RFF's Risk Matrix and Expert Survey: There's More Consensus Than You Think

RESOURCES FOR THE FUTURE

The National Academies Roundtable on Science and Technology for Sustainability

December 10, 2014

The Roundtable Principles

- Focus on strategic needs and opportunities for science and technology to contribute to sustainability
  - ➔ shale gas revolution debate
- Focus on issues for which progress requires cooperation among stakeholders
  - ➔ expert survey of stakeholders
- Focus on activities where scientific knowledge can help advance practices and identify research priorities
  - ➔ expert elicitation, priority framing

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Background on the Shale Gas Revolution Debate

- Rapid development
- In new places
- Lack of data
- Regulatory catch-up
- Lack of understanding
- Poor communications

➔ Acrimonious atmosphere

➔ Survey the experts

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Site Development and Drilling Preparation
After locating a site for shale gas development, the area must be excavated and prepared for drilling. Preparation activity also often includes leveling of the site.

Activity	Intermediate Impacts					
	Groundwater	Surface Water	Soil Quality	Air Quality	Habitat Disruption	Community Disruption
Clearing of land/construction of roads, well pads, pipelines, other infrastructure		Stormwater flows Invasive species	Stormwater flows	Conventional air pollutants and CO_2	Habitat fragmentation Invasive species	Industrial landscape Light pollution Noise pollution
On-road vehicle activity		Stormwater flows		Conventional air pollutants and CO_2	Other	Noise pollution Road congestion/accidents
Off-road vehicle activity		Stormwater flows		Conventional air pollutants and CO_2	Other	Noise pollution

Return to Top

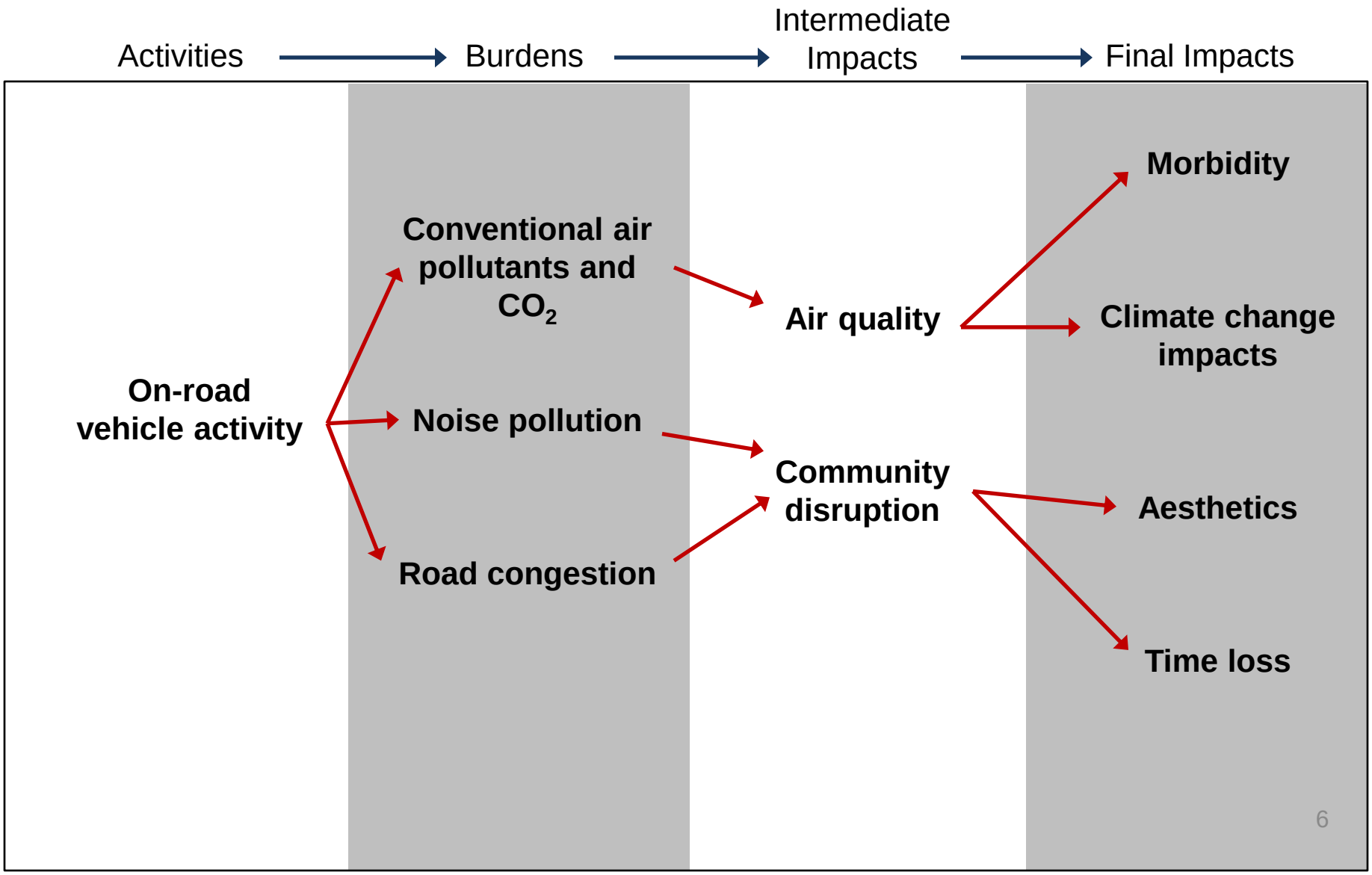
Drilling Activities
Drilling begins by boring a single well shaft vertically into the desired formation. One or more lateral wells are then drilled from the end of the vertical wellbore, angling to run horizontally through the shale formation.

