September 28). Dark side of the boom: North Dakota’s oil rush brings cash and promise to reservation along with drug-fueled crime. *The Washington Post*. Retrieved from <http://www.washingtonpost.com/sf/national/2014/09/28/dark-side-of-the-boom/>

⁹⁶⁵ Tankersley, J. (2014, September 11). Fracking hasn’t restored the Rust Belt’s lost jobs. *The Washington Post*. Retrieved from <http://www.washingtonpost.com/news/storyline/wp/2014/09/11/fracking-hasnt-restored-the-rust-belts-lost-jobs/>

regardless of the nature of the harm, most were “persistent and omnipresent” rather than short-lived, isolated problems.⁹⁶⁶

- September 6, 2014 – In Williams County, North Dakota, in the Bakken Shale, increases in crime have corresponded with the flow of oil. The infusion of cash has attracted career criminals who deal in drugs, violence, and human sex trafficking. The *Williston Herald* portrayed, in a “reader’s discretion advised” article, the rapid rise of “index crimes”—“violent crimes that result in the immediate loss of an individual’s property, health or safety, such as murder, larceny and rape.” With fewer than 100 law enforcement personnel, crime in Williams County “has risen in kind with the county’s population, but funding, staffing and support training for law enforcement has not.”⁹⁶⁷
- September 2014 – Reporting on the social, environmental, health and safety, and economic burdens endured by localities from fracking, the magazine *Governing: The States and Localities* found that “fracking, in many cases, negatively impacts property values, which in turn depresses property tax revenue. For property owners who own the rights to the oil and gas on their land, the effects of drilling can be offset by royalty payments. But localities have no revenue offset if properties lose value.”⁹⁶⁸
- August 26, 2014 – The U.S. Justice Department Office on Violence Against Women awarded three million dollars to five rural and tribal communities to prosecute crimes of violence against women and provide services to victims of sexual assault, domestic violence, and stalking in the Bakken Region of North Dakota and Montana.⁹⁶⁹ Rationale documented by tribal leaders, law enforcement, and the FBI included, “rapid development of trailer parks and modular housing developments often referred to as ‘man camps;’ abrupt increase in cost of living, especially housing; rapid influx of people, including transients, in a previously rural and stable community; constant fear and perception of danger; and a lost way of life. Local and tribal officials and service providers reported that these changes have been accompanied by a rise in crime, including domestic and sexual violence.”⁹⁷⁰
- May 27, 2014 – A *Bloomberg News* analysis of 61 shale-drilling companies found that the economic picture of shale oil and gas is unstable. Shale debt has almost doubled over the last four years while revenue has gained just 5.6 percent. For the 61 companies in

⁹⁶⁶ Opsal, T., & Shelley T. O. (2014). Energy crime, harm, and problematic state response in Colorado: A case of the fox guarding the hen house? *Critical Criminology*, 22 (4), 561-577.

⁹⁶⁷ Bell, T. (2014, September 6). Modernized slavery. *Williston Herald*. Retrieved from http://www.willistonherald.com/news/modernized-slavery/article_84e257d8-3615-11e4-a4f8-001a4bcf887a.html

⁹⁶⁸ Shafroth, F. (2014, September). Fracking’s financial losers: local governments. *Governing: The States and Localities*. Retrieved from <http://www.governing.com/columns/public-money/gov-frackings-financial-losers.html>

⁹⁶⁹ U.S. Department of Justice. (2014, August 26). Associate Attorney General West announces \$3 million in grants to address violence against women in rural and tribal communities in the Bakken Region. *Justice News*. Retrieved from <http://www.justice.gov/opa/pr/associate-attorney-general-west-announces-3-million-grants-address-violence-against-women>

⁹⁷⁰ U.S. Department of Justice. (2014). OVW Fiscal Year 2014 Violence Against Women Bakken Region Initiative: Enhanced response to victims application guidelines. Retrieved from <http://www.justice.gov/sites/default/files/ovw/legacy/2014/04/25/fy2014-initiative-for-the-bakken-region-enhanced-services-for-victims.pdf>

their analysis, *Bloomberg News* reported: “In a measure of the shale industry’s financial burden, debt hit \$163.6 billion in the first quarter.” Further, *Bloomberg* noted that drillers are caught in a bind because they must keep borrowing to pay for exploration needed to “offset steep production declines typical of shale wells.... For companies that can’t afford to keep drilling, less oil coming out means less money coming in, accelerating the financial tailspin.”⁹⁷¹

- May 5, 2014 – An Associated Press analysis found that traffic fatalities have spiked in heavily drilled areas of six states, whereas most other roads in the nation have become safer even as population has grown. In North Dakota drilling counties, for instance, traffic fatalities have increased 350 percent.⁹⁷²
- April 16, 2014 – A comprehensive article in the *Albany Law Review* concluded that the risks inherent with fracking are not covered by homeowner’s insurance, not fully insured by the oil and gas industry, and threaten mortgages and property value.⁹⁷³
- April 2014 – A report by the Multi-State Shale Research Collaborative, “Assessing the Impacts of Shale Drilling: Four Community Case Studies,” documented economic, community, government, and human services impact of fracking on four rural communities. The study found that fracking led to a rapid influx of out-of-state workers and, although some new jobs were created, these were accompanied by additional costs for police, emergency services, road damage, and social services. In addition, increased rents, and a shortage of affordable housing accompanied the fracking boom. Unemployment rose after one county’s boom ended; in another county, unemployment stayed above the state average throughout.⁹⁷⁴
- March 27, 2014 – A report by researchers at Rand Corporation determined that each shale gas well in Pennsylvania causes between \$5,400 and \$10,000 in damage to state roads. The report did not calculate damage to local roads, which is also significant. Researchers used estimates of truck trips that are significantly below the number

⁹⁷¹ Loder, A. (2014, May 27). Shakeout threatens shale patch as frackers go for broke. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2014-05-26/shakeout-threatens-shale-patch-as-frackers-go-for-broke.html>

⁹⁷² Begos, K., & Fahey, J. (2014, May 5). AP impact: Deadly side effect to fracking boom. *Associated Press*. Retrieved from <http://bigstory.ap.org/article/ap-impact-deadly-side-effect-fracking-boom-0>

⁹⁷³ Radow, E. L. (2014). At the intersection of Wall Street and Main: Impacts of hydraulic fracturing on residential property interests, risk allocation, and implications for the secondary mortgage market. *Albany Law Review*, 77(2), 673-704.

⁹⁷⁴ Multi-State Shale Research Collaborative. (2014, April 10). *Assessing the impacts of shale drilling county case studies* (Rep.). Retrieved from <https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbntdWx0aXN0YXRlc2hhbGV8Z3g6NGU4MjIyNWU5ZjFhZjM4Yg>

estimated for New York by the New York State Department of Environmental Conservation (NYS DEC).^{975, 976}

- February 15, 2014 – The *Los Angeles Times* detailed steep increases in crime that have accompanied fracking in parts of the Eagle Ford Shale in Texas, including sexual assaults and thefts.⁹⁷⁷
- February 14, 2014 – Pennsylvania landowners with fracking leases rallied in Bradford County against gas companies for precipitous drops in royalty payments.⁹⁷⁸
- December 20, 2013 – The National Association of Realtors' *RealtorMag* summarized a growing body of research, including a University of Denver survey and a *Reuters* analysis, that shows threats property values from fracking and gas drilling.⁹⁷⁹
- December 12, 2013 – A *Reuters* analysis discussed how oil and gas drilling has made making some properties “unsellable” and researched the link between drilling and property value declines. The analysis highlighted a Duke University working paper that finds shale gas drilling near homes can decrease property values by an average of 16.7 percent if the house depends on well water.⁹⁸⁰
- December 10, 2013 – Pennsylvania's *Daily Review* reported that more gas companies are shifting costs to leaseholders and that royalty payments are drastically shrinking. The story quoted Bradford County Commissioner Doug McLinko saying that some gas companies “are robbing our landowners” and that the problem of royalty payments being significantly reduced by deductions for post-production costs “is widespread throughout our county.”⁹⁸¹
- November 30, 2013 – The *New York Times* reported striking increases in crime in Montana and North Dakota where the oil and gas boom is prevalent, as well as challenges faced by local residents from the influx of out-of-area workers and the accompanying costs. The *New York Times* reported, “‘It just feels like the modern-day Wild West,’ said

⁹⁷⁵ Cusick, M. (2014, March 27). Report finds each Marcellus gas well costs thousands in road damage. *StateImpact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2014/03/27/report-finds-each-marcellus-gas-well-costs-thousands-in-road-damage/>

⁹⁷⁶ Abramzon, S., Samaras, C., Curtright, A., Litovitz, A., & Burger, N. (2014). Estimating the consumptive use costs of shale natural gas extraction on Pennsylvania roadways. *Journal of Infrastructure Systems*. 20(3). doi: 10.1061/(ASCE)IS.1943-555X.0000203, 06014001

⁹⁷⁷ Hennessy-Fiske, M. (2014, February 15). Fracking brings oil boom to south Texas town, for a price. Retrieved from <http://www.latimes.com/nation/la-na-texas-oil-boom-20140216%2C0%2C7621618.story#ixzz30Iw9FXoz>.

⁹⁷⁸ Marshall, J. (2014, February 14). Landowners rally for royalties from gas companies. Retrieved from <http://www.wbng.com/news/local/Landowners-rally-for-245596511.html>

⁹⁷⁹ Daily Real Estate News. (2013, December 20). ‘Fracking’ sparks concern over nearby home values. *National Association of Realtors*. Retrieved, from <http://realtormag.realtor.org/daily-news/2013/12/20/fracking-sparks-concern-over-nearby-home-values#.UrmDIIPmVu8.twitter>

⁹⁸⁰ Conlin, M. (2013, December 12). Gas drilling is killing property values for some Americans. *Reuters*. Retrieved from <http://www.businessinsider.com/drilling-can-make-some-properties-unsellable-2013-12#ixzz2nMgFv8FU>

⁹⁸¹ Loewenstein, J. (2013, December 10). Shrinking royalty checks. *TheDailyReview.com*. Retrieved from <http://thedailyreview.com/news/shrinking-royalty-checks-1.1598195>

Sgt. Kylan Klauzer, an investigator in Dickinson, in western North Dakota. The Dickinson police handled 41 violent crimes last year, up from seven only five years ago.”⁹⁸²

- November 21, 2013 – The Multi-State Shale Research Collaborative released a six-state collaborative report demonstrating that the oil and gas industry has greatly exaggerated the number of jobs created by drilling and fracking in shale formations. The report found that far from the industry’s claims of 31 direct jobs created per well, only four jobs are created for each well. It also demonstrated that almost all of the hundreds of thousands of ‘ancillary’ jobs that the drilling industry claims are related to shale drilling existed before such drilling occurred. As Frank Mauro, Executive Director Emeritus of the Fiscal Policy Institute put it, “Industry supporters have exaggerated the jobs impact in order to minimize or avoid altogether taxation, regulation, and even careful examination of shale drilling.”⁹⁸³
- November 12, 2013 – *The American Banker* reported that the “Fracking Boom Gives Banks Mortgage Headaches,” with a number of financial institutions refusing to make mortgages on land where oil and gas rights have been sold to an energy company. The article stated that the uniform New York state mortgage agreement used by Fannie Mae and Freddie Mac requires that homeowners not permit any hazardous materials to be used or located on their property. Fracking is therefore a problem because it is just such a hazardous activity with use of hazardous materials.⁹⁸⁴
- September 25, 2013 – A report found that fracking is linked to significant road damage, increased truck traffic, crime, and strain on municipal and social services. Data from the past ten years on the social costs of fracking including truck accidents, arrests, and higher rates of sexually transmitted diseases are all causes for alarm.⁹⁸⁵
- September 12, 2013 – In a feature titled “Pa. fracking boom goes bust,” *The Philadelphia Inquirer* presented data from the independent Keystone Research Center detailing “flat at best” job growth and declines in production and royalty payments.⁹⁸⁶

⁹⁸² Healy, J. (2013, November 30). As oil floods plains towns, crime pours in. *The New York Times*. Retrieved from <http://www.nytimes.com/2013/12/01/us/as-oil-floods-plains-towns-crime-pours-in.html?smid=tw-share&r=0>

⁹⁸³ Campbell, J. (2013, November 21). Report: Industry-backed studies exaggerate fracking job estimates. *Politics on the Hudson*. Retrieved from <http://polhudson.lohudblogs.com/2013/11/21/report-industry-backed-studies-exaggerate-fracking-job-estimates/>

⁹⁸⁴ Peters, A. (2013, November 12). Fracking boom gives banks mortgage headaches. *American Banker*. Retrieved from http://www.americanbanker.com/issues/178_218/fracking-boom-gives-banks-mortgage-headaches-1063561-1.html

⁹⁸⁵ Gibbons, B. S. (2013, September 25). Environmental groups calculate social cost of natural gas boom. *The Times-Tribune*. Retrieved from <http://thetimes-tribune.com/news/environmental-groups-calculate-social-cost-of-natural-gas-boom-1.1558186>

⁹⁸⁶ Bunch, W. (2013, September 12). Pa. fracking boom goes bust. *Philly.com*. Retrieved from http://articles.philly.com/2013-09-12/news/41974274_1_fracking-boom-penn-state-marcellus-center-marcellus-shale

- August 22, 2013 – A University of Denver study in the *Journal of Real Estate Literature* found a 5-15 percent reduction in bid value for homes near gas drilling sites.⁹⁸⁷
- August 21, 2013 – *The Atlantic Cities* and *MSN Money* reported that fracking operations may be damaging property values and may impair mortgages or the ability to obtain property insurance.^{988, 989}
- August 13, 2013 – A *ProPublica* investigative analysis found that Chesapeake Energy is coping with its financial difficulties in Pennsylvania by shifting costs to landowners who are now receiving drastically reduced royalty payments.⁹⁹⁰
- August 4, 2013 – In a survey of West Virginia landowners with shale wells on their property, more than half reported problems including damage to the land, decline in property values, truck traffic, and lack of compensation by the oil and gas company.⁹⁹¹
- May 24, 2013 – Pennsylvania Department of Transportation Secretary Allen D. Buihler and Pennsylvania State Police Commissioner Frank Pawlowski said that gas drilling has led to increases in truck traffic, traffic violations, crime, demand for social services, and the number of miles of roads that are in need of repairs. They noted that drilling companies that committed to repairing roads have not kept pace with the roads they damage. Commissioner Pawlowski reported that 56 percent of 194 trucks checked were over the legal weight limit and 50 percent were also cited for safety violations.⁹⁹²
- May 4, 2013 – Pennsylvania’s *Beaver County Times* asked, “What boom?” in pointing to Keystone Research Center data showing that the number of jobs numbers created by shale gas extraction do not add up to what the gas industry claims, noting that unemployment has increased and the state actually fell to 49th in the nation for job creation.⁹⁹³

⁹⁸⁷ Downing, B. (2013, April 22). Survey says home values hurt by fracking at drill sites. *Ohio.com*. Retrieved from <http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/survey-says-home-values-hurt-by-fracking-at-drill-sites-1.422838>

⁹⁸⁸ Drouin, R. (2013, August 19). How the fracking boom could lead to a housing bust. *Citylab*. Retrieved from <http://www.theatlanticcities.com/politics/2013/08/how-fracking-boom-could-lead-housing-bust/6588/>

⁹⁸⁹ Notte, J. (2013, August 21). Fracking leaves property values tapped out. *MSN Money*. Retrieved from <http://money.msn.com/now/post--fracking-leaves-property-values-tapped-out>

⁹⁹⁰ Lustgarten, A. (2013, August 13). Unfair share: How oil and gas drillers avoid paying royalties. *ProPublica*. Retrieved from <http://www.propublica.org/article/unfair-share-how-oil-and-gas-drillers-avoid-paying-royalties>

⁹⁹¹ Collins, A. R., & Nkansah, K. (2013, August 4). *Divided rights, expanded conflict: The impact of split estates in natural gas production* [Scholarly project]. Retrieved from http://ageconsearch.umn.edu/bitstream/150128/2/Collins_Nkansah_Split%20estate.pdf

⁹⁹² PR Newswire. (2014, May 24). Increased gas drilling activities bringing new challenges to local governments in Pennsylvania. *PR Newswire*. Retrieved from <http://www.prnewswire.com/news-releases/increased-gas-drilling-activities-bringing-new-challenges-to-local-governments-in-pennsylvania-94774764.html>

⁹⁹³ Morgan, R. (2013, May 4). Beaver County Times: What boom? Industry pundits claim thousands of jobs will be created, but numbers don't quite add up. *Keystone Research Center*. Retrieved from <http://keystoneresearch.org/media-center/media-coverage/beaver-county-times-what-boom-industry-pundits-claim-thousands-jobs-will>

- April 2, 2013 – The *New York Times* reported that manufacturing jobs resulting from an abundance of shale gas have not appeared. “The promised job gains, other than in the petrochemical industry, have been slow to materialize,” The *New York Times* reported. The article suggested that increased automation has made it unlikely that manufacturers will add many jobs.⁹⁹⁴
- March 19, 2013 – The *Wall Street Journal* reported that the shale gas boom has not had a big impact on U.S. manufacturing because lower energy prices are only one factor in a company’s decision on where to locate factories, and not always the most important factor. “Cheap energy flowing from the U.S. shale-gas boom is often touted as a ‘game changer’ for manufacturing,” the *Journal* reported. “Despite the benefits of lower energy costs, however, the game hasn’t changed for most American manufacturers.”⁹⁹⁵
- February 2013 – A peer-reviewed analysis of industry-funded and independent studies on the economics of fracking found that it is unlikely that fracking will lead to long-term economic prosperity for communities. The analysis noted that shale gas development brings a number of negative externalities including the potential for water, air, and land contamination; negative impacts on public health; wear and tear on roads and other infrastructure; and costs to communities due to increased demand for services such as police, fire departments, emergency responders, and hospitals.⁹⁹⁶
- November 16, 2012 – A Duke University study showed a drop in home values near fracking for properties that rely on groundwater.⁹⁹⁷
- September 27, 2012 – The *New York Times* reported that the prospect of fracking has hindered home sales in the Catskills and raised concerns about drops in property values, according to real estate agents and would-be buyers.⁹⁹⁸
- August 17, 2012 – A study by the state agencies, the Montana All Threat Intelligence Center and the North Dakota State and Local Intelligence Center, found that crime rose by 32 percent since 2005 in communities at the center of the oil and gas boom.⁹⁹⁹

⁹⁹⁴ Schwartz, N. D. (2013, April 01). Rumors of a cheap-energy jobs boom remain just that. *The New York Times*. Retrieved from http://www.nytimes.com/2013/04/02/business/economy/rumors-of-a-cheap-energy-jobs-boom-remain-just-that.html?_r=0

⁹⁹⁵ Hagerty, J. R. (2013, March 19). Shale-gas boom alone won't propel U.S. industry. *The Wall Street Journal*. Retrieved from <http://online.wsj.com/news/articles/SB10001424127887324392804578362781776519720>

⁹⁹⁶ Barth, J. M. (2013). The Economic Impact of Shale Gas Development on State and Local Economies: Benefits, Costs, and Uncertainties. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, 23(1), 85-101. doi: 10.2190/NS.23.1.f

⁹⁹⁷ Muoio, D. (2012, November 16). Duke researchers show dip in home value caused by nearby fracking. *The Chronicle*. Retrieved from <http://www.dukechronicle.com/articles/2012/11/16/duke-researchers-show-dip-home-value-caused-nearby-fracking>

⁹⁹⁸ Navarro, M. (2012, September 27). Gas drilling jitters unsettle Catskills sales. *The New York Times*. Retrieved from <http://www.nytimes.com/2012/09/30/realestate/fracking-fears-hurt-second-home-sales-in-catskills.html?pagewanted=1>

⁹⁹⁹ Montana All Threat Intelligence Center, & North Dakota State and Local Intelligence Center. (2012, August 17). *Impact of population growth on law enforcement in the Williston Basin region* (Rep.). Retrieved from <http://www.ag.nd.gov/reports/JOINTPRODUCTFINAL.pdf>

- October 30, 2011 – A comprehensive article in the *New York State Bar Association Journal* concluded that the risks inherent with fracking threaten mortgages.¹⁰⁰⁰
- October 26, 2011 – The Associated Press reported that areas with significant fracking activity, including Pennsylvania, Wyoming North Dakota and Texas, are “seeing a sharp increase in drunken driving, bar fights and other hell-raising.”¹⁰⁰¹
- October 19, 2011 – A *New York Times* investigation found that fracking can create conflicts with mortgages, and that “bankers are concerned because many leases allow drillers to operate in ways that violate rules in landowners’ mortgages,” and further that “[f]earful of just such a possibility, some banks have become reluctant to grant mortgages on properties leased for gas drilling. At least eight local or national banks do not typically issue mortgages on such properties, lenders say.”¹⁰⁰²
- September 7, 2011 – The NYS DEC estimated that 77 percent of the workforce on initial shale gas drilling projects would consist of transient workers from out of state. Not until the thirtieth year of shale gas development would 90 percent of the workforce be comprised of New York residents.¹⁰⁰³
- August 15, 2011 – The *Pittsburgh Post-Gazette* reported that increases in crime followed the Pennsylvania gas drilling boom, noting, for instance, that drunken driving arrests in Bradford County were up 60 percent, DUI arrests were up 50 percent in Towanda, and criminal sentencing was up 35 percent in 2010.¹⁰⁰⁴
- July 26, 2011 – A New York State Department of Transportation document estimated that fracking in New York could result in the need for road repairs and reconstruction costing \$211 million to \$378 million each year.¹⁰⁰⁵

¹⁰⁰⁰ Radow, E. N. (2011). Homeowners and gas drilling leases: Boon or bust? *New York State Bar Association Journal*, 83(9). Retrieved from http://www.s-oacc.org/resources/NYSBA_Journal_nov-dec2011_lead_article_with_reprint_info.pdf

¹⁰⁰¹ Levy, M. (2011, October 26). Towns see crime, carousing surge amid gas boom. *Associated Press*. Retrieved from <http://news.yahoo.com/towns-see-crime-carousing-surge-amid-gas-boom-135643480.html>

¹⁰⁰² Urbina, I. (2011, October 19). A rush to sign leases for gas runs into mortgage restriction. *The New York Times*. Retrieved from http://www.nytimes.com/2011/10/20/us/rush-to-drill-for-gas-creates-mortgage-conflicts.html?_r=2&hp&

¹⁰⁰³ New York State Department of Environmental Conservation. (2011). *Supplemental generic environmental impact statement on the oil, gas and solution mining regulatory program, well permit issuance for horizontal drilling and high-volume hydraulic fracturing to develop the Marcellus shale and other low-permeability gas reservoirs* (6-233, 234, Rep.).

¹⁰⁰⁴ Needles, Z. (2011, August 15). Must crime follow Pennsylvania's gas drilling boom? *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/stories/business/legal/must-crime-follow-pennsylvanias-gas-drilling-boom-310373/>

¹⁰⁰⁵ Reilly, S. (2011, July 26). Document estimates fracking's toll on N.Y. roads. *Pressconnects.com*. Retrieved from <http://www.pressconnects.com/article/20110726/NEWS01/107260384/Document-estimates-fracking-s-toll-N-Y-roads>

- June 20, 2011 – A Keystone Research Center study found that the gas industry’s claim of 48,000 jobs created between 2007 and 2010 as a result of natural gas drilling in Pennsylvania is a far cry from the actual number of only 5,669 jobs—many of which were out-of-state hires.¹⁰⁰⁶
- May 9, 2011 – A study in the *Journal of Town & City Management* found that shale gas development can impose “significant short- and long-term costs” to local communities. The study noted that shale gas development creates a wide range of potential environmental hazards and stressors, all of which can adversely impact regional economies, including tourism and agriculture sectors.¹⁰⁰⁷
- November 30, 2010 – The *Dallas Morning News* featured a story, “Drilling Can Dig into Land Value,” reporting that the Wise County Central Appraisal District Appraisal Review Board found that a drilling company had caused an “extraordinary reduction” in property value, by 75 percent.¹⁰⁰⁸
- November 28, 2010 – The *Texas Wise County Messenger* reported that some landowners near fracking operations experience excessive noise, exposure to diesel fumes, and problems with trespassing by workers.¹⁰⁰⁹

Inflated estimates of oil and gas reserves and profitability

Industry estimates of oil and gas reserves and profitability of drilling have proven unreliable, casting serious doubts on the bright economic prospects the industry has painted for the public, media, and investors. Increasingly, well production has been short-lived, which has led companies drilling shale to reduce the value of their assets by billions of dollars, creating shortfalls that are largely filled through asset sales and increasing debt load. Beginning in 2014, a fall in oil and gas prices led to a two-year downturn in fracking operations. As interest payments consumed the revenue of many smaller companies, more than 70 U.S. oil and gas companies declared bankruptcy, and the number of oil and gas rigs declined by 75 percent or more. When companies abandoned operations, they also abandoned the wells they drilled, raising questions about who serves as the custodian of inactive wells and their associated infrastructure, now and hereafter. In Alberta, Canada, newly abandoned wells dot the landscape, with many leaking methane, leaving the provincial government to close down and dismantle them—a task estimated to require decades of work.

¹⁰⁰⁶ Herzenberg, S. (2011). Drilling deeper into job claims. Keystone Research Center. Retrieved from http://keystoneresearch.org/sites/keystoneresearch.org/files/Drilling-Deeper-into-Jobs-Claims-6-20-2011_0.pdf

¹⁰⁰⁷ Christopherson, S. & Rightor, N. (2011). How shale gas extraction affects drilling localities: Lessons for regional and city policy makers. *Journal of Town & City Management*, 2(4), 1-20. Retrieved from http://www.greenchoices.cornell.edu/downloads/development/shale/Economic_Effects_on_Drilling_Localities.pdf

¹⁰⁰⁸ Heinkel-Wolfe, P. (2010, September 18). Drilling can dig into land value. *Dallas News*. Retrieved from <http://www.dallasnews.com/incoming/20100918-Drilling-can-dig-into-land-value-9345.ece>

¹⁰⁰⁹ Evans, B. (2010, November 28). Rising volume: ‘Fracking’ has bolstered economies, but noise still echoes around drilling. *WCMessenger.com*. Retrieved from <http://www.wcmessenger.com/2010/news/rising-volume-fracking-has-bolstered-economies-but-noise-still-echoes-around-drilling/>

In 2017, a modest recovery in prices brought renewed industry enthusiasm for fracking. However, because of the rapid depletion of individual shale wells and the falling output of major shale basins, including the Bakken and the Marcellus, operators must reinvest profits to drill new wells at an increasingly rapid pace just to maintain the same level of extraction. According to the U.S. Energy Information Administration, half of all U.S. oil is now produced by wells that are two years old or younger. The need to stabilize economic fundamentals by increasing production is contributing to the shift toward “mega-fracking,” with ever-longer laterals to access more oil or gas—and with requirements for higher volumes of water, sand, and chemicals per well.

- June 16, 2017 – Because of a persistent slump in gas prices and the declining productivity of many of its Marcellus Shale wells, the revenue from gas drilling fees fell for a third straight year in Pennsylvania. The annual fee revenue goes to county and municipal governments, roadway repairs, and infrastructure upgrades, among other things.¹⁰¹⁰
- March 25, 2017 – The *Economist* took shale fracking to task for its unstable finances and inability to turn a profit. “Shale firms are on an unparalleled money-losing streak. About \$11bn was torched in the last quarter, as capital expenditures exceeded cashflows. The cash-burn rate may well rise again this year. . . . The oil bulls of Houston have yet to prove that they can pump oil and create value at the same time.”¹⁰¹¹
- March 21, 2017 – An MIT study questioned the U.S. Energy Information Administration’s rosy projections on the abundance and availability of shale gas and oil. Analyzing field data on oil wells in North Dakota’s Williston Basin, the authors found that advances in fracking technology, such as the shift to longer laterals per well, have had a more modest impact on boosting oil and gas production than the agency had estimated. At the same time, the attraction of operators to the most productive areas of basins has had a greater impact. As time goes by, the prime drilling spots with the easy-to-extract oil or gas will get used up, the authors argued, and technology may not be able to compensate.^{1012, 1013}
- July 7, 2016 – “Oil-field-services companies are depleted after slashing prices and laying off workers, and their slow recovery could crimp the energy industry’s overall ability to bounce back from the oil bust,” according to the *Wall Street Journal*. Almost 70 percent of fracking equipment in the United States has been idled, and 60 percent of field workers involved in fracking have been laid off. Halliburton alone has laid off over 28,500

¹⁰¹⁰ Carlson, C. (2017, June 16). Pennsylvania gas drilling fee revenue falls for third year. *WENY.com*. Retrieved from http://www.weny.com/story/35680098/pennsylvania-gas-drilling-fee-revenue-falls-for-third-year?utm_medium=social&utm_source=twitter_WENYTV

¹⁰¹¹ America’s shale firms don’t give a frack about financial returns. (2017, March 25). *Economist*. Retrieved from <https://www.economist.com/news/business-and-finance/21719436-exploration-and-production-companies-are-poised-go-another-investment-spree-americas>

¹⁰¹² Montgomery, J. B., & O’Sullivan, F. M. (2017). Spatial variability of tight oil well productivity and the impact of technology. *Applied Energy*, 195, 344–355. doi: 10.1016/j.apenergy.2017.03.038

¹⁰¹³ Marshall, C. (2017, October 6). Studies attack conventional wisdom on natural gas. *E&E News*. Retrieved from <https://www.eenews.net/stories/1060062933>

workers, which is one third of its workforce. More than 70 oilfield services companies have filed for bankruptcy since the beginning of 2015.¹⁰¹⁴

- June 15, 2016 – Billions of dollars of proven reserves have become unproven this year, as “59 U.S. oil and gas companies deleted the equivalent of 9.2 billion barrels, more than 20 percent of their inventories,” according to *Bloomberg*. In 2009, the Securities and Exchange Commission (SEC) made it easier for the companies to include in their proven reserves undeveloped acreage and wells that wouldn’t be drilled for years on the grounds that “shale prospects are predictable across wide expanses.” Since then, the SEC has become more strict about inflated reserves estimates.¹⁰¹⁵
- May 16, 2016 – *CNN Money* reported on the two latest U.S. oil and gas bankruptcies: SandRidge Energy’s Chapter 11 filing was based on roughly \$4 billion of debt and came the week after the biggest such bankruptcy to date—that of Linn Energy with more than \$10 billion in debt. There had been at least 29 U.S. oil and gas bankruptcies in 2016 at the date of the article’s publication, bringing the 2015-2016 total to at least 64. “The industry has historically been full of wildcatters and speculators. It’s not surprising we’re going through this boom-and-bust cycle,” the article quoted the managing director at oil restructuring firm SOLIC Capital, George Koutsonicolis, as saying.¹⁰¹⁶
- May 9, 2016 – “The pace of oil patch bankruptcies is picking up,” a *Forbes* piece read, listing the 15 biggest such bankruptcies to date. “All told, 69 oil and gas producers with \$34.3 billion in cumulative secured and unsecured debt have gone under.”¹⁰¹⁷
- March 25, 2016 – Oil and gas borrowers “feasted on what Bloomberg estimates was \$237 billion of easy money without scrutinizing whether the loans could endure a drastic downturn,” according to a *Washington Post* piece focusing on one company, Swift Energy, which itself was \$1.349 billion in debt and had entered bankruptcy. Despite having been cautious prior to the Texas fracking boom, “[a]s the company began to frack more often, the amount it spent on exploration and drilling skyrocketed by hundreds of millions of dollars.” Those expenses combined with global developments led to its failure, along with over 40 other oil and gas companies in 2015. “The consequences are far-reaching. The U.S. oil industry, having grown into a giant on par with Saudi Arabia’s, is shrinking, with the biggest collapse in investment in energy in 25 years. More than 140,000 have lost energy jobs. Banks are bracing for tens of billions of dollars of

¹⁰¹⁴ Sider, A. (2016, July 7). Revving up oil fields won’t be so easily done. *Wall Street Journal*. Retrieved from <http://www.wsj.com/articles/revving-up-oil-fields-wont-be-so-easily-done-1467883807>

¹⁰¹⁵ Loder, A. (2016, June 15). Why billions in proven shale oil reserves suddenly became unproven. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/articles/2016-06-15/shale-drillers-paper-wells-draw-sec-scrutiny-before-vanishing>

¹⁰¹⁶ Egan, M. (2016, May 16). Oil bankruptcies mount despite crude rebound. *CNN Money*. Retrieved from <http://money.cnn.com/2016/05/16/investing/sandridge-energy-oil-bankruptcy/>

¹⁰¹⁷ Helman, C. (2016, May 9). The 15 biggest oil bankruptcies (so far). *Forbes*. Retrieved from <http://www.forbes.com/sites/christopherhelman/2016/05/09/the-15-biggest-oil-bankruptcies-so-far/#7c765e10739b>

defaults, and economists and lawyers predict the financial wreckage will accelerate this year.”¹⁰¹⁸

- March 10, 2016 – Crude oil production is not falling as quickly as predicted, given the sharp decline in prices and the drop-off in new drilling and fracking operations. As reported by Reuters, this disconnect is due to refracking of older wells, along with other unconventional techniques such as “choking” and “lifting,” which can extend the productive lives of wells or otherwise capture more product from them.¹⁰¹⁹
- March 1, 2016 – An analysis of fracking trends in the journal *Nature* concluded that a European shale gas boom was unlikely due to disappointing early yields (Poland, Lithuania and Denmark), links to earthquakes (United Kingdom), and intense public opposition in densely populated areas throughout the continent.¹⁰²⁰
- June 19, 2015 – A *Bloomberg Business* analysis of the 62 drilling companies in the Bloomberg Intelligence North America Independent Exploration and Production Index found that the companies’ debt continued to be a major problem. For 27 of the 62 companies, interest payments were consuming more than 10 percent of revenue. Drillers’ debt rose to \$235 billion at the end of the first quarter, a 16 percent increase over the year prior. *Bloomberg Business* expressed concern that shale drillers have “consistently spent money faster than they’ve made it, even when oil was \$100 a barrel.” S&P assigned speculative, or junk, ratings to 45 of the 62 companies in Bloomberg’s index.¹⁰²¹
- April 7, 2015 – A Moody’s Investors Service analysis of LNG prospects found that lower oil prices were causing suppliers to defer or cancel most proposed LNG projects. Moody’s found that this was due in part to the drop in international oil prices relative to U.S. natural gas prices, thus removing the economic advantage of U.S. LNG projects. Moody’s stated, “LNG is a capital-intensive infrastructure business prone to periodic construction cycles that lead to overcapacity, which we expect will continue for the rest of the decade.”¹⁰²²
- March 20, 2015 – A study by the Energy Watch Group in Germany found that the costs of allowing fracking in Germany would outweigh the benefits, noting in part that natural gas trading in the United States has been declining since 2009. The study also noted the

¹⁰¹⁸ Harlan, C. (2016, March 25). The big bust in the oil fields. *The Washington Post*. Retrieved from <https://www.washingtonpost.com/news/wonk/wp/2016/03/25/the-big-bust-in-the-oil-fields/>

¹⁰¹⁹ Gopinath, S., & Gayathri, A. (2016, March 10). Forget fracking. Choking and lifting are latest efforts to stem U.S. shale bust. *Reuters*. Retrieved from <http://www.reuters.com/article/us-usa-shale-analysis-idUSKCN0WB1AI>

¹⁰²⁰ Inman, M. (2016). Can fracking power Europe? *Nature*, 531, 22-24. Retrieved from <http://www.nature.com/news/can-fracking-power-europe-1.19464>

¹⁰²¹ Loder, A. (2015, June 18). The shale industry could be swallowed by its own debt. *Bloomberg Business*. Retrieved from <http://www.bloomberg.com/news/articles/2015-06-18/next-threat-to-u-s-shale-rising-interest-payments>

¹⁰²² Moody’s Investors Service. (2015, April 7). Lower oil prices cause suppliers of liquefied natural gas to nix projects. Retrieved from https://www.moodys.com/research/Moodys-Liquefied-natural-gas-projects-nixed-amid-lower-oil-prices--PR_322439

costs of infrastructure, environmental and health risks and pointed to the need to expand renewable energy.¹⁰²³