Activity	Intermediate Impacts					
	Groundwater	Surface Water	Soil Quality	Air Quality	Habitat Disruption	Community Disruption
Drilling equipment operation at surface	Drilling fluids/cuttings	Drilling fluids/cuttings	Drilling fluids/cuttings	Conventional air pollutants and CO_2		Industrial landscape Light pollution Noise pollution
Drilling of vertical and lateral wellbore	Methane Drilling fluids/cuttings Intrusion of saline-formation water into fresh groundwater	Drilling fluids/cuttings		Methane		

Creating Impact Pathways (Risk Matrices on the web)

Activities	Burdens	Intermediate Impacts	Final Impacts
Site development and drilling preparation	**Air pollutants**	**Groundwater**	**Human health impacts**
Vertical drilling	**Drilling fluids and cuttings**	**Surface water**	**Market impacts**
Horizontal drilling	**Saline water intrusion**	**Soil quality**	**Ecosystem impacts**
Fracturing and completion	**Fracturing fluids**	**Air quality**	**Climate change impacts**
Well production and operation	**Flowback constituents (other than fracturing fluids)**	**Habitat disruption**	**Quality of life impacts**
Flowback and produced water storage/disposal	**Produced water constituents**	**Community disruption**	
Shutting-in, plugging and abandonment	**Condenser and dehydration additives**	**Occupational hazard**	
Workovers	**Habitat/community disruptions**		
Upstream and downstream activities	**Other**		

Creating Impact Pathways (cont.'d)



Our Sample of Experts

Where drawn

Surveyed 215 experts (30% response rate) in academia, NGOs, industry and government; representing 199 “institutions”

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The survey: Core ideas

Routine vs. Accident risks

Routine

- Impact pathways (Activity ➔ Burdens ➔ Impact)
- High priority impact pathways: those needing further government or voluntary industry attention
- Risk matrix (website) of 264 possible impact pathways

Accidents

- High priority accidents (choices from 14 categories)
- Eight probability, 5 severity categories ➔

  “notional expected values”