- December 19, 2014 – An International Energy Agency (IEA) report projected that U.S. domestic oil supplies, dominated by fracking, face challenges, and oil output from shale formations output, will level off and decline in the early 2020s.¹⁰²⁴ IEA Chief Economist Fatih Birol said, “A well-supplied oil market in the short-term should not disguise the challenges that lie ahead.”¹⁰²⁵
- August 29, 2014 – Andrew Nikiforuk, a Canadian energy analyst, reported on diminishing returns and the higher-cost, higher-risk nature of fossil fuel extraction by fracking. Nikiforuk wrote, “Most of the world’s oil and gas firms are now pursuing extreme hydrocarbons because the cheap and easy stuff is gone.... That means industry will spend more good money chasing poor quality resources. They will inefficiently mine and frack ever larger land bases at higher environmental costs for lower energy returns.”¹⁰²⁶
- July 29, 2014 – According to the U.S. Energy Information Administration, energy companies are incurring increasing debt and selling assets to continue drilling in shale. “Based on data compiled from quarterly reports, for the year ending March 31, 2014, cash from operations for 127 major oil and natural gas companies totaled \$568 billion, and major uses of cash totaled \$677 billion, a difference of almost \$110 billion. This shortfall was filled through a \$106 billion net increase in debt and \$73 billion from sales of assets . . .”¹⁰²⁷
- July 2014 – Researchers at the Washington, DC-based Environmental Law Institute and Washington & Jefferson College in Pennsylvania collaborated to produce a report designed in part to help communities avoid the “boom and bust” cycles of extractive industries. Authors warned, “While resource extraction has long been regarded as an economic benefit, a body of academic literature suggests that long term growth based chiefly on resource extraction is rare.” Confounding factors include transience of the workforce, localized inflation, widening disparities in royalties and impact fee

¹⁰²³ Sagner, N. (2015, March 26). Fracking costs outweigh benefits for Germany and Europe, study says. *EurActiv*. Retrieved from <http://www.euractiv.com/sections/energy/fracking-costs-outweigh-benefits-germany-and-europe-study-says-313087>

¹⁰²⁴ International Energy Agency. (2014, December). World Energy Outlook 2014 Executive Summary. Retrieved from http://www.iea.org/publications/freepublications/publication/WEO_2014_ES_English_WEB.pdf

¹⁰²⁵ Dimick, D. (2014, December 19). How long can the U.S. oil boom last? *National Geographic*. Retrieved from <http://news.nationalgeographic.com/news/2014/12/141219-fracking-oil-supply-price-reserves-profits-environment/>

¹⁰²⁶ Nikiforuk, A. (2014, August 29). A big summer story you missed: Soaring oil debt returns diminish as energy companies resort to higher-cost, higher-risk hydrocarbons. *The Tyee*. Retrieved from <http://thetyee.ca/Opinion/2014/08/29/Soaring-Oil-Debt-Summer/>

¹⁰²⁷ US Energy Information Administration. (2014, July 29). As cash flows flatten, major energy companies increase debt, sell assets. *Today in Energy*. Retrieved from <http://www.eia.gov/todayinenergy/detail.cfm?id=17311>

disbursement, commodity price volatility, and communities overspending on infrastructure.¹⁰²⁸

- June 19, 2014 – Energy analyst Deborah Lawrence Rogers outlined the spiraling debt and severe deterioration of the assets of five major shale gas drillers over the last five years. She concluded, “This is not sustainable. It could be argued that it is not even moral. It is a failed business model of epic proportion. While companies could make the argument at one time that this was a short term downtrend, that no longer holds water because this pattern is long term.”¹⁰²⁹
- April 10, 2014 – A report by a petroleum geologist and petroleum engineer concluded the 100-year supply of shale gas is a myth, distinguished between what is technically recoverable and economically recoverable shale gas, and asserted that at current prices, New York State has no economically recoverable shale gas.¹⁰³⁰
- February 28, 2014 – Maria van der Hoeven, Executive Director of the IEA, said in an interview with *The Christian Science Monitor* that there is only a decade left in the U.S. shale oil and gas boom, noting that her agency’s analysis predicts that production will soon flatten out and, by 2025, begin to decline.¹⁰³¹
- December 18, 2013 – A University of Texas study in *Proceedings of the National Academy of Sciences* found that fracking well production drops sharply with time, which undercuts the oil and gas industry’s economic projections.¹⁰³² In an interview about the study with *StateImpact NPR* in Texas, Tad Patzek, Chair of the Department of Petroleum and Geosystems Engineering at University of Texas at Austin, noted that fracking “also interferes now more and more with daily lives of people. Drilling is coming to your neighborhood, and most people abhor the thought of having somebody drilling a well in their neighborhood.”¹⁰³³

¹⁰²⁸ Environmental Law Institute and Washington & Jefferson College. (2014, July). Getting the boom without the bust: Guiding Southwestern Pennsylvania through shale gas development. Retrieved from <http://www.eli.org/sites/default/files/eli-pubs/getting-boom-final-paper-exec-summary-2014-07-28.pdf>

¹⁰²⁹ Rogers, D. L. (2014, June 19). Huge CAPEX = free cash flow? Not in shales. *Energy Policy Forum*. Retrieved from <http://energypolicyforum.org/2013/06/19/huge-capex-free-cash-flow-not-in-shales/>

¹⁰³⁰ Labyrinth Consulting Services, Inc., Berman, A., and Pittinger, L. (2014). Resource Assessment of Potentially Producible Natural Gas Volumes From the Marcellus Shale, State of New York. Retrieved from: <http://www.lwvny.org/>

¹⁰³¹ Unger, D. J. (2014, February 28). IEA chief: Only a decade left in US shale oil boom. *Christian Science Monitor*. Retrieved from <http://www.csmonitor.com/Environment/Energy-Voices/2014/0228/IEA-chief-Only-a-decade-left-in-US-shale-oil-boom>

¹⁰³² Patzek, T. W., Male, F., & Marder, M. (2013). Gas production in the Barnett Shale obeys a simple scaling theory. *Proceedings of the National Academy of Sciences*, 110(49), 19731-19736. doi: 10.1073/pnas.1313380110

¹⁰³³ Buchele, M. (2013, December 18). New study shows how gas production from “fracked” wells slows over time. *StateImpact*. Retrieved from <http://stateimpact.npr.org/texas/2013/12/18/new-study-shows-how-gas-production-from-fracked-wells-slows-over-time/>

- August 18, 2013 – *Bloomberg News* reported that low gas prices and disappointing wells have led major companies to devalue oil and gas shale assets by billions of dollars.¹⁰³⁴
- October 21, 2012 – The *New York Times* reported that many gas drilling companies overproduced natural gas backed by creative financing and now “are committed to spending far more to produce gas than they can earn selling it.” “We are all losing our shirts today,” said Exxon CEO Rex Tillerson in the summer of 2012.¹⁰³⁵
- July 13, 2012 – *The Wall Street Journal* reported that ITG Investment Research, at the request of institutional investors, evaluated the reserves of Chesapeake Energy Corporation’s shale gas reserves in the Barnett and Haynesville formations and found them to be only 70 percent of estimates by Chesapeake’s engineering consultant for the company’s 2011 annual report. Chesapeake and its consultant defended their figures.¹⁰³⁶
- August 23, 2011 – The U.S. Geological Survey (USGS) cut the government’s estimates of natural gas in the Marcellus Shale from 410 trillion cubic feet to 84 trillion cubic feet, equivalent to a reduction from approximately 16 years of U.S. consumption at current levels of natural gas use, to approximately 3.3 years of consumption. The USGS’s updated estimate was for natural gas that is technically recoverable, irrespective of economic considerations such as the price of natural gas or the cost of extracting it.¹⁰³⁷
- June 26-27, 2011 – As reported in two *New York Times* stories, hundreds of emails, internal documents, and analyses of data from thousands of wells from drilling industry employees, combined with documents from federal energy officials, raised concerns that shale gas companies were overstating the amount of gas in their reserves and the profitability of their operations.^{1038, 1039, 1040} The *New York Times*’ public editor criticized the stories, but offered no evidence that the major findings were wrong.¹⁰⁴¹ The *New York*

¹⁰³⁴ Monks, M., Penty, R., & De Vynck, G. (2013, August 18). Shale grab in U.S. stalls as falling values repel buyers. *Bloomberg*. Retrieved from <http://www.bloomberg.com/news/2013-08-18/shale-grab-in-u-s-stalls-as-falling-values-repel-buyers.html>

¹⁰³⁵ Krauss, C., & Lipton, E. (2012, October 20). After the boom in natural gas. *The New York Times*. Retrieved from <http://www.nytimes.com/2012/10/21/business/energy-environment/in-a-natural-gas-glut-big-winners-and-losers.html?pagewanted=all>

¹⁰³⁶ Wirz, M. (2013, July 13). Chesapeake reserve doubted. *Wall Street Journal*. Retrieved from <http://online.wsj.com/news/articles/SB10001424052702303644004577523411723501548>

¹⁰³⁷ United States Geological Survey. (2011, August 23). USGS releases new assessment of gas resources in the Marcellus shale, Appalachian Basin. *USGS Newsroom*. Retrieved from http://www.usgs.gov/newsroom/article.asp?ID=2893&from=rss_home#.Uok0mGRO_GA.

¹⁰³⁸ Urbina, I. (2011, June 25). Insiders sound an alarm amid a natural gas rush. *The New York Times*. Retrieved from <http://www.nytimes.com/2011/06/26/us/26gas.html?pagewanted=all>

¹⁰³⁹ U.S. Energy Information Administration. (2014, May 30). U.S. Natural Gas Summary. Retrieved from http://www.eia.gov/dnav/ng/ng_sum_lsum_dcu_nus_a.htm

¹⁰⁴⁰ Urbina, I. (2011, August 24). Geologists sharply cut estimate of shale gas. *The New York Times*. Retrieved from <http://www.nytimes.com/2011/08/25/us/25gas.html>

¹⁰⁴¹ Brisbane, A. S. (2011, July 16). Clashing views on the future of natural gas. *The New York Times*. Retrieved from http://www.nytimes.com/2011/07/17/opinion/sunday/17pubed.html?gwh=7D408242717755A0E06B0D265498E177&gwt=pay&assetType=opinion&_r=0

Times' news editors publicly defended both stories against the public editor's criticism.^{1042, 1043}

Disclosure of serious risks to investors

A snapshot of the dangers posed by natural gas drilling and fracking can be found in the annual Forms 10-K that oil and natural gas companies are required to file with the U.S. Securities and Exchange Commission (SEC). The information so contained in these reports, which provide a comprehensive summary of a company's financial performance, provides a window into the harms and risks of fracking that are otherwise shielded from view by "gag order" clauses in court settlements, non-disclosure agreements between industry and landowners, and trade secret claims in regards to the chemical ingredients of fracking fluid. In this way, the Form 10-K can serve as an imperfect surrogate for right-to-know data. Recently, Forms 10-K have been used to warn investors about risks from climate change lawsuits.

Federal law requires that companies offering stock to the public disclose in their Form 10-K, among other things, the "most significant factors that make the offering speculative or risky."¹⁰⁴⁴ In a review of Forms 10-K spanning the past decade available on the SEC's website, oil and natural gas companies have routinely warned of drilling's serious risks. In the words of Exxon Mobil Corporation's subsidiary XTO Energy, "our operations are subject to hazards and risks inherent in drilling."¹⁰⁴⁵ In the language of Range Resources Corporation: "development and exploratory drilling and production activities are subject to many risks."¹⁰⁴⁶

Such hazards and risks include leaks, spills, explosions, blowouts, environmental damage, property damage, injury, and death. Chesapeake Energy Corporation has stated that "horizontal and deep drilling activities involve greater risk of mechanical problems than vertical and shallow drilling operations."¹⁰⁴⁷ Over the past 15 years, companies have combined horizontal drilling with hydraulic fracturing to tap natural gas and oil in shale formations.

The companies also routinely warn of inadequate insurance to cover drilling harms. According to XTO Energy, "we are not fully insured against all environmental risks, and

¹⁰⁴² Brisbane, A. S. (2011, July 17). Times editors respond to my shale gas column. *The New York Times*. Retrieved from <http://publiceditor.blogs.nytimes.com/2011/07/17/times-editors-respond-to-my-shale-gas-column/>

¹⁰⁴³ Brisbane, A. S. (2011, July 30). Times editors respond to column on redactions. *The New York Times*. Retrieved from <http://publiceditor.blogs.nytimes.com/2011/07/30/times-editors-respond-to-column-on-redactions/>

¹⁰⁴⁴ See 17 C.F.R. § 229.503(c) (companies must disclose the "most significant" risks); 17 C.F.R. § 230.405 ("the term material, when used to qualify a requirement for the furnishing of information as to any subject, limits the information required to those matters to which there is a substantial likelihood that a reasonable investor would attach importance in determining whether to purchase the security registered"); 17 C.F.R. § 240.10b-5 (it is illegal "to make any untrue statement of a material fact or to omit to state a material fact . . . in connection with the purchase or sale of any security"); 17 C.F.R. 249.310 (requiring Form 10-K, "for annual and transition reports pursuant to sections 13 or 15(d) of the Securities Exchange Act of 1934.")

¹⁰⁴⁵ XTO Energy Corp., Annual Report (Form 10-K) (Feb. 25, 2010) at 25.

¹⁰⁴⁶ Range Resources Corp., Annual Report (Form 10-K) (Feb. 24, 2015) at 22.

¹⁰⁴⁷ Chesapeake Energy Corp., Annual Report (Form 10-K) (Feb. 27, 2015) at 18.

no coverage is maintained with respect to any penalty or fine required to be paid by us.”¹⁰⁴⁸ Range Resources states, “we can provide no assurance that our coverage will adequately protect us against liability from all potential consequences, damages and losses.”¹⁰⁴⁹

Houston-based Noble Energy provides a representative example of the risks that at least several drilling companies include in their annual reports. Noble states:

Our operations are subject to hazards and risks inherent in the drilling, production and transportation of crude oil, natural gas and NGLs [natural gas liquids], including:

- injuries and/or deaths of employees, supplier personnel, or other individuals;
- pipeline ruptures and spills;
- fires, explosions, blowouts and well cratering;
- equipment malfunctions and/or mechanical failure on high-volume, high-impact wells;
- leaks or spills occurring during the transfer of hydrocarbons from an FPSO [floating production storage and offloading vessels] to an oil tanker;
- loss of product occurring as a result of transfer to a rail car or train derailments;
- formations with abnormal pressures and basin subsidence which could result in leakage or loss of access to hydrocarbons;
- release of pollutants;
- surface spillage of, or contamination of groundwater by, fluids used in operations;
- security breaches, cyber attacks, piracy, or terroristic acts;
- theft or vandalism of oilfield equipment and supplies, especially in areas of active onshore operations;
- hurricanes, cyclones, windstorms, or “superstorms,” which could affect our operations in areas such as the Gulf Coast, deepwater Gulf of Mexico, Marcellus Shale or Eastern Mediterranean;
- winter storms and snow which could affect our operations in the DJ Basin [Denver-Julesburg Basin in Colorado] or Marcellus Shale;
- extremely high temperatures, which could affect third party gathering and processing facilities in the DJ Basin;
- volcanoes which could affect our operations offshore Equatorial Guinea;
- flooding which could affect our operations in low-lying areas;
- harsh weather and rough seas offshore the Falkland Islands, which could limit certain exploration activities; and
- pandemics and epidemics, such as the Ebola virus, which is ongoing in certain regions of West Africa and may adversely affect our business operations through travel or other restrictions.

Any of these can result in loss of hydrocarbons, environmental pollution and other damage to our properties or the properties of others.¹⁰⁵⁰

¹⁰⁴⁸ XTO Energy Corp., Annual Report (Form 10-K) (Feb. 25, 2010) at 17.

¹⁰⁴⁹ Range Resources Corp., Annual Report (Form 10-K) (Feb. 24, 2015) at 26.

¹⁰⁵⁰ Noble Energy, Annual Report (Form 10-K) (Feb. 19, 2015) at 38.

Noble has language similar to that found in other companies' annual reports about inadequate insurance and adds, "we do not have insurance for gradual pollution nor do we have coverage for penalties or fines that may be assessed by a governmental authority."¹⁰⁵¹

Forms 10-K are also a tool of disclosure for risks concerning climate change beyond specific negative impacts on operations (hurricanes, flooding, etc.) listed, for example, in Noble Energy's annual report cited above. In 2016, Chevron became the first major oil company to warn investors in its Form 10-K about the risk of climate change lawsuits: "Increasing attention to climate change risks has resulted in an increased possibility of governmental investigations and, potentially, private litigation against the company."¹⁰⁵² Also in 2016, the SEC began investigating Exxon Mobil for valuing its assets in ways that do not account for the possible depreciation of oil and gas under a policy framework that shifts investments in energy away from fossil fuels and toward renewable sources.¹⁰⁵³ Under pressure from investors, Exxon agreed in December 2017 to disclose more details about climate risks by filing with the SEC, in a Form 8-K, a statement that said the company would no longer resist motions from shareholders seeking this information.¹⁰⁵⁴

At this writing, it is not clear whether, under the current Administration, the SEC will continue its push toward investor disclosure of climate change risks.¹⁰⁵⁵ Nevertheless, the unsolved problem of methane leaks is increasingly recognized as a rising risk for oil and gas investors concerned that methane emissions are not transparently managed, may negate the claim that natural gas is more climate-friendly than coal, and hence pose a risk to their investments.^{1056, 1057}

The risks identified by these oil and gas companies are not just hypothetical. Many, if not all of these risks are reflected in the evidence compiled in other sections of this Compendium.

¹⁰⁵¹ Noble Energy. Annual Report (Form 10-K) (Feb 19, 2015) at 79.

¹⁰⁵² Romm, J. (2017, March 2). Chevron is first oil major to warn investors of risks from climate change lawsuits. *ThinkProgress*. Retrieved from <https://thinkprogress.org/chevron-admits-climate-lawsuits-threaten-profits-33937dd562fd/#.56j1qq4h3>

¹⁰⁵³ Olson, B., & Viswanatha, A. (2016, September 20). SEC probes Exxon over accounting for climate change. *Wall Street Journal*. Retrieved from <https://www.wsj.com/articles/sec-investigating-exxon-on-valuing-of-assets-accounting-practices-1474393593>

¹⁰⁵⁴ Cushman, Jr., J. H., & Hasemyer, D. (2017, December 12). Exxon agrees to disclosure climate risks under pressure from investors. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/12122017/exxon-climate-risk-disclosure-sec-shareholder-investigation-pressure>

¹⁰⁵⁵ Griffen, P., & Jaffe, A. M. (2017, February 15). Are fossil fuel companies telling investors enough about the risks of climate change? *The Conversation*. Retrieved from <https://theconversation.com/are-fossil-fuel-companies-telling-investors-enough-about-the-risks-of-climate-change-72562>

¹⁰⁵⁶ Connan, M.-S. (2016, December 1). *Methane: The next frontier for fossil fuel emissions*. Retrieved from <https://us.allianzgi.com/en-us/insights/capital-markets-and-economics/methane-the-next-frontier-for-fossil-fuel-emissions>

¹⁰⁵⁷ Gilblom, K. (2017, December 19). Insidious gas leaks are casting doubts over Shell's clean credentials. *Bloomberg*. Retrieved from <https://www.bloomberg.com/news/articles/2017-12-20/as-shell-gambles-on-gas-leaks-cast-cloud-over-clean-credentials>

Medical and scientific calls for more study, reviews confirming evidence for harm, and calls for increased transparency and science-based policy

With increasing urgency, groups of medical and other health professionals and scientists are issuing calls for comprehensive, long-term study of the full range of potential health and ecosystem effects of drilling and fracking. These appeals underscore the accumulating evidence of harm, point to the major knowledge gaps that remain, and decry the atmosphere of secrecy and intimidation that continues to impede the progress of scientific inquiry. Published reviews and international governmental reports underscore the existing evidence of health risks including developmental, neurological, carcinogenic, respiratory, reproductive, and psychological. Health professionals and scientists in the United States and around the world increasingly call for the suspension of unconventional gas and oil extraction activities in order to limit, mitigate, or eliminate its serious, adverse public health hazards, including health threats from climate change.

- December 12, 2017 – Commissioned by the Australian government, the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory released its Draft Final Report. Tasked with identifying and assessing the risks of shale gas fracking for Australia’s remote Northern Territory—and with making recommendations to mitigate those risks where possible—the Inquiry describes a multiplicity of risks, including many that are ill-defined and understudied¹⁰⁵⁸ Most notably, it recommends a halt on all fracking production licenses until a two-to-three-year study can be launched to further understand the nature of the risks for the particular ecology and culture of the region.”¹⁰⁵⁹ Fracking is currently prohibited in the Northern Territory, which is estimated to hold over one-third of Australia’s shale gas.
- November 7, 2017 – In a commentary published in *JAMA*, two South Dakota physicians reviewed the data on the potential public health implications of fracking, including asthma, water contamination, exposures to fracking fluid, and exposure of workers to silica dust. They voiced specific concerns about parkinsonism, neuropathy, and kidney disease, and called for prospective toxicity studies.¹⁰⁶⁰
- October 25, 2017 – Scientists and physicians (including two co-authors of this *Compendium*) reviewed the body of evidence on the potential of unconventional oil and natural gas (UOG) development and operations to contribute to neurological and developmental harm via increased air and water pollution in the surrounding communities where it takes place. Highlighting data gaps and research limitations (such

¹⁰⁵⁸ Scientific Inquiry into Hydraulic Fracturing in the Northern Territory. (2017). *Draft final report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory*. Retrieved from <https://frackinginquiry.nt.gov.au/inquiry-reports/draft-final-report>

¹⁰⁵⁹ Reuters staff. (2017, December 12). Study seen needed before lifting fracking ban in remote Australia. *Reuters*. Retrieve from <https://www.reuters.com/article/us-australia-fracking/study-seen-needed-before-lifting-fracking-ban-in-remote-australia-idUSKBN1E60TL>

¹⁰⁶⁰ Wilke, R. A., & Freeman, J. W. (2017). Potential health implications related to fracking. *JAMA*, 318(17), 1645-1646. doi: 10.1001/jama.2017.14239

as the nondisclosure by industry of chemical mixtures), they nevertheless pinpointed evidence in the existing literature showing that “the chemicals that are used in or are byproducts of UOG operations have been linked to serious neurodevelopmental health problems in infants.”¹⁰⁶¹ Interviewed by the *Guardian*, a co-author said, “Given the profound sensitivity of the developing brain and the central nervous system, it is very reasonable to conclude that young children who experience frequent exposure to these pollutants are at particularly high risk for chronic neurological problems and disease.”¹⁰⁶² The research team concluded that there is “a need for public health prevention techniques, well-designed studies, and stronger state and national regulatory standards.”

- October 23, 2017 – A Yale University research team reported that carcinogens involved in fracking operations have the potential to contaminate both air and water in nearby communities in ways that may increase the risk of childhood leukemia. The team identified 55 known or possible carcinogens that may be released into air and water from fracking operations. Of these, 20 are linked to leukemia or lymphoma.¹⁰⁶³ “This analysis creates a priority list of carcinogens to target for future exposure and health studies.”¹⁰⁶⁴
- July 31, 2017 – A review by a team of medical, psychological, occupational, and environmental health professionals concluded, “there appears to be an array of levels of psychosocial functioning that are deleteriously affected by the fracking process and industries and their aftermath.” Though much of the research they identified linking fracking to psychological functioning was preliminary, documented impacts included: individual-level impacts, such as feelings of stress and powerlessness; community-level impacts, such as disrupted social fabric and new gender/sex imbalances in the community; collective trauma such as caused by a boom-and-bust cycle; and worker impacts, such as psychosocial impacts of being a transient worker. The review provided “an important first step in understanding the psychological toll that this energy development strategy has on fracking communities and sets the stage for advancements in research, clinical and policy, that will help us to better understand, assist, and advocate for those affected by fracking.”¹⁰⁶⁵

¹⁰⁶¹ Webb, E., Moon, J., Dyrzka, L., Rodriguez, B., Cox, C., Patisaul, H., . . . London, E. (2017).

Neurodevelopmental and neurological effects of chemicals associated with unconventional oil and natural gas operations and their potential effects on infants and children. *Reviews on Environmental Health*. Advance online publication. doi: 10.1515/reveh-2017-0008

¹⁰⁶² Davis, N. (2017, October 25). Pollutants from fracking could pose health risk to children, warn researchers. *Guardian*. Retrieved from <https://www.theguardian.com/environment/2017/oct/25/pollutants-from-fracking-could-pose-health-risk-to-children-warn-researchers>

¹⁰⁶³ Elliot, E. G., Trihn, P., Ma, X., Leaderer, B. P., Ward, M. H., & Deziel, N. C. (2017). Unconventional oil and gas development and risk of childhood leukemia. *Science of the Total Environment*, 576. doi: 10.1016/j.scitotenv.2016.10.072

¹⁰⁶⁴ Yale News. (2016, October 24). Fracking linked to cancer-causing chemicals, new YSPH study finds. Retrieved from <https://publichealth.yale.edu/news/article.aspx?id=13714>

¹⁰⁶⁵ Hirsch, J. K., Smalley, K. B., Selby-Nelson, E. M., Hamel-Lambert, J. M., Rosmann, M. R., Barnes, T. A. Daniel, . . . LaFromboise, T. (2017). Psychosocial impact of fracking: A review of the literature on the mental health consequences of hydraulic fracturing. *International Journal of Mental Health and Addiction*. doi: 10.1007/s11469-017-9792-5

- May 1, 2017 – The Southwest Pennsylvania Environmental Health Project established a voluntary public health registry “aimed at tracking and eventually analyzing the impacts of shale gas development on people living near wells, impoundments, compressor stations and pipelines.” According to a spokesperson, “The point is that the vast majority of independent science is looking at [shale gas development] and saying something’s not good there. We need to know more... The findings of this registry will allow the health care community to be more informed about what problems people are experiencing when they walk into their offices. It will give the doctors some idea of what they should be looking for.”¹⁰⁶⁶
- February 8, 2017 – Addressing the community health and safety harms linked with camps that house temporary workers in extractive industries, the British Columbia Ministry of Aboriginal Relations and Reconciliation funded a research project carried out in consultation with Indigenous nations. The premise, that “Indigenous women and youth can experience negative impacts of resource extraction at every phase of resource development,” was borne out by the project’s community dialogues and literature review. “Increased domestic violence, sexual assault, substance abuse, and an increased incidence of sexually transmitted infections (STIs) and HIV/AIDS due to rape, prostitution, and sex trafficking are some of the recorded negative impacts of resource extraction projects, specifically as a result of the presence of industrial camps and transient work forces.” The objectives of the project were to stimulate dialogue and to develop detailed protective steps for Nations, government, and industry in advance of the initiation of planned extraction projects in the region, such as the TransCanada and Spectra Energy pipelines, in order to prevent violence against women and other life changing negative effects linked to the industrial camps.¹⁰⁶⁷
- February 8, 2017 – Los Angeles County health officials criticized as insufficient the allocation of only one million dollars by the Southern California Gas Company to fund an independent health study in the aftermath of the massive methane leak at Aliso Canyon that lasted from October 2015 until February 2016. “‘It’s a study, but not a health study,’ said Angelo Bellomo, the Los Angeles County deputy director for health protection. ‘It is not responsive to addressing the health needs and concerns to this community. More importantly, it’s inconsistent with advice given to [South Coast Air Quality Management District] by health officials.’” Health experts from across the state had suggested a design “that was comprehensive and larger in scope as well as consistent with a state Senate bill introduced last year that estimated such a design would cost \$13 million in the first three years, and up to \$40 million to complete.”¹⁰⁶⁸

¹⁰⁶⁶ Hopey, D. (2017, May 1). Registry will study health impact from living near shale gas wells. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/consumers-powersource/2017/05/01/Registry-will-study-health-impact-from-living-near-shale-gas-wells/stories/201705010018>

¹⁰⁶⁷ Gibson, G., Yung, K., Chisholm, L., & Quinn, H., with Lake Babine Nation and Nak’azdli Whut’en. 2017. *Indigenous Communities and Industrial Camps: Promoting healthy communities in settings of industrial change*. Retrieved from http://www.thefirelightgroup.com/thoushallnotpass/wp-content/uploads/2016/03/Firelight-work-camps-Feb-8-2017_FINAL.pdf

¹⁰⁶⁸ Gazzar, B., & Abram, S. (2017, February 8). \$1 million health study ‘shortchanges’ Porter Ranch gas leak victims, critics say. *Los Angeles Daily News*. Retrieved from <https://www.dailynews.com/2017/02/08/1-million-health-study-shortchanges-porter-ranch-gas-leak-victims-critics-say/>

- January 19, 2017 – An epidemiologist at Brown University reviewed studies to date on health outcomes in communities living close to unconventional natural gas development, and identified areas requiring further study. “Future epidemiologic studies should implement personal exposure assessments to examine associations between individual contaminants and relevant health outcomes, particularly to explain associations seen with respiratory and birth outcomes,” the author concluded.¹⁰⁶⁹
- November 1, 2016 – The government of Scotland released a health impact assessment that reconfirmed the evidence for potential contamination of air and water, threats to worker health from silica dust exposure, and risks to the health of nearby residents.¹⁰⁷⁰
- October 23, 2016 – In a unanimous vote of the society’s 300-member House of Delegates, the Pennsylvania Medical Society called for a moratorium on new shale gas drilling and fracking in Pennsylvania and an initiation of a health registry in communities with pre-existing operations.^{1071, 1072}
- October 11, 2016 – A group of health care professionals in Massachusetts called for an immediate moratorium on major new natural gas infrastructure until the impact of these projects on the health of the communities affected can be adequately determined through a Comprehensive Health Impact Assessment.¹⁰⁷³ The group noted that the operation of natural gas facilities risks human exposures to toxic, cancer-causing, and radioactive pollution due to the presence of naturally co-occurring contaminants, toxic additives to the hydraulic fracturing process, and through the operation of transmission pipelines.¹⁰⁷⁴
- September 15, 2016 – A systematic review of 45 studies, primarily but not exclusively addressing conventional oil and gas activities, showed an emerging body of evidence documenting harm to reproductive health from residential and occupational exposure to these operations. The strongest evidence existed for increased risk of miscarriage, prostate cancer, birth defects, and decreased semen quality. Authors state that there is “ample evidence for disruption of the estrogen, androgen, and progesterone receptors with individual chemicals and waste products related to oil and gas extraction,” and “impacts from unconventional oil and gas activities will likely be greater, given that

¹⁰⁶⁹ Stacy, S. L. (2017). A Review of the Human Health Impacts of Unconventional Natural Gas Development. *Current Epidemiology Reports*, 4, 38–45. doi: 10.1007/s40471-017-0097-9

¹⁰⁷⁰ Health Protection Scotland. (2016). *A health impact assessment of unconventional oil and gas in Scotland, Vol. 1*. Retrieved from <http://www.hps.scot.nhs.uk/resourcedocument.aspx?resourceid=3102>

¹⁰⁷¹ Pennsylvania Medical Society (2016, October 23). Resolution 16-206: Pennsylvania Medical Society support for a moratorium on fracking. Retrieved from https://www.pamedsoc.org/PAMED_Downloads/HODAEC/16-206.pdf

¹⁰⁷² Hopey, D. (2016, October 28). Doctors call for a state ban on drilling and fracking. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/local/region/2016/10/27/Doctors-group-calls-for-moratorium-on-fracking-in-Pennsylvania/stories/201610270226>

¹⁰⁷³ Massachusetts Health Care Professionals Against Fracked Gas (2016, October). Call for a moratorium on natural gas projects undergoing construction or review in the Commonwealth of Massachusetts. Retrieved from <http://mhcpafg.org/>

¹⁰⁷⁴ Massachusetts Health Care Professionals Against Fracked Gas. (2016, February 20). The role of comprehensive health impact assessment in evaluating natural gas infrastructure proposals in Massachusetts. Retrieved from <http://mhcpafg.org/>

unconventional activities have many similarities to conventional ones and employ dozens of endocrine-disrupting chemicals in the process of hydraulic fracturing.”¹⁰⁷⁵

- September 14, 2016 – In a commentary about fracking in the *American Journal of Public Health*, Weill Cornell Medicine physicians wrote, “mounting empirical evidence shows harm to the environment and to human health . . . and we have no idea what the long-term effects might be. . . . Ignoring the body of evidence, to us, is not a viable option anymore.”¹⁰⁷⁶
- July 7, 2016 –The UK health professional organization Medact released an updated assessment of the potential health impacts of shale fracking in England that confirm the findings of its 2015 report, *Health and Fracking*. The new report, *Shale Gas Production in England*, concluded, “Our view that the UK should abandon its policy to encourage [shale gas production] remains unchanged.” The new report included hundreds of new academic papers addressing impacts on air and water quality, health, climate change, social wellbeing, economics, noise and light pollution, and seismic events. Still, authors wrote, “the absence of an independent social, health and economic impact assessment of [shale gas production] at scale is a glaring omission. Given the availability of alternative sources of energy, these are grounds for placing an indefinite moratorium on SGP (a position adopted by many jurisdictions across the world) until such time that there is greater clarity and certainty about the relative harms and benefits of shale gas.”¹⁰⁷⁷
- May 31, 2016 – “There are too many science, technology and risk-assessment gaps to green-light fracking in western Newfoundland,” according to a panel that studied the question. In an interview with Canada’s *Globe and Mail*, panel leader and engineering professor Ray Gosine said, “The science, the studies that have been done, have been somewhat limited – certainly limited compared to what we’d expect to have done in order to plan this kind of operation. . . . There are a number of gaps and deficiencies that are significant.”¹⁰⁷⁸
- May 13, 2016 – Physicians for Social Responsibility called for a ban on hydraulic fracturing, pointing both to the irremediable climate harm caused by methane emissions as well to the multiple health risks from industrial-scale water consumption, air pollution, seismic effects, the generation of large quantities of toxic liquid waste, and long-term impacts on drinking water aquifers. “We cannot stay healthy in an unhealthy environment. Nor can we survive indefinitely on a planet growing hotter and more prone to extreme, unpredictable and destructive weather. These factors impel PSR to call for a

¹⁰⁷⁵ Balise, V. D., Meng, C-X., Cornelius-Green, J. N., Kassotis, C. D., Kennedy, R., & Nagel, S. C. (2016). Systematic review of the association between oil and natural gas extraction processes and human reproduction. *Fertility and Sterility*, 106(4). doi: 10.1016/j.fertnstert.2016.07.1099

¹⁰⁷⁶ Finkel, M. L., & Law, A. (2016). The rush to drill for natural gas: a five-year update. *American Journal of Public Health*, 106(10). doi: 10.2105/AJPH.2016.303398

¹⁰⁷⁷ McCoy, D. & Munro, A. (2016). *Shale gas production in England: An updated public health assessment*. Retrieved from http://www.medact.org/wp/wp-content/uploads/2016/07/medact_shale-gas_WEB.pdf

¹⁰⁷⁸ Bailey, S. (2016, May 31). Too many gaps to recommend fracking in Newfoundland: Panel. *Globe and Mail*. Retrieved from <http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/too-many-unknowns-to-recommend-fracking-in-western-newfoundland-panel/article30216746/>

ban on fracking and for a rapid transition to cleaner, healthier, carbon-free sources of energy.”¹⁰⁷⁹