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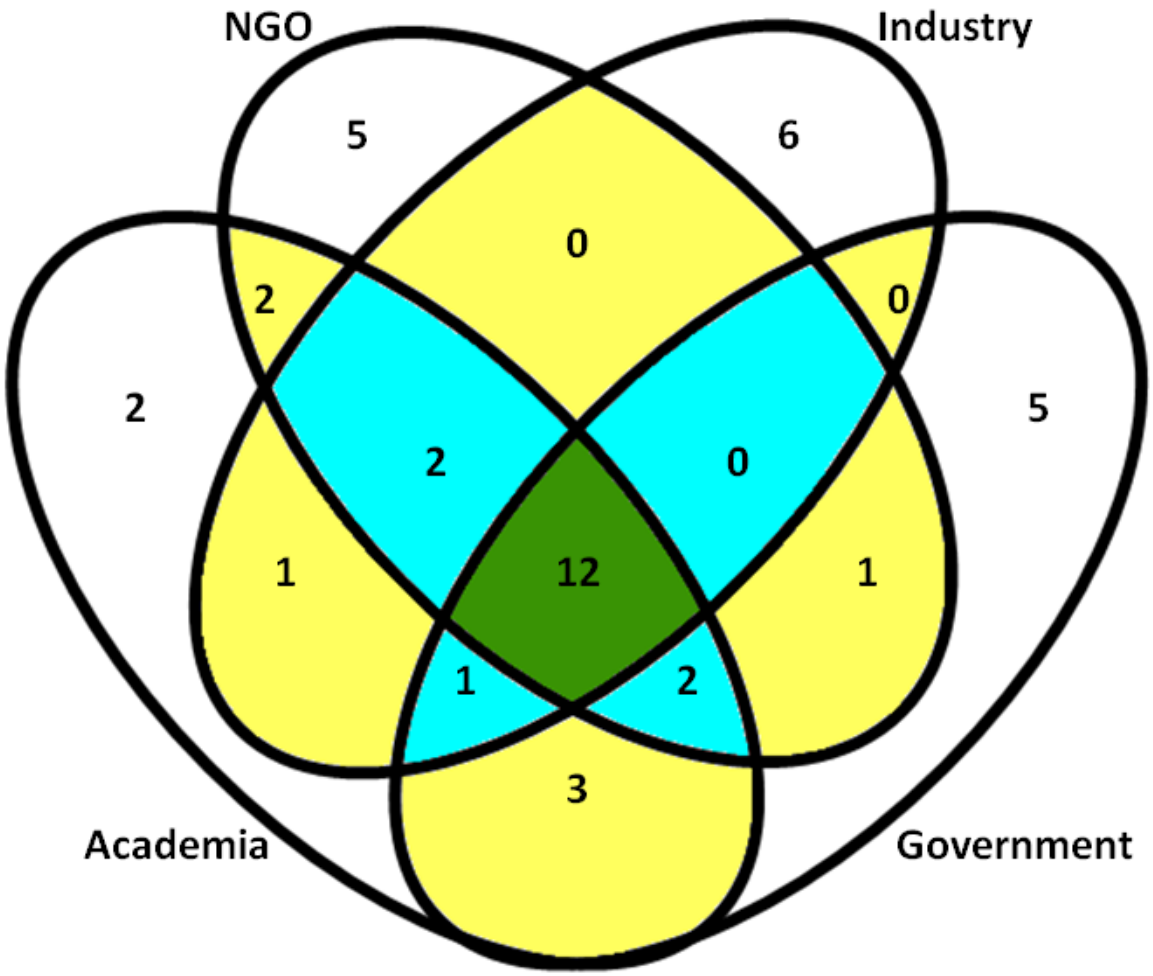
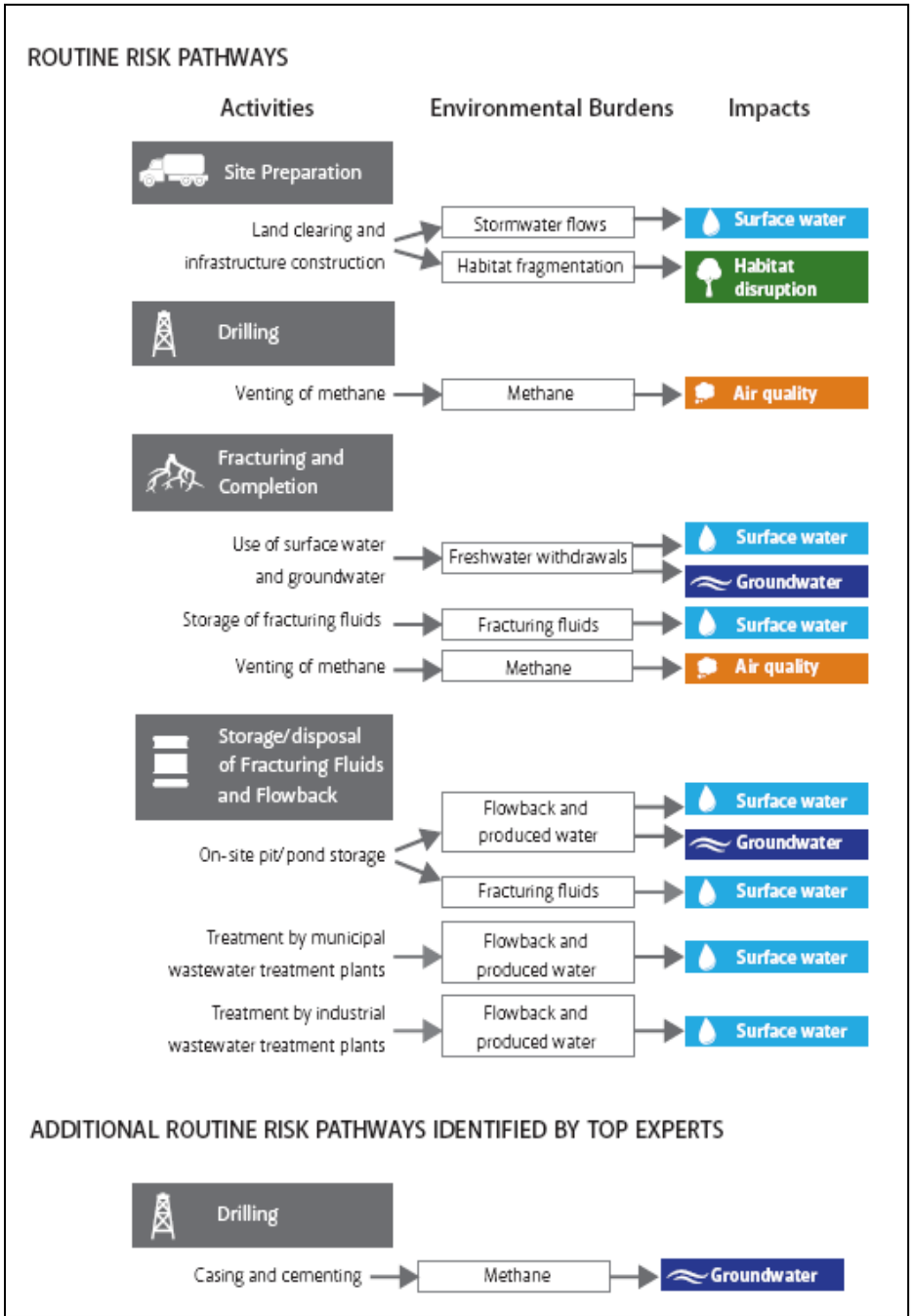
Top “20” Priorities, by Group