- March 27, 2016 – Noting that many chemicals used in fracking fluids are known or suspected endocrine disruptors, a group of public health researchers called for an endocrine-centric component for health assessments in areas impacted by oil and gas operations. The team outlined a series of recommendations to assess the “potential endocrine-related risks from chemical exposures associated with oil and natural gas operations. We present these recommendations in light of the growing body of information regarding both chemical concentrations in the environment and adverse health outcomes reported in humans and wildlife.”¹⁰⁸⁰
- January 6, 2016 – A Yale University team of epidemiologists called for a systematic evaluation of chemicals in fracking fluid and wastewater for reproductive and development toxicity. While basic toxicity information is lacking for more than three-quarters of the more than 1,000 chemicals known to be used in fracking fluid, many of the remainder, the authors note, are linked to reproductive and developmental harm. “Therefore, carefully designed, rigorous exposure, and epidemiologic studies are urgently needed to investigate public health uncertainties.... The 67 chemicals we identified as possibly associated with either reproductive or developmental toxicity with a current or proposed federal drinking water standard or health-based guideline represent a feasible starting point for evaluation in future drinking water exposure studies or human health studies....”¹⁰⁸¹
- November 24, 2015 – A Harvard University team identified a trend toward increasing chemical secrecy and less transparency by examining 96,000 chemical disclosure forms filed by fracking companies between March 2011 and April 2015. These forms were submitted to the Fracfocus website, a chemical disclosure portal for the fracking industry that operates on a voluntary basis but for which reporting is mandated in more than 20 states. Fracfocus is the largest public database on chemicals used in U.S. fracking operations.¹⁰⁸² Companies involved in fracking withheld chemical data at significantly higher rates in 2015 (16.5 percent) as compared to 2011-2013 (11 percent). The research team also found that withholding drops by a factor of four when companies report aggregate data without attribution to the specific products in the fracking fluid. The

¹⁰⁷⁹ Physicians for Social Responsibility (2016, May 13). PSR position statement calling for a ban on hydraulic fracturing. Retrieved from <http://www.psr.org/assets/pdfs/psr-fracking-policy.pdf>

¹⁰⁸⁰ Kassotis, C. D., Tillitt, D. E., Lin, C-H., Mcelroy, J. A., & Nagel, S. (2016). Endocrine-disrupting chemicals and oil and natural gas operations: Potential environmental contamination and recommendations to assess complex environmental mixtures. *Environmental Health Perspectives*, 124(3). doi: 10.1289/ehp.1409535

¹⁰⁸¹ Elliot, E. G., Ettinger, A. S., Leaderer, B. P., Bracken, M. B., & Deziel, N. C. (2016). A systematic evaluation of chemicals in hydraulic-fracturing fluids and wastewater for reproductive and developmental toxicity. *Journal of Exposure Science and Environmental Epidemiology*. Advance online publication. doi: 10.1038/jes.2015.81

¹⁰⁸² Song, L. (2015, Nov. 24). What chemicals are used in fracking? Industry discloses less and less. *InsideClimate News*. Retrieved from <https://insideclimatenews.org/news/24112015/fracking-natural-gas-drilling-chemicals-frac-focus-study>

authors called for state governments to retain authority in requiring disclosure of “product-specific ingredient lists.”¹⁰⁸³

- August 7, 2015 – While acknowledging the “dramatic increase in the number of peer-reviewed published studies” on environmental and health impacts of fracking, Weill Cornell Medical College’s Dr. Madelon Finkel and co-author PSE Healthy Energy’s Jake Hays called for more well-designed longer-term epidemiologic studies to quantify the connections between fracking-related risk factors and health outcomes. Without such studies it is challenging to capture, for example, outcomes such as cancer that take many years to present. The authors described several important studies that are currently underway that will add to the body of knowledge in the future.¹⁰⁸⁴
- June 9, 2015 – Information on individual exposures and local environmental conditions prior to the commencement of fracking in a given area is often “unavailable or hard to obtain. These and other data gaps have hindered the kind of large-scale epidemiological studies that can link exposures to actual health outcomes, with valid comparison groups,” wrote public health journalist David Tuller in the journal *Health Affairs*.¹⁰⁸⁵ In an interview with *Michigan Radio*, Tuller noted that, because well development happens quickly, there was generally a lack of pre-drilling baseline studies.¹⁰⁸⁶
- April 17, 2015 – Using sophisticated Geographic Information Systems (GIS) tools to examine distribution of fracking wells compared to distribution of vulnerable populations, Clark University researchers found consistent evidence that, in the Pennsylvania Marcellus Shale region, census tracts with potential exposure to pollution from fracking wells contained “significantly higher” percentages of poor people. They also found clusters of vulnerable populations concentrated near drilling and fracking in all three states they studied: Pennsylvania (for poverty and elderly population), West Virginia (for poverty, elderly population, and education level) and Ohio (for children). Researchers also reported difficulty in accessing high quality and consistent unconventional well data in all three states, demonstrating an “urgent need” for common data collection and reporting.¹⁰⁸⁷ Another GIS-based study sought to begin to fill this gap in data on spatially distributed risks of fracking, identifying Pennsylvania populations at “very high” and “high” risk in over a dozen counties. The author called for more focus on those areas to understand the impacts of fracking.¹⁰⁸⁸

¹⁰⁸³ Konschnik, K., & Dayalu, A. (2016). Hydraulic fracturing chemicals reporting: Analysis of available data and recommendations for policymakers. *Energy Policy*, 88. doi: 10.1016/j.enpol.2015.11.002

¹⁰⁸⁴ Finkel, M. L. & Hays, J. (2015). Environmental and health impacts of ‘fracking’: Why epidemiological studies are necessary. *Journal of Epidemiology and Community Health*. Advance online publication. doi: 10.1136/jech-2015-205487

¹⁰⁸⁵ Tuller, D. (2015). As fracking booms, dearth of health risk data remains. *Health Affairs*, 34 (6), 903-906.

¹⁰⁸⁶ Williams, R. (June 9, 2015). Why there are gaps in public health studies on fracking. *Michigan Radio*. Retrieved from <http://michiganradio.org/post/why-there-are-gaps-public-health-studies-fracking#stream/0>

¹⁰⁸⁷ Ogneva-Himmelberger, Y., & Huang, L. (2015). Spatial distribution of unconventional gas wells and human populations in the Marcellus Shale in the United States: Vulnerability analysis. *Applied Geography*, 60. 165-174.

¹⁰⁸⁸ Meng, Q. (2015). Spatial analysis of environment and population at risk of natural gas fracking in the state of Pennsylvania, USA. *Science of the Total Environment*, 515-516. 198-206.

- March 30, 2015 – The UK medical organization Medact published a report, *Health & Fracking: The Impacts and Opportunity Costs*, which concluded that fracking poses significant risks to public health and called for an immediate moratorium to allow time for a full and comprehensive health and environmental impact assessment to be completed.¹⁰⁸⁹ The report was supported by a letter published in the *British Medical Journal* calling for shale gas development to be put on hold, signed by the Climate and Health Council and over a dozen senior health professionals. The letter stated, “The arguments against fracking on public health and ecological grounds are overwhelming. There are clear grounds for adopting the precautionary principle and prohibiting fracking.”¹⁰⁹⁰
- February 17, 2015 – Writing in the *Canadian Medical Association Journal*, a public health scientist and medical doctor briefly reviewed the human health risks of fracking documented to date and made the case for a health care worker role in insisting on improved understanding. They cited worker and community safety issues as the biggest short-term risks, but emphasized that more needs to be known “before health care providers can definitively respond to their patients’ and communities’ concerns.... Physicians may wish to advocate delaying new development activities until the potential health effects are better understood.”¹⁰⁹¹
- January 22, 2015 –The acting head of research at the Cancer Association of South Africa, Carl Albrecht, said that known carcinogenic chemicals used in fracking could lead to an epidemic of cancer in South Africa’s Karoo desert. As South Africa was poised to publish draft regulations, Albrecht said that the effect of fracking on human health was ignored.¹⁰⁹²
- January 19, 2015 – In an article that reviewed research and research gaps, a team of British and U.S. medical and scientific professionals urged the United Kingdom and other nations to engage in science before engaging in fracking. They warned that even strong regulations may not effectively address air pollution from fracking, and that “permanent, adverse environmental, climatic, and population health impacts” may exist in some cases.¹⁰⁹³
- December 17, 2014 – In an editorial, Rutgers University environmental exposure expert Paul J. Liroy (now deceased) highlighted fracking as an area in which accurate exposure monitoring and risk assessment did not yet exist. Liroy emphasized that the relevant

¹⁰⁸⁹ Medact. (2015). *Health & fracking: The impacts and opportunity costs*. London: McCoy, D. & Saunders, P.

¹⁰⁹⁰ Stott, R., Atkinson, S., Montgomery, H., Rao, M., McKee, M., Gerada, C., . . . Popay, J. (2014). Public Health England’s draft report on shale gas extraction. *BMJ*, 348. Retrieved from <http://www.bmj.com/content/348/bmj.g2728/rr>

¹⁰⁹¹ Bharadwaj, L. & Goldstein, B. D. (2015). Shale gas development in Canada: What are the potential health effects? *CMAJ*, 187(3), E99-E100.

¹⁰⁹² Vecchiato, P. (January 22, 2015). Chemicals used in fracking ‘could cause cancer.’ *Business Day BDLive*. Retrieved from <http://www.bdlive.co.za/business/energy/2015/01/22/chemicals-used-in-fracking-could-cause-cancer>

¹⁰⁹³ Hays, J., Finkel, M. L., Depledge, M., Law, A., & Shonkoff, S. B. C. (2015). Considerations for the development of shale gas in the United Kingdom. *Science of the Total Environment*, 512–513, 36–42. doi: 10.1016/j.scitotenv.2015.01.004

research was compartmentalized and fragmented and that exposures and health outcomes around unconventional natural gas development need to be systematically addressed through “well-defined exposure studies in communities and workplaces.”¹⁰⁹⁴

- December 5, 2014 – A team of medical and scientific researchers, including from the Institute for Health and Environment at the State University of New York (SUNY) at Albany, reviewed the scientific evidence that both adult and early life—including prenatal—exposure to chemicals from fracking operations can result in adverse reproductive health and developmental effects. These include: endocrine-disrupting chemicals potentially increasing risk for reproductive problems, breast cancer, abnormal growth and developmental delays, and changes in immune function; benzene, toluene and xylene (BTX chemicals) increasing risk for impaired sperm quantity and quality in men and menstrual and fertility problems in women; and heavy metals increasing the risk of miscarriage and/or stillbirths. Potential exposures occur through both air and water. Based on their review, the authors concluded, “Taken together, there is an urgent need for the following: 1) biomonitoring of human, domestic and wild animals for these chemicals; and 2) systematic and comprehensive epidemiological studies to examine the potential for human harm.”¹⁰⁹⁵ Lead author Susan Nagel said in an accompanying interview, “We desperately need biomonitoring data from these people. What are people actually exposed to? What are the blood levels of people living in these areas? What are the levels in the workers?”¹⁰⁹⁶
- November 12, 2014 – A team of Australian researchers reviewed the strength of evidence for environmental health impacts of fracking based on publications from 1995 to 2014. They noted that the rapid expansion of fracking had outstripped the pace of science and that most studies focused on short-term, rather than long-term, health. Hence, “very few studies examined health outcomes with longer latencies such as cancer or developmental outcomes.” Noting that no evidence exists to rule out health impacts, the team called for direct and clear public health assessments before projects are approved, longitudinal studies that include baseline data, and government and industry transparency.¹⁰⁹⁷
- September 15, 2014 – Researchers led by University of Rochester’s Environmental Health Sciences Center conducted interviews in New York, North Carolina, and Ohio to evaluate community health concerns about unconventional natural gas development. They identified many areas where more study is needed, including baseline measures of

¹⁰⁹⁴ Liroy, P.J. (2015). Exposure science and its places in environmental health sciences and risk assessment: why is its application still an ongoing struggle in 2014? *Journal of Exposure Science and Environmental Epidemiology*, 25, 1-3. doi: 10.1038/jes.2014.59

¹⁰⁹⁵ Webb, E., Bushkin-Bedient, S., Cheng, A., Kassotis, C.D., Balise, V., & Nagel, S.C. (2014). Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations. *Reviews on Environmental Health*, 29(4), 307-318. doi: 10.1515/reveh-2014-0057

¹⁰⁹⁶ Sample, I. (2014, December 5). Fracking chemicals could pose risks to reproductive health, say researchers. *Guardian*. Retrieved from <http://www.theguardian.com/environment/2014/dec/05/fracking-chemicals-could-pose-risks-to-reproductive-health-say-researchers>

¹⁰⁹⁷ Werner, A.K., Vink, S., Watt, K., & Jagals, P. (2015). Environmental health impacts of unconventional natural gas development: A review of the current strength of evidence. *Science of the Total Environment*, 505, 1127-1141. doi: 10.1016/j.scitotenv.2014.10.084

air quality, ongoing environmental monitoring, and health impact assessments. They noted that other areas where data are lacking involve the assessment of drilling and fracking impacts on vulnerable populations such as very young children, and the potential consequences of interactions between exposures resulting from shale gas extraction operations. Researchers suggested incorporating the input of potentially affected community members into the development of the research agenda.¹⁰⁹⁸

- July 21, 2014 – An independent assessment report by Scientists for Global Responsibility and the Chartered Institute of Environmental Health reviewed current evidence across a number of issues associated with shale gas extraction by hydraulic fracturing, including environmental and public health risks, drawing on academic research. Among the report's conclusions: there are major shortcomings in regulatory oversight regarding local environmental and public health risks; there is a large potential for UK shale gas exploitation to undermine national and international efforts to tackle climate change; the water-intensive nature of the fracking process which could cause water shortages in many areas; the complete lack of evidence behind claims that shale gas exploitation will bring down UK energy bills; and concerns that it will impact negatively on UK energy security. Despite claims to the contrary, the report noted that evidence of local environmental contamination from shale gas exploitation is well reported in the scientific literature. It emphasizes that, “[t]here are widespread concerns over the lack of evidence on fracking-related health impacts,” and that there is a lack of “substantive epidemiological study for populations exposed to shale gas extraction.”¹⁰⁹⁹
- July 18, 2014 – A working group of the Environmental Health Sciences Core Centers, supported by the National Institute of Environmental Health Sciences, reviewed the available literature on the potential health impacts of fracking for natural gas. They concluded that further research is urgently needed. Needs identified included: monitoring of air and water quality over the entire lifetime of wells; further epidemiologic research addressing health outcomes and water quality; and research addressing whether air pollution associated with fracking increases the risk of pulmonary and cardiovascular disease. The working group advocated for the participation of potentially affected communities in all areas of research.¹¹⁰⁰
- July 12, 2014 – Eli Avila, Pennsylvania's former Secretary of Health, said that health officials need to be proactive in protecting the public from the health effects of

¹⁰⁹⁸ Korfmacher, K.S., Gray, K.M., & Haynes, E. (2014, September 15). Health impacts of unconventional natural gas development: A comparative assessment of community information needs in New York, North Carolina, and Ohio. *Project Report, UR-UNC-UC Supplement 2012-13*. Retrieved from <http://www.urmc.rochester.edu/MediaLibraries/URMCMedia/environmental-health-sciences-center/COEC/documents/UNGD-information-needs-assessment-Final-project-report-091514.pdf>

¹⁰⁹⁹ Harrison, G., Parkinson, S., & McFarlane, G. (2014). Shale gas and fracking: examining the evidence. Published by Scientists for Global Responsibility (SGR) and the Chartered Institute of Environmental Health (CIEH). Retrieved from <http://www.cieh.org/WorkArea/showcontent.aspx?id=53520>

¹¹⁰⁰ Penning, T. M., Breyse, P.N., Gray, K., Howarth, M., & Yan, B. (2014). Environmental health research recommendations from the Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations. *Environmental Health Perspectives*, 122(11), 1155-1159. doi: 10.1289/ehp.1408207

unconventional shale gas extraction. In 2011, funding was approved for a Pennsylvania public health registry to track drilling related complaints and address concerns, but was cut at the last minute. Speaking to the problem posed by the dearth of information, Avila asked, “How can you keep the public safe if you’re not collecting data?”¹¹⁰¹

- June 30, 2014 – The immediate past chair of the Executive Committee of the Council on Environmental Health for the American Academy of Pediatrics, Jerome A. Paulson, MD, called for industry disclosure of all ingredients of fracking fluid; thorough study of all air contaminants released from drilling and fracking operations and their protected dispersal patterns; and study and disclosure of fracking-related water contamination and its mechanisms. In a letter to the Pennsylvania Department of Environmental Protection (PA DEP), Paulson said:

In summary, neither the industry, nor government agencies, nor other researchers have ever documented that [unconventional gas extraction] can be performed in a manner that minimizes risks to human health. There is now some evidence that these risks that many have been concerned about for a number of years are real risks. There is also much data to indicate that there are a number of toxic chemicals used or derived from the process, known or plausible routes of exposure of those chemicals to humans; and therefore, reason to place extreme limits on [unconventional gas extraction].¹¹⁰²

- June 20, 2014 – Highlighting preliminary studies in the United States that suggest an increased risk of adverse health problems among individuals living within ten miles of shale gas operations, a commentary in the British medical journal *The Lancet* called for a precautionary approach to gas drilling in the United Kingdom. According to the commentary, “It may be irresponsible to consider any further fracking in the UK (exploratory or otherwise) until these prospective studies have been completed and the health impacts of fracking have been determined.”¹¹⁰³
- June 20, 2014 – Led by an occupational and environmental medicine physician, a Pennsylvania-based medical and environmental science research team documented “... the substantial concern about adverse health effects of [unconventional natural gas development] among Pennsylvania Marcellus Shale residents, and that these concerns may not be adequately represented in medical records.” The teams identified the continued need to pursue environmental, clinical, and epidemiological studies to better

¹¹⁰¹ Associated Press. (2014, July 12). Expert: Pa. didn’t address fracking health impacts. *York Dispatch*. Retrieved from http://www.yorkdispatch.com/ci_26135724/expert-pa-didnt-address-fracking-health-impacts

¹¹⁰² Paulson, J.A. (2014, June 30). Letter to the Pennsylvania Department of Environmental Protection. Retrieved from <http://concernedhealthny.org/letter-from-dr-jerome-a-paulson-to-the-pennsylvania-department-of-environmental-protection/>

¹¹⁰³ Hill, M. (2014, June 20). Shale gas regulation in the UK and health implications of fracking. *The Lancet*. Advance online publication. doi: 10.1016/S0140-6736(14)60888-6

understand associations between fracking, medical outcomes, and residents' ongoing concerns.¹¹⁰⁴

- June 17, 2014 – A discussion paper by the Nova Scotia Deputy Chief Medical Officer and a panel of experts identified potential economic benefits as well as public health concerns from unconventional oil and gas development. On the health impacts, they wrote, “uncertainties around long term environmental effects, particularly those related to climate change and its impact on the health of both current and future generations, are considerable and should inform government decision making.” The report noted potential dangers including contamination of groundwater, air pollution, surface spills, increased truck traffic, noise pollution, occupational health hazards, and the generation of greenhouse gases. It also noted that proximity of potential fracking sites to human habitation should give regulators pause and called for a health impact assessment and study of long-term impacts.¹¹⁰⁵ Responding to the report, the Environmental Health Association of Nova Scotia applauded the go-slow approach and called for a 10-year moratorium on fracking.¹¹⁰⁶
- May 29, 2014 – In New York State, more than 250 medical organizations and health professionals released a letter detailing emerging trends in the data on fracking that show significant risk to public health, air quality, and water, as well as other impacts. With signatories including the American Academy of Pediatrics, District II, the American Lung Association in New York, Physicians for Social Responsibility, and many leading researchers examining the impacts of fracking, they wrote, “The totality of the science—which now encompasses hundreds of peer-reviewed studies and hundreds of additional reports and case examples—shows that permitting fracking in New York would pose significant threats to the air, water, health and safety of New Yorkers.”^{1107, 1108}
- May 9, 2014 – In a peer-reviewed analysis, leading toxicologists outlined some of the potential harm and uncertainty relating to the toxicity of the chemical and physical agents associated with fracking, individually and in combination. While acknowledging the need for more research and greater involvement of toxicologists, they noted the potential for surface and groundwater contamination from fracking, growing concerns about air

¹¹⁰⁴ Saberi, P., Propert, K. J., Powers, M. Emmett, E., & Green-McKenzie, J. (2014). Field survey of health perception and complaints of Pennsylvania residents in the Marcellus Shale region. *International Journal of Environmental Research and Public Health*, 11(6), 6517-6527. doi: 10.3390/ijerph110606517

¹¹⁰⁵ Atherton, F. (2014, June 17). *Discussion paper: Hydraulic fracturing and public health in Nova Scotia*. Nova Scotia Hydraulic Fracturing Independent Review and Public Engagement Process.

¹¹⁰⁶ Macdonald, M. (2014, June 17). Nova Scotia expert calls for go-slow approach for hydraulic fracturing. *The Canadian Press*. Retrieved from <http://www.calgaryherald.com/health/Health+studies+needed+hydraulic+fracturing+approved+Nova+Scotia/9946368/story.html>

¹¹⁰⁷ Concerned Health Professionals of New York. (2014, May 29). Letter to Governor Cuomo and Acting Health Commissioner Howard A. Zucker. Retrieved from <http://concernedhealthny.org/letters-to-governor-cuomo/>

¹¹⁰⁸ Hughes, K. (2014, May 29). NY fracking opponents call for moratorium of 3 to 5 years. *Daily Freeman*. Retrieved from <http://www.dailyfreeman.com/general-news/20140529/ny-fracking-opponents-call-for-moratorium-of-3-to-5-years>

pollution particularly in the aggregate, and occupational exposures that pose a series of potential hazards to worker health.^{1109, 1110}

- May 1, 2014 – A 292-page report from a panel of top Canadian scientists urged caution on fracking, noting that it poses “the possibility of major adverse impacts on people and ecosystems” and that significantly more study is necessary to understand the full extent of the risks and impacts.¹¹¹¹ The *Financial Post* reported that the panel of experts “found significant uncertainty on the risks to the environment and human health, which include possible contamination of ground water as well as exposure to poorly understood combinations of chemicals.”¹¹¹²
- April 30, 2014 – Medical professionals spoke out on the dearth of public health information collected and lack of long-term study five years into Pennsylvania’s fracking boom. Walter Tsou, MD, MPH, past president of the American Public Health Association and former Health Commissioner of Philadelphia commented, “That kind of study from a rigorous scientific perspective has never been done.” Other experts added, “There has been more health research involving fracking in recent years, but every study seems to consider a different aspect, and ... there is no coordination.”¹¹¹³
- April 17, 2014 – In the preeminent *British Medical Journal*, authors of a commentary, including an endocrinologist and a professor of clinical public health, wrote, “Rigorous, quantitative epidemiological research is needed to assess the risks to public health, and data are just starting to emerge. As investigations of shale gas extraction in the US have continually suggested, assurances of safety are no proxy for adequate protection.”¹¹¹⁴
- April 15, 2014 – The *Canadian Medical Association Journal* reported on the increasing legitimacy of concerns about fracking on health: “While scientists and area residents have been sounding the alarm about the health impacts of shale gas drilling for years, recent

¹¹⁰⁹ Society of Toxicology. (2014). Toxicologists outline key health and environmental concerns associated with hydraulic fracturing. *ScienceDaily*. Retrieved from

<http://www.sciencedaily.com/releases/2014/05/140509172545.htm>

¹¹¹⁰ Goldstein, B. D., Brooks, B. W., Cohen, S. D., Gates, A. E., Honeycutt, M. E., Morris, J. B., . . . Snawder, J. (2014). The role of toxicological science in meeting the challenges and opportunities of hydraulic fracturing [Abstract]. *Toxicological Sciences*, 139(2). doi: 10.1093/toxsci/kfu061

¹¹¹¹ The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction. (2014). Environmental impacts of Hurricane Mitch. *Council of Canadian Academies*. Retrieved from

http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/shale%20gas/shalegas_fullreporten.pdf

¹¹¹² Canadian Press. (2014, May 1). Top Canadian scientists urge cautious approach to fracking until more known of impact. *Financial Post*. Retrieved from http://business.financialpost.com/2014/05/01/top-canadian-scientists-urge-cautious-approach-to-fracking-until-more-known-of-impact/?__lsa=3b44-76a1

¹¹¹³ Khan, N. (2014, April 30). Health impact of gas fracking left in the dark. *Pocono Record*. Retrieved from <http://www.poconorecord.com/apps/pbcs.dll/article?AID=/20140430/NEWS90/404300301/-1/NEWS01>

¹¹¹⁴ Law, A., Hays, J., Shonkoff, S. B., & Finkel, M. L. (2014). Public Health England’s draft report on shale gas extraction [Abstract]. *BMJ*, 1840. doi: <http://dx.doi.org/10.1136/bmj.g2728>

studies, a legal decision and public health advocates are bringing greater legitimacy to concerns.”¹¹¹⁵

- March 3, 2014 – In the *Medical Journal of Australia*, researchers and a physician published a strongly worded statement, “Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia’s energy future.” They cited knowledge to date on air, water, and soil pollution, and expressed concern about “environmental, social and psychological factors that have more indirect effects on health, and important social justice implications” yet to be understood. They wrote in summary:

The uncertainties surrounding the health implications of unconventional gas, when considered together with doubts surrounding its greenhouse gas profile and cost, weigh heavily against proceeding with proposed future developments. While the health effects associated with fracturing chemicals have attracted considerable public attention, risks posed by wastewater, community disruption and the interaction between exposures are of also of concern.¹¹¹⁶

- March 1, 2014 – In the prestigious British medical journal *The Lancet*, researchers summarized workshops and research about the health impacts of fracking, noting that the scientific study on the health impacts of fracking is “in its infancy.” Nevertheless, the existing evidence suggests, said these researchers, that health risks posed by fracking exceed those posed by conventional oil and gas wells due to the sheer number and density of well pads being developed, their proximity to densely populated areas, and the need to transport and store large volumes of materials.¹¹¹⁷
- February 24, 2014 – In a review of the health effects of unconventional natural gas extraction published in the journal *Environmental Science & Technology*, leading researchers identified a range of impacts and exposure pathways that can be detrimental to human health. Noting how fracking disrupts communities, the review states, “For communities near development and production sites the major stressors are air pollutants, ground and surface water contamination, truck traffic and noise pollution, accidents and malfunctions, and psychosocial stress associated with community change.” They concluded, “Overall, the current scientific literature suggests that there are both substantial public concerns and major uncertainties to address.”¹¹¹⁸
- August 30, 2013 – A summary of a 2012 workshop by the Institute of Medicine Roundtable on Environmental Health Sciences, Research, and Medicine featured various

¹¹¹⁵ Glauser, W. (2014). New legitimacy to concerns about fracking and health. *Canadian Medical Association Journal*, 186(8), E245-E246. doi: 10.1503/cmaj.109-4725

¹¹¹⁶ Coram, A., Moss, J., & Blashki, G. (2014). Harms unknown: Health uncertainties cast doubt on the role of unconventional gas in Australia's energy future. *The Medical Journal of Australia*, 200(4), 210-213. doi: 10.5694/mja13.11023

¹¹¹⁷ Kovats, S., Depledge, M., Haines, A., Fleming, L. E., Wilkinson, P., Shonkoff, S. B., & Scovronick, N. (2014). The health implications of fracking. *The Lancet*, 383(9919), 757-758. doi: 10.1016/S0140-6736(13)62700-2

¹¹¹⁸ Adgate, J. L., Goldstein, B. D., & McKenzie, L. M. (2014). Potential public health hazards, exposures and health effects from unconventional natural gas development [Abstract]. *Environmental Science & Technology*. doi: 10.1021/es404621d

experts who discussed health and environmental concerns about fracking and the need for more research. The report in summary of the workshop stated, “The governmental public health system, which retains primary responsibility for health, was not an early participant in discussions about shale gas extraction; thus public health is lacking critical information about environmental health impacts of these technologies and is limited in its ability to address concerns raised by regulators at the federal and state levels, communities, and workers employed in the shale gas extraction industry.”¹¹¹⁹

- June 2013 – A group of three nursing professors published a cautionary review questioning the rollout of new shale-based energy practices at a time when, “anecdotal reports make clear that the removal of fossil fuels from the earth directly affects human health.” Although the results of longterm studies are not yet available, the authors point to emerging evidence for negative human and ecologic health effects of fracking. Furthermore, they continue, “sufficient evidence has been presented to the [American Nurses Association], the American Public Health Association, and the American Medical Association’s Resident and Fellow Section to result in a call for a moratorium on the issuance of new fracking permits nationally.” They urge nurses to contribute to keeping health issues “front and center as we address national energy needs and policies.”¹¹²⁰
- April 22, 2013 – In one of the first peer-reviewed nursing articles summarizing the known health and community risks of fracking, Professor Margaret Rafferty, Chair of the Department of Nursing at New York City College of Technology wrote, “Any initiation or further expansion of unconventional gas drilling must be preceded by a comprehensive Health Impact Assessment (HIA).”¹¹²¹
- May 10, 2011 – In the *American Journal of Public Health*, two medical experts cautioned that fracking “poses a threat to the environment and to the public's health. There is evidence that many of the chemicals used in fracking can damage the lungs, liver, kidneys, blood, and brain.” The authors urged that it would be prudent to invoke the precautionary principle in order to protect public health and the environment.¹¹²²

¹¹¹⁹ Coussens, C., & Martinez, R. (2013). *Health impact assessment of shale gas extraction: workshop summary*. Washington: The National Academies Press. Retrieved from <http://www.iom.edu/Reports/2013/Health-Impact-Assessment-of-Shale-Gas-Extraction.aspx>

¹¹²⁰ McDermott-Levy, R., Kaktins, N., & Sattler, B. (2013). Fracking, the environment, and health: New energy practices may threaten public health. *American Journal of Nursing*, *113*(6), 45-51.

¹¹²¹ Rafferty, M. A., & Limonik, E. (2013). Is shale gas drilling an energy solution or public health crisis? *Public Health Nursing*, *30*(5), 454-462. doi: 10.1111/phn.12036

¹¹²² Finkel, M. L., & Law, A. (2011). The rush to drill for natural gas: A public health cautionary tale. *American Journal of Public Health*, *101*(5), 784-785. doi: 0.2105/AJPH.2010.300089

Conclusion

All together, findings to date from scientific, medical, and journalistic investigations combine to demonstrate that fracking poses significant threats to air, water, health, public safety, climate stability, seismic stability, community cohesion, and long-term economic vitality. Emerging data from a rapidly expanding body of evidence continue to reveal a plethora of recurring problems and harms that cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly or without imperiling climate stability upon which public health depends. In the words of investigative journalist Andrew Nikiforuk:

Industry swore that its cracking rock technology was safe and proven, but science now tells a different story. Brute force combined with ignorance ... has authored thousands of earthquakes ... [and] called forth clouds of migrating methane.... The science is complicated but clear: cracking rock with fluids is a chaotic activity and no computer model can predict where those fractures will go. The regulatory record shows that they often go out of zone; extend into water; and rattle existing oil and gas wells, and these rattled wells are leaking more methane.¹¹²³

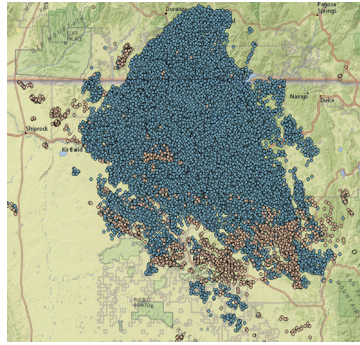
We close with an observation by Maryland physician Judy Stone, MD, whose recent essay in *Forbes* speaks for all who have contributed to this Compendium:

Fracking profits go to private industry but the public—families and communities—bear the costs of the many health complications from the drilling.

There is growing evidence of a variety of health problems being associated with fracking. Common sense dictates that drinking and breathing cancer-causing agents will take their toll. The correlation is too strong to ignore, especially when we have other, cleaner energy options. For our safety and that of future generations, we should not allow the new administration to sell off public lands, nor allow drilling on our land, and should ban fracking completely.¹¹²⁴

¹¹²³ Nikiforuk, A. (2016, October 16). Acceptance speech, USA National Science in Society Journalism Awards reception, San Antonio, Texas. Retrieved from <http://www.ernstversusencana.ca/andrew-nikiforuk-wins-usa-national-science-in-society-award-slick-water-nasws-awards-honor-outstanding-investigative-interpretive-reporting-sciences-their-impact-for-good-and-ill/>

¹¹²⁴ Stone, J. (2017, February 23). Fracking is dangerous to your health—here's why. *Forbes*. Retrieved from <https://www.forbes.com/sites/judystone/2017/02/23/fracking-is-dangerous-to-your-health-heres-why/#82aa5c75945f>



Health Impact Report Summary

Air Quality and Oil Well Exposure in Counselor 2018

Executive Summary and History

Since 2015, the Navajo Nation Chapters of Counselor, Torreon-Star Lake, and Ojo Encino, have experienced increasing levels of health and safety impacts from the development of over 400 oil wells on thousands of acres of lands, leased by the Farmington Field Office (FFO) of Bureau of Land Management (BLM), and in close proximity to Chapter facilities, schools and homes. Currently, the FFO is conducting an Environmental Impact Study (EIS) on hydraulic fracturing impacts in the Mancos Shale/Gallup formation scheduled to be completed in 2018. In the 2003 Resource Management Plan, the FFO reported that horizontal fracturing in the region was “technologically and economically **infeasible**”.

In 2014, FFO agreed it needed to update the EIS to analyze the impacts of hydraulic fracturing and allowed hundreds of “exploratory” wells to be drilled near Counselor, Torreon-Star Lake and Ojo Encino. Counselor Chapter has taken steps to hold meetings for members and the general public to inform them about the potential risks of exposure to oil and gas operations as well as documented health impacts from contaminated air and water to both humans and livestock.

Chapter Resolutions

Resolution of Counselor Chapter Counselor, New Mexico

#COUN-2015-03-_____

“Furthermore, Counselor Chapter requests assistance to secure funding to conduct health impact assessments, baseline water and soil testing and air quality monitoring for the impacted acres.”

Eleven (11) Navajo Chapter subdivisions in the Eastern Agency have passed similar resolutions that state, in part:

1. The Chapter is against all pending and future federal fluid mineral BLM leases within Navajo Eastern Agency areas (or other lease sales which could directly or indirectly impact Eastern Agency Areas) until a reasonable revenue sharing mechanism is developed, the new Farmington Field Office Resource Management Plan Amendment is developed, and a full understanding of potential environmental and health impacts of horizontal hydraulic fracturing is developed: and
6. The Chapter shall cooperate with other chapters, the Navajo Nation, and federal entities to better understand potential environmental and health impacts of horizontal hydraulic fracturing activities that could affect Navajo communities.

Part One: What is a Health Impact Assessment (HIA)

Preface

*HIA is used to evaluate objectively the potential health impacts of a project or policy before it is built or implemented. **HIA can provide recommendations to increase positive health outcomes and minimize adverse health outcomes.** The HIA framework is used to bring potential public health impacts and considerations to the decision-making process for plans, projects, and policies that fall outside of traditional public health arenas, such as transportation and land use. - Centers for Disease Control*

Part Two: Chapter Health and Safety Concerns reported to BLM by Counselor Chapter



Flaring along Highway 550 close to Lybrook Community School, causing parents to report symptoms of headaches, inability to concentrate, sleeplessness, nosebleeds, irritability and nausea in children

2015 to Present



Oil drilling and heavy industrial traffic moves closer to Chaco Culture NHP and community causing health and safety problems. Fatal accidents involving tankers, hot oil trucks, and private vehicles reported along with many non-fatal crashes and serious road damage

2015 to Present



Unfenced wastewater pits are used by livestock causing illness and mortality. Polluted water causes health problems in local livestock. Deformed lambs born in Counselor and unable to survive are reported (Indian Country Today Media Network 7/20/2016)

2016 to Present

Public Health and Safety Concerns reported by members at Chapter Meeting on May 23, 2017

Number of Attendees 33

Health Related

Cancer Cases reported – 2

Asthma Cases reported - 2

Overall General Health (Weakness, Fatigue, Weight loss/gain, Dizziness) – 1

Eyes, Ears, Nose & Throat (Irritation, Hearing, Smell, Sinus, Nose bleeds) - 2

Respiratory/Cardiac (Coughing, Shortness of breath, Difficulty breathing, Chest pain) - 3

Gastro-Intestinal (Nausea, Vomiting, Abdominal pain, Appetite loss, Diarrhea, Bleeding) - 2

Reproductive (Pregnancy issues, Birth defects, Low birth weight/APGAR) - 1

Neurological (Headaches, Falling, Numbness, Concentration, Memory loss) - 3

Psychological (Sleeping difficulty, Irritability, Anxiety, Depression, Anger, Stress) - 2

Safety Related

Road Damage from oversize vehicles - 25
Traffic Safety (Accidents, Speeding, Dust, Unsafe driving) - 12
Odor from Well Sites (Air quality) - 6
Wastewater from Wells (Water quality & Livestock illness) - 3
Noise from Well Sites - 1
Light Pollution from Well Sites - 1
Lack of Education on Hydraulic Fracturing Risks- 2

Health Concerns over High Ozone levels in San Juan Basin

High ozone (O₃) and methane levels reported in 2016 in the San Juan Basin are an ongoing source of public concern. Tropospheric or ground level ozone – what we breathe – is formed primarily from photochemical reactions between two major classes of air pollutants, volatile organic compounds (VOC) and nitrogen oxides (NO_x). When inhaled, *ozone* can damage the lungs. Relatively low amounts of *ozone* can cause chest pain, coughing, shortness of breath and, throat irritation. It may also worsen chronic respiratory diseases such as asthma as well as compromise the ability of the body to fight respiratory infections. (“*Health Effects of Ozone in the General Population*”, US EPA)

Health impacts of BTEX and other Oil and Gas Emissions

Repeated exposure to Benzene, Toluene, Ethyl benzene and Xylene (BTEX) emissions have been shown to have negative health outcomes. BTEX emissions are released during the flaring period of gases from oil wells that can last up to 75 days in San Juan Basin. BTEX emission exposure has been repeatedly cited¹ as a leading cause of life-threatening birth defects in infants born to mothers exposed to benzene in their first trimester of pregnancy. Birth defects include congenital heart defects (CHDs), neural tube defects (NTDs), and pre-term and low weight birth.