ROUTINE RISK PATHWAYS
Activities
Environmental Burdens
Impacts
Site Preparation
Land clearing and infrastructure construction
Stormwater flows
Habitat fragmentation
Surface water
Habitat disruption
Drilling
Venting of methane
Methane
Air quality
Fracturing and Completion
Use of surface water and groundwater
Freshwater withdrawals
Surface water
Groundwater
Storage of fracturing fluids
Fracturing fluids
Surface water
Venting of methane
Methane
Air quality
Storage/disposal of Fracturing Fluids and Flowback
On-site pit/pond storage
Flowback and produced water
Surface water
Groundwater
Fracturing fluids
Surface water
Treatment by municipal wastewater treatment plants
Flowback and produced water
Surface water
Treatment by industrial wastewater treatment plants
Flowback and produced water
Surface water
ADDITIONAL ROUTINE RISK PATHWAYS IDENTIFIED BY TOP EXPERTS
Drilling
Casing and cementing
Methane
Groundwater

Some surprises

- Surface waters dominate; groundwater risks identified less frequently
- Only two pathways are unique to the shale gas development process
- Habitat fragmentation

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Other Findings

- Infrequent votes for soil-related pathways, conventional air pathways
- Priorities of only one group
  - Industry: community impacts
  - NGOs: conventional air pollution
  - Government: groundwater
  - Academics: landscape, groundwater withdrawals
- Consensus of more than one group (examples)
  - Using flowback for dust suppression/deicing (not industry)
  - Seismic vibrations from deep injection (academics and industry only)
  - Groundwater risks from fracturing (academics and NGOs)

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Does sub-affiliation, experience, expertise, education matter?