Health & Safety Concerns reported at BLM Meeting in Counselor - September 28, 2016

Farmington Field Office Manager, Richard Fields, and Realty Specialist, Mark Ames, heard dozens of residents, organization representatives and chapter officials speak in opposition to more leasing of Tribal land or BLM land for oil development citing contaminated water, air pollution, speeding traffic, dangerous road conditions, accidents, and public health and safety problems:

- WPX new storage facility explosion and fire that destroyed 36 storage tanks and caused the evacuation of 55 local residents and extensive damage to private property located closest to the accident site, as well as release of chemicals and pollutants, as yet unidentified, into the Tri-Chapter communities’ air and water over a 5 day period while the fire burned out of control.
- Danger from speeding over-sized oil company tankers and trucks to local drivers, to children getting off school buses and walking home and to local livestock near or crossing rural roads.
- Lack of resident protection from flaring emissions (flaring average 75 days)
- Impact of air emissions on children, teachers and staff at local Lybrook Community School on Highway 550 (Enrollment: 116 children K-8th Grade)
- Lack of communication to the public regarding air pollution, school shut downs or road closures due to oil drilling activities or breaking a waterline
- Lack of fencing around waste water pits that attract livestock and wildlife
- Lack of resident protection from flaring that continues an average of 75 days instead of 14 days in BLM regulations

¹ EHP Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, McKenzie et al, Vol. 122, April 2014

Health Effects

Brain and Nervous System

Dizziness, headache, confusion, memory problems, impaired motor function: hydrogen sulfide, benzene, toluene, ethylbenzene, xylene, methylene chloride

Lungs

Cough, asthma, difficulty breathing, COPD (chronic obstructive pulmonary disease), silicosis, lung cancer: Fine particulate matter, benzene, toluene, ethylbenzene, xylene, hydrogen sulfide, ozone, silica, radon, methane. Children and pregnant women are especially vulnerable to these impacts.

Skin

Irritation, rashes, hair loss: Benzene, toluene, nitrogen oxide

Eyes, Nose, and Throat

Rashes, irritation, tearing eyes, bloody nose, cancer of the nose and throat: benzene, toluene, ethylbenzene, xylene, hydrogen sulfide, nitrogen oxide, formaldehyde

Heart and blood

Anemia, chest pain, heart attack: arsenic, carbon monoxide, fine particulate matter, radium

Digestive System and Liver

Irritation of stomach and intestines, nausea, vomiting, diarrhea, liver damage: formaldehyde, arsenic, xylenes

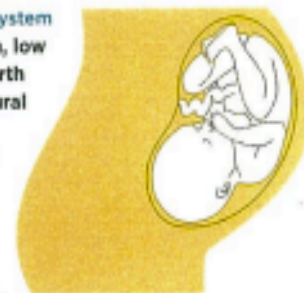
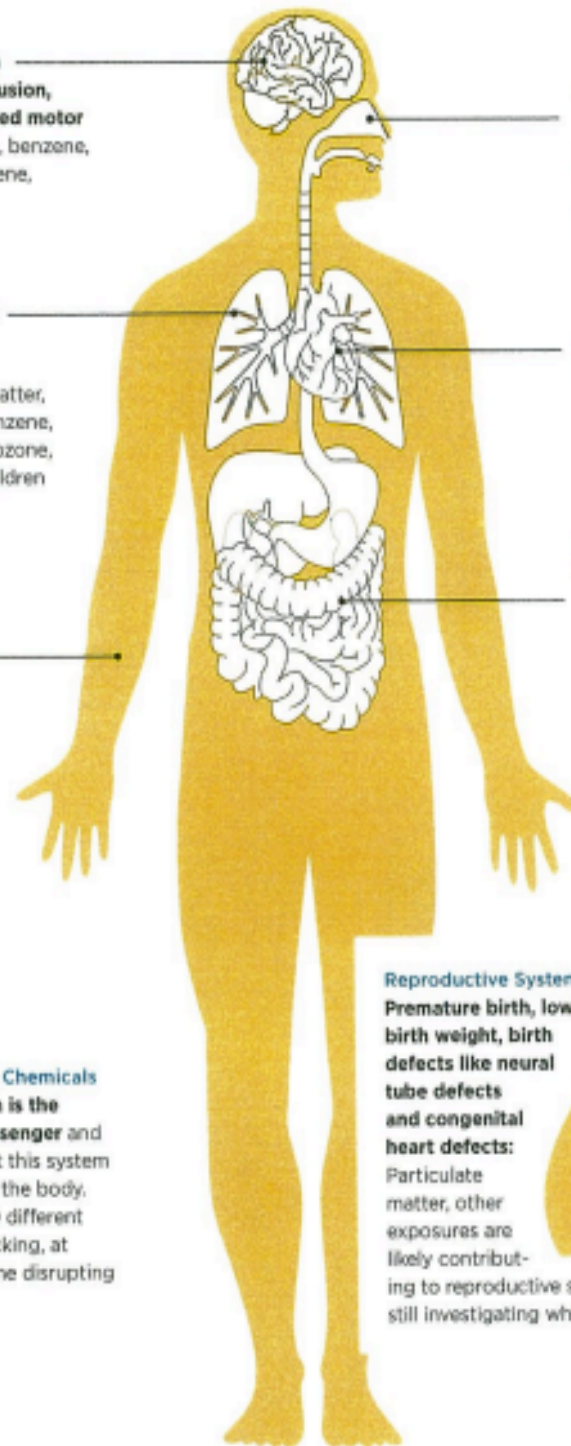
Endocrine Disrupting Chemicals

The endocrine system is the body's hormonal messenger and exposures that impact this system can affect any part of the body. Of the more than 600 different chemicals used in fracking, at least 37% are endocrine disrupting chemicals.

Reproductive System

Premature birth, low birth weight, birth defects like neural tube defects and congenital heart defects:

Particulate matter, other exposures are likely contributing to reproductive system effects but research is still investigating which chemicals are implicated.



This image indicates the common symptoms and health impacts known to be linked to chemicals associated with unconventional oil and gas development, including some of the chemicals captured in air samples as part of this project.

Part Three: Air Quality Monitoring Data Collection

Lab: ALS Environmental. Additional analysis: Mark Cherniak, PhD.

Test 1: Two toxic substances were detected at the two sites collected on October 14, 2016, relatively modest levels of **ethyl acetate** and **toluene**. The levels of ethyl acetate in the two samples (21 $\mu\text{g}/\text{m}^3$ and 24 $\mu\text{g}/\text{m}^3$) are not of a health or environmental significance because of the low toxicity of this chemical.

The levels of **toluene** in the two samples (19 $\mu\text{g}/\text{m}^3$ and 72 $\mu\text{g}/\text{m}^3$) are under relevant health-based standards <http://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary> however; these two toluene levels are unusually high. A 2013 survey of air quality in more than 100 locations across the United States found daily arithmetic mean concentrations of toluene ranging from 0.073 $\mu\text{g}/\text{m}^3$ to 19.0 $\mu\text{g}/\text{m}^3$. <https://www.atsdr.cdc.gov/toxprofiles/tp56-c6.pdf>.

Test 2: Three air samples were collected April 18, 2017 along Highway 550. One sample was collected at mile marker 100 north of the Lybrook School (Report P1701856); a second sample was collected along Highway 550, at mile marker 107.5, approximately $\frac{1}{2}$ mile south of the highway near the San Juan and Rio Arriba county line (Report P1701857); and a third sample was collected along Highway 550 at the intersection of CR 7900 (Report P17018568.)

Hydrogen sulfide was detected in air sample #2 collected on Highway 550 at mile marker 100 north of the Lybrook School at a level of **7.6 $\mu\text{g}/\text{m}^3$** . Hydrogen sulfide is a gas that possesses a potently offensive odor of rotten eggs. Long-term exposure to hydrogen sulfide is associated with an elevated incidence of respiratory infections, irritation of the eye and nose, cough, breathlessness, nausea, headache, and mental symptoms, including depression. The U.S. EPA reference concentration for hydrogen sulfide is **2 $\mu\text{g}/\text{m}^3$** (for preventing nasal lesions of the olfactory mucosa). **The level of hydrogen sulfide detected in the sample collected north of the Lybrook School exceeds the U.S. EPA reference concentration for hydrogen sulfide, but is below the California OEHHA chronic reference exposure level for hydrogen sulfide. If hydrogen sulfide levels of 7.6 $\mu\text{g}/\text{m}^3$ north of Lybrook School generally prevail, then these levels may pose risk to human health.**

Conclusion: Residents affected by the fumes and odors identified in the air samples, should notify their medical providers that they are being routinely exposed to these substances, as well as report any symptoms they may be experiencing. NM State Land Office has been notified of the leaking well and requested to notify the oil company operating the well to lower the release of Hydrogen Sulfide to regulatory levels. The Counselor Chapter also communicated with the state Oil Conservation Division but has not received a response that the well has been inspected.

Lab data and analysis are available upon written request.

Counselor HIA Committee

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87018

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Counselor HIA

Air Quality Monitoring

1/2 Mile Active Horizontal,
Vertical, & New Well Boundaries

Legend

Chapter Boundaries

Townships

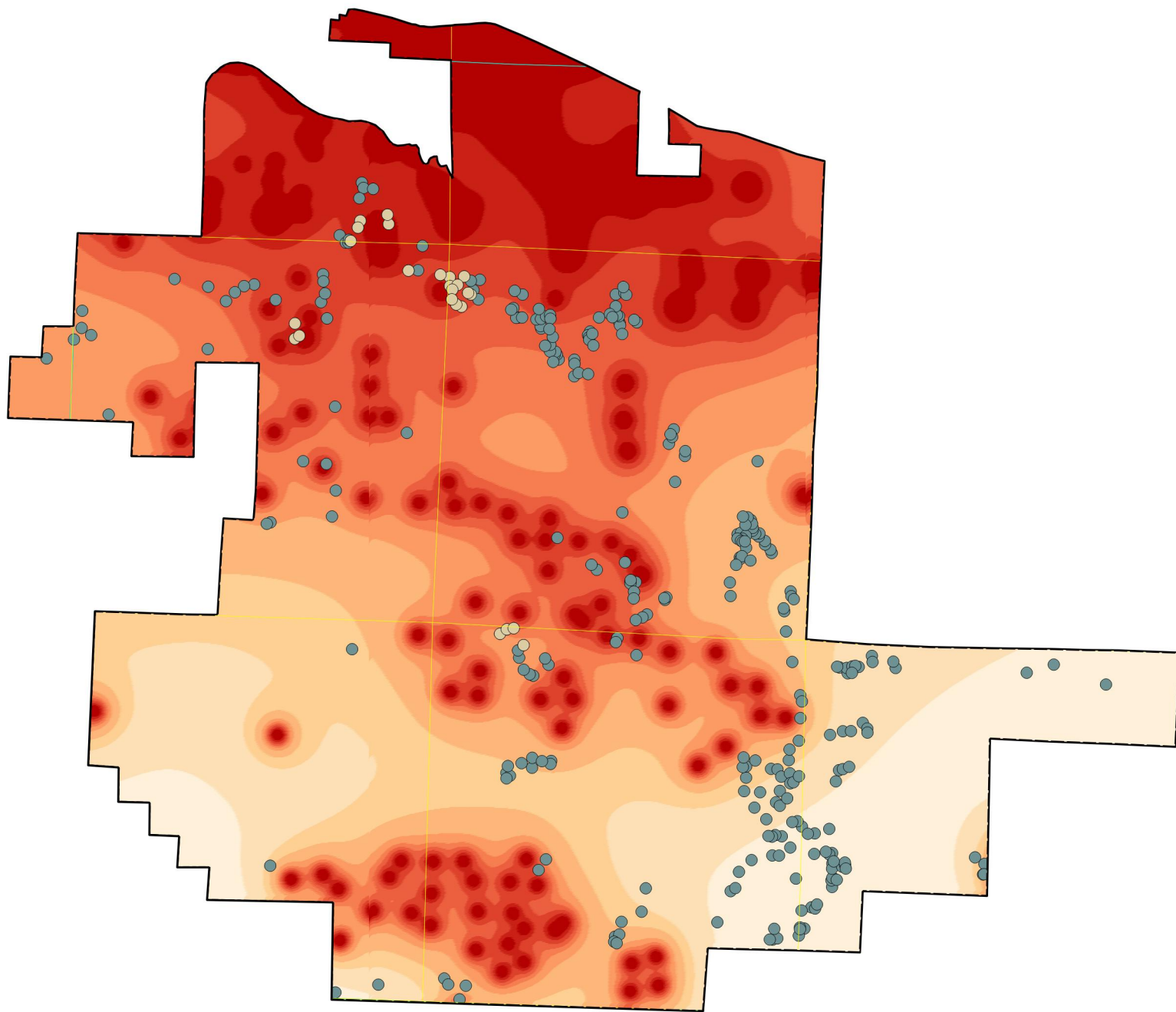
County Boundaries

Counselor Structures

Struct 1/2 mile of H. Well

OGDIF August 2017

- 1 - 1
- 1 - 2
- 2 - 2
- 2 - 2
- 2 - 3
- 3 - 3
- 3 - 4
- 4 - 5
- 5 - 8
- 8 - 572



Sources: BLM, Eastern Navajo Land Commission, NMOCD (2/14/2018), Google Earth Professional.

Disclaimer: Data is subject to errors. Author is not responsible for inaccuracies and any resulting damages. Data should be reverified.

0 1 miles



May 31, 2018

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Royalty Policy Committee
U.S. Department of the Interior

Re: Responses to the Planning, Analysis and Competitiveness Subcommittee's Recommendations for the Bureau of Land Management's Onshore Renewable Energy Program

Dear Royalty Policy Committee,

These responses to the Planning, Analysis and Competitiveness Subcommittee's Recommendations for the Bureau of Land Management's Onshore Renewable Energy Program are submitted on behalf of The Wilderness Society, Defenders of Wildlife, Natural Resources Defense Council and the National Audubon Society. We strongly support responsible renewable energy development on public lands, and we appreciate that the Royalty Policy Committee (RPC) is exploring ways to ensure that the policies of the Department of the Interior (DOI) and agencies such as the Bureau of Land Management (BLM) support an efficient and competitive permitting process for solar and wind development on public lands.

Some of the recommendations proposed by the Subcommittee on Planning, Analysis and Competitiveness (Subcommittee) may help achieve these goals.¹ We generally support the issuance of an Instruction Memorandum to update and clarify rent and fee requirements for solar energy rights-of-way (ROWS) as well as to provide further guidance on the implementation of the rule on Competitive Processes, Terms, and Conditions for Leasing Public Lands for Solar and Wind Energy Development and Technical Changes and Corrections, 81 Fed. Reg. 92,122 (Dec. 16, 2016) (Wind and Solar Leasing Rule). However, we have serious concerns that some of the recommendations would also undermine the BLM's policies and goals that 1) focus and facilitate solar and wind development in low-conflict Designated Leasing Areas (DLAs); and 2) focus agency resources on review of those applications for solar and wind projects outside of DLAs that meet criteria that show they are most likely to be successfully permitted and built.

The BLM has demonstrated the benefits of these policies for efficient and responsible renewable energy development on public lands focused within pre-screened leasing areas. For example, at the Dry Lake DLA outside of Las Vegas, Nevada, the zone-based approach resulted in lower conflict development and projects permitted in half the average time.² Further, there is broad support for continued implementation of the BLM's renewable energy program and Wind and Solar Leasing Rule; see for example the attached May 4, 2018 letter from the Public Lands Foundation to the BLM (Attachment 2). **The RPC should ensure that any recommendations it makes do not undermine the elements of the Western Solar Plan and the Wind and Solar Leasing Rule that made the kind of permitting success demonstrated at Dry Lake possible, and DOI and the BLM should ensure that any changes they make to the policies also do not undermine these elements of the policies.**

The Subcommittee proposes two recommendations: 1) that the Secretary of the Interior direct the BLM to issue an Instruction Memorandum (IM) to update and clarify solar energy right-of-way (ROW) acreage rent schedules, megawatt (MW) capacity fees, and other policy elements in the BLM's Western Solar Plan and Wind and Solar Leasing Rule; 2) that the Secretary issue a Secretarial Order that grandfathers projects which were under construction or development at the time when the BLM issued its Wind and Solar Leasing Rule. Our responses to the Subcommittee's proposed recommendations are detailed below.

¹ See pp. 10-15: https://www.doi.gov/sites/doi.gov/files/uploads/pac_recommendations_-_with_page_numbers.pdf

² See DOI press release: <https://www.doi.gov/pressreleases/interior-department-approves-first-solar-energy-zone-projects>; see also attached factsheet (Attachment 1).

I. Elements of Subcommittee-Proposed Recommendations that may be appropriate

a. Elements of proposed Instruction Memorandum that may be appropriate

As stated in the proposed recommendations, the current regulations under 43 CFR § 2807.22 allow the BLM to renew a grant or lease if the holder is in compliance with the renewal terms and conditions, stipulations of the grant or lease and other applicable laws and regulations. If renewal provisions are not included in the grant or the lease, the BLM may still renew the lease or grant. Subcommittee-proposed recommendations p. 12. We agree that the ability to extend leases or grants beyond the 30-year maximum duration would make solar energy development on public lands more competitive with development on private lands. In addition, it provides longer term certainty for the developer which can be crucial in attracting investment. Therefore, we think allowing a 10-year extension of a 30-year ROW grant or lease after compliance with the National Environmental Policy Act (NEPA) will facilitate development under the Western Solar Plan.

We also think that adjustments to rents and fees for solar energy development on public lands may be appropriate, so long as fair market value is maintained. However, as detailed in Section II.a.i. of this letter, we have concerns about the other policy implications of some elements of the proposed Instruction Memorandum, such as the proposal to eliminate the Megawatt Capacity Fee.

b. Elements of proposed Secretarial Order that may be appropriate

The Subcommittee's proposed recommendations state that issuing a Secretarial Order grandfathering projects that were under construction or development at the time the BLM issued its Wind and Solar Leasing Rule would allow such projects "to play under the same regulatory system that was in effect when projects first started permitting with Interior," and that "making this change continues Interior's commitment to advancing renewable projects on federal lands and can provide some certainty to upcoming projects that the rules of the game will not change during the course of permitting." Subcommittee-proposed recommendations p. 15.

The rest of the text of this proposed recommendation appears to be focused on grandfathering the Acreage Rent and MW Capacity Fee. We note that the BLM has the authority to change its rents and fees at any time to achieve fair market value. However, if the Secretarial Order is indeed narrowly focused on grandfathering the Acreage Rent and MW Capacity Fee for projects that were under construction or development, we believe this policy change may be appropriate, so long as the definition of "under development" is modified as detailed in Section II.b.ii. of this letter.

II. Elements of Subcommittee-proposed recommendations that should not be implemented

We have serious concerns that some of the Subcommittee-proposed recommendations would undermine the BLM's policies and goals that 1) focus and facilitate solar and wind development in low-conflict DLAs; and 2) focus agency resources on review of those applications for solar and wind projects outside of DLAs that meet criteria that show they are most likely to be successfully permitted and built.

The RPC should ensure that any recommendations it makes do not undermine these elements of the Western Solar Plan and the Wind and Solar Leasing Rule, and DOI and the BLM should ensure that any changes they make to their policies also do not undermine these elements of the policies.

a. Elements of proposed Instruction Memorandum that should not be implemented

i. The BLM should not eliminate the MW Capacity Fee

The Subcommittee's proposed recommendations state that the guidance the BLM published in IM 2017-096 for implementation of the Wind and Solar Leasing Rule resulted in strong economic disincentives for solar developers to seek to build projects on BLM lands because of the costs associated with Acreage Rent, MW Capacity Fee and Bond

Rates.³ Subcommittee-proposed recommendations pp. 10-12. The proposed recommendations also state that these costs are much higher than the relevant costs for solar development on private land, making BLM lands uncompetitive for solar development.

The Federal Land Policy and Management Act requires that the BLM charge fair market value for the use of public lands, including for wind and solar development. If valid data can be presented that shows that the Acreage Rent, MW Capacity Fee and Bond Rates are indeed higher than fair market value, we agree that it is appropriate for the BLM to adjust them to achieve fair market value, which would make development on BLM lands more competitive with development on private lands.

However, we strongly disagree that the BLM should *eliminate* MW Capacity Fee as part of an effort to make solar development on BLM lands more competitive. Doing so would eliminate one of the key incentives for development in DLAs: the 10-year phase in for the MW Capacity fee vs. the 3-year phase in for development outside of DLAs. Eliminating this financial incentive would undermine the BLM's smart approach to solar development on public lands. Rather than eliminating the MW Capacity Fee, the BLM should consider a combination of adjustments to both the Acreage Rent and MW Capacity Fee that would achieve fair market value and increased competitiveness.

ii. The BLM should not weaken or eliminate the application priority criteria

The Subcommittee-proposed recommendations are unclear regarding whether the proposed IM would affect the BLM's application priority criteria for projects outside of DLAs. These criteria have been in place for over seven years, having been first established in early 2011 in IM 2011-061, then incorporated into the Western Solar Plan in 2012, and ultimately included in BLM's 2016 Wind and Solar Leasing Rule. The criteria provide critical guidance to BLM staff for prioritizing limited agency resources on first considering those applications which are most likely to be successfully permitted and built (High Priority applications), then those that have some likely conflicts and challenges (Medium Priority applications), and finally those applications that have significant likely conflicts and challenges (Low Priority applications). 43 CFR 2800 § 2804.35.

The proposed recommendations mention application priority in the "Recommendation" section, but do not elaborate further on this policy element in the background and analysis sections (in contrast to the other policy elements listed in the Recommendation section, which are discussed in the background and analysis sections). This makes it unclear whether the proposed IM is intended to make changes to the application priority criteria.

We strongly recommend that the BLM not weaken or eliminate the application priority criteria; if changes are considered to the criteria, the BLM should strengthen them, as recommended by numerous stakeholders during development of the Wind and Solar Leasing Rule.

b. Elements of proposed Secretarial Order that should not be implemented

i. The BLM should not weaken or eliminate the application priority criteria

Like the Subcommittee-proposed recommendations on the IM, the proposed recommendations on the proposed Secretarial Order are unclear whether they are indeed focused on grandfathering the rents and fees for projects under construction or development when the Wind and Solar Leasing Rule was established, or whether they include other policy elements. We recommend that the Secretarial Order should not weaken or eliminate the application priority criteria for grandfathered projects; if changes are considered to the criteria for grandfathered projects, the Secretarial Order should strengthen them, as recommended by numerous stakeholders during development of the Wind and Solar Leasing Rule.

³ This subcommittee-proposed recommendation also included recommendations on BLM's discretion to hold competitive bidding for lands outside of DLAs, which is not addressed in this letter.

- ii. **BLM should only grant grandfather status based on the submission of a completed project application and BLM acceptance of a plan of development prior to promulgation of Wind and Solar Rule.**

We also take issue with the implication that projects “having submitted a ROW application at the time when the BLM issued its Wind and Solar Leasing Rule” should be considered “under development” for the purpose of grandfathering. Only those projects where BLM has certified that a completed application had been submitted and a plan of development had been accepted by BLM at the time the Wind and Solar Rule was adopted should be considered for grandfathering. These applications represent instances where a developer has committed considerable time and resources to a project.

We appreciate the opportunity to share our recommendations and would be happy to meet with you to discuss them further.

Sincerely,

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Attachments

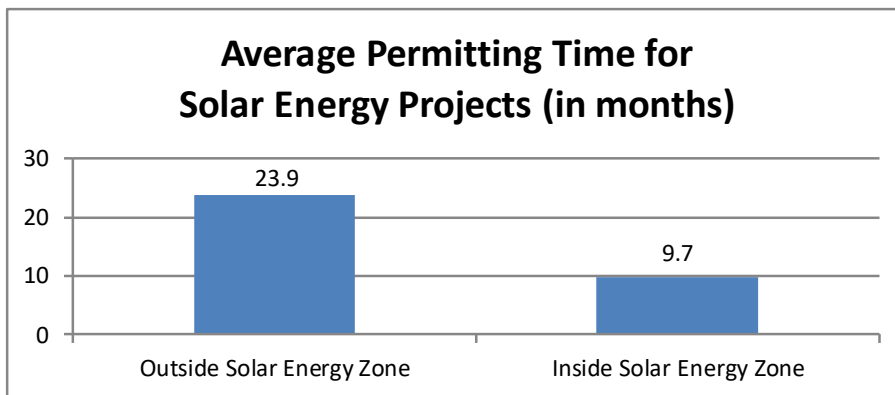
- Attachment 1: Factsheet on cutting permitting time in half in DLAs
- Attachment 2: May 4, 2018 letter from Public Lands Foundation to the BLM supporting implementation of the BLM renewable energy program and Wind and Solar Leasing Rule

CC: Marissa Mitchell – Subcommittee on Planning, Analysis and Competitiveness
Colin McKee – Subcommittee on Planning, Analysis and Competitiveness

Attachment 1



Solar Energy Zones Cut Permitting Time in Half



More Solar Energy—Lower Costs—Improved Conservation

The first projects inside a Solar Energy Zone (SEZ) were approved in June 2015 in the Dry Lake SEZ near Las Vegas, NV. These projects took an average of 9.7 months to receive their permit. The average time for a solar project on BLM land outside of a SEZ is 23.9 months.

[Cutting permitting time in half](#) is a significant accomplishment, allowing more clean energy to be brought online in a timely manner and decreased costs for project developers. Public land solar projects within solar energy zones should also see lower costs for mitigation to offset impacts because the areas have been chosen specifically for their low-conflict nature.

SMART FROM THE START

The BLM's Western Solar Plan and Wind and Solar Leasing Rule help to balance the growing demand for clean energy on our public lands with the need to conserve wildlands. Critical to this approach is identifying designated leasing areas like solar energy zones with input from the public, energy developers and scientists. These areas should be high in renewable energy potential and low in environmental conflict. This upfront planning is what makes "Smart from the Start" renewable energy development possible.

Solar Projects on BLM Land (Updated May 2018)	Application/ Notice of Intent (NOI)	Record of Decision (ROD)	Permitting Months
Ivanpah Solar Electric Generating System (SEGS)	11/6/2007	10/7/2010	35
Silver State Solar Energy Project (North)	9/17/2009	10/12/2010	13
Blythe Solar Power Project	3/16/2017	10/22/2010	43
Genesis Solar Energy Project	11/23/2009	11/12/2010	12
Crescent Dunes Solar Project	11/24/2009	12/20/2010	13
Desert Sunlight Solar Farm	1/13/2010	8/9/2011	19
Sonoran Solar Project	7/8/2009	12/20/2011	29
McCoy Solar Project	8/29/2011	3/13/2013	19
Desert Harvest Solar Project	9/15/2011	3/13/2013	17
Quartzsite Solar	1/14/2010	5/30/2013	40
Silver State Solar South	9/1/2011	2/14/2014	29
Stateline Solar	8/4/2011	2/21/2014	30
Dry Lake Solar Energy Zone — Playa Solar	7/18/2014	5/27/2015	10
Dry Lake Solar Energy Zone — Harry Allen Solar Energy Center	7/28/2014	5/27/2015	10
Dry Lake Solar Energy Zone — Solar Energy Center	8/6/2014	5/27/2015	9
Luning Solar	7/31/2013	6/30/2015	23
Soda Mountain Solar	10/22/2012	3/28/2016	41

Finding the Right Places for Solar Energy on Public Lands

Solar energy production is rapidly increasing on our public lands. Since 2009, 18 large-scale solar projects have been approved on BLM lands, along with over a dozen additional connected-action projects (transmission on BLM lands and generation on non-BLM lands). Smart planning for renewable energy, including finding low-impact areas for development and mitigating impacts, is necessary to protect our nation's treasured landscapes and wildlife. Solar Energy Zones (SEZs) accomplish this by bringing together federal, state and local land managers, as well as conservationists and the clean energy industry, to determine the best areas for solar development. SEZs create consistency and predictability for developers by reducing conflict with sensitive natural resources and increasing efficiency of permitting and environmental review.



Front photo: Tom Brewster Photography. Back photo: Mike Baker; flickr

Attachment 2



For America's Heritage

Public Lands Foundation

P.O. Box 7226 Arlington, Virginia 22207

May 4, 2018

Mr. Brian Steed, Acting Director
Bureau of Land Management
1849 C Street NW, Room 5665
Washington, D.C. 20240

Dear Mr. Steed:

The Public Lands Foundation acknowledges the renewable energy accomplishments of the BLM and encourages continued support for a diversified energy portfolio on the public lands that recognizes the growing demand for renewable energy resources as part of the Administration's commitment to achieve American energy dominance and boost economic growth. The BLM has approved over 17,000 megawatts of solar, wind and geothermal energy projects, with a current total installed and operating capacity of over 11,200 megawatts of renewable energy on the public lands. This installed capacity is enough to power some 3.4 million homes. This is a significant accomplishment and is a reflection of the hard-working and dedicated professionals throughout the BLM organization that serve our nation so well.

The BLM published a final rule in December 2016 that amended the right-of-way regulations to facilitate the responsible development of solar and wind energy projects on the public lands and to receive fair market value for such development. In September 2017, the BLM subsequently issued policy memoranda implementing several provisions of the new regulations. These policies included IM 2017-096 regarding rents and fees for solar and wind energy grants and leases, and IM 2017-099 regarding technical and financial evaluation procedures for solar and wind energy grants and leases on the public lands. We applaud these efforts and recognize these are critically important steps to assure continuity, clarity and certainty for industry and the American public in the development of renewable energy on the public lands. The BLM clearly now has the experience and the regulatory framework in place to aggressively move forward with future development, expedite the review and permitting process, provide for competitive leasing opportunities, and secure fair returns to the public for development on the public lands. It is also important that the BLM move forward in finalizing updated policies on mitigation for development activities on the public lands, including mitigation strategies for renewable energy projects on the public lands.

We acknowledge that the BLM has included funding in the FY 2019 proposed budget to support the renewable energy program and we encourage the BLM to continue to support and fund the renewable energy program in the future. This funding is critically important to support continued land use planning efforts for renewable energy development, the identification and designation of renewable energy "designated leasing areas," studies and inventory efforts, collaborative efforts with DOE and other agencies, tribal

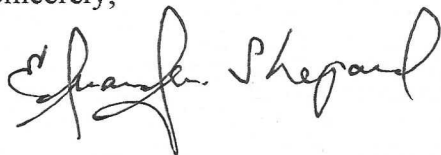
consultation efforts, continued coordination with solar, wind and geothermal industry organizations and other stakeholder groups, competitive leasing efforts, as well as funding support for expedited permitting and inspection and monitoring activities.

We encourage the BLM to continue to expedite the review and permitting process for renewable energy projects on the public lands, including connected-action projects such as electric transmission line right-of-way authorizations on the public lands that help facilitate renewable energy development on adjacent non-federal lands. We acknowledge and applaud the current BLM efforts underway to expand the Dry Lake Solar Energy Zone in Nevada through a land use plan amendment process and the initiation of a solar energy competitive leasing process under the new regulations for the Milford Flats South Solar Energy Zone in Utah. These efforts are in addition to the processing of permit applications for the Crimson Solar, Desert Quartzite Solar, and Palen Solar projects in California; the Crescent Peak Wind project in Nevada; and the Sweetwater Solar project in Wyoming. The Sweetwater Solar project would be the first solar project on public lands in Wyoming.

The BLM also continues to respond to geothermal lease applications and process geothermal development expansion projects, including the Dixie Meadows and Tuscarora projects in Nevada. Keep up the good work and ensure the renewable energy program remains an important part of the BLM's overall energy initiatives.

The Public Lands Foundation (PLF) is a national nonprofit membership organization that advocates and works for the retention of America's Public Lands in public hands, professionally and sustainably managed for responsible use and enjoyment by American citizens. The PLF endorses and embraces the multiple use mission of the BLM. Members are predominately retired employees of the BLM from across the United States and as such have spent their careers dedicated to the sound management of these valuable lands and resources. And, they have personal knowledge of these lands and resources and expertise in their management.

Sincerely,

A handwritten signature in black ink that reads "Edward W. Shepard". The signature is written in a cursive, flowing style.

Edward W. Shepard, President

Cc: Assistant Secretary, Land and Minerals Management, Joe Balash

Public Comment Submission
Royalty Policy Committee Meeting
June 6, 2018

Thank you for the opportunity to comment on the record today before the Royalty Policy Committee. My name is Mary Ellen Kustin, and I am the policy director for public lands at the Center for American Progress, or CAP.

The focus of today's meeting makes plain that the RPC is simultaneously [falling short of its mission while also exceeding the scope](#) of its [charter](#). Contrary to its founding mandate, the RPC is not ensuring that taxpayers receive a fair return on the energy extracted from public lands. In fact, today's agenda [indicates](#) that the Fair Return and Value Subcommittee does not currently have any recommendations for the RPC to consider even though this subcommittee is at the crux of what the RPC charter sets out to do. Rather, many members of this industry-heavy committee appear to be looking out for their own interests. Given the committee's past actions and today's slate of proposed recommendations, the RPC is on track to formally push for actions that favor oil and gas companies and continue the Trump administration's legacy of putting multibillion-dollar industries ahead of the American people.

CAP is concerned that today's proposed recommendations take swipes at public scrutiny and environmental reviews of oil and gas leases on public lands; expand opportunities for industry to not pay royalties; and propose changing regulations designed to ensure accurate reporting and calculations of royalty payments. These recommendations exceed the scope of the [RPC's charter](#), and—if adopted—would put industry's wish list ahead of public interests in providing for other economic development opportunities on public lands. Such actions could ignite a firestorm of criticism from state, tribal, and local governments; be highly vulnerable to legal challenge; invite congressional oversight and investigations of conflicts of interest; and further erode Secretary Zinke's fragile public image.

CAP is also alarmed to see in the summaries posted online that at least [three](#) additional allies of the fossil fuel industry have been present at [subcommittee meetings](#) representing organizations not initially appointed to the RPC. Rather than represent the public interest, it is far more likely that these groups will create an echo chamber of agreement on existing RPC recommendations.

Additionally, the subcommittee discussion [summaries](#) sporadically refer to the idea that reductions in royalty payments will encourage higher levels of fossil fuel production from federal lands. CAP urges the RPC to remember that federal law [requires](#) payments to taxpayers on publicly owned fossil fuels reflect fair market value, not be used as tools to increase production. If the subcommittee is indeed recommending reducing royalty payments in order to boost fossil fuel production, the DOI should beware. Not only do government [reports](#) not support the theory that oil and gas production would rise due to cuts in royalty rates, the RPC could be recommending an action that goes against the law.

Please let me know if I can provide any additional materials. Thank you all for your time.

Mary Ellen M. Kustin
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