- Sub-affiliation
  - States (fluids, cutting disposal) vs. federal (air quality/methane)
  - E&P experts: more likely to vote for community disruptions than other industry
- Personal qualities generally don't matter
- Affiliation (not experience or education) a much better predictor

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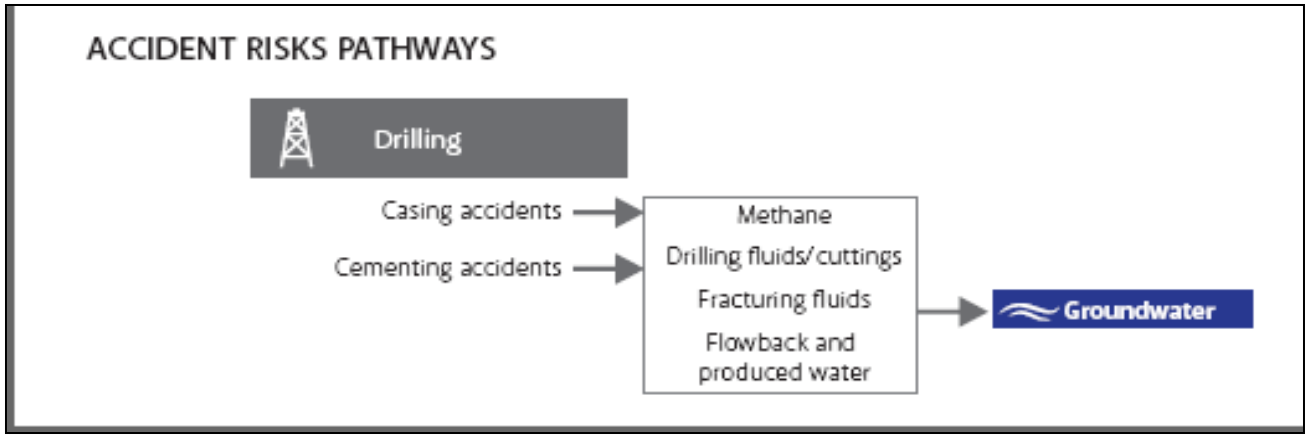
Accident Priorities

- All groups share the top two accident priorities: cement failure and casing failure



- All but industry identify impoundment failure as #3
- Industry identifies truck accidents.

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Probabilities and severities for top accident priorities

Severity

Probability	Very Low	Low	Medium	High	Very High	Total
<0.1	27	34	64	57	46	228
	3.1%	3.8%	7.2%	6.4%	5.2%	25.8%
0.1-1	17	42	77	70	27	233
	1.9%	4.8%	8.7%	7.9%	3.1%	26.4%
1-2%	4	28	51	47	19	149
	0.5%	3.2%	5.8%	5.3%	2.1%	16.9%
3-5%	0	16	48	44	9	117
	0.0%	1.8%	5.4%	5.0%	1.0%	13.2%
6-10%	3	8	33	13	15	72
	0.3%	0.9%	3.7%	1.5%	1.7%	8.1%
11-15%	0	1	14	12	6	33
	0.0%	0.1%	1.6%	1.4%	0.7%	3.7%
26-50%	1	0	3	20	11	35
	0.1%	0.0%	0.3%	2.3%	1.2%	4.0%
>50%	0	1	7	3	6	17
	0.0%	0.1%	0.8%	0.3%	0.7%	1.9%
Total	52	130	297	266	139	884
	5.9%	14.7%	33.6%	30.1%	15.7%	100.0%

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NGOs

Severity

Probability	Very Low	Low	Medium	High	Very High	Total
<0.1	0	0	7	3	6	16
	0.0%	0.0%	3.8%	1.6%	3.2%	8.6%
0.1-1	0	1	10	11	9	31
	0.0%	0.5%	5.4%	5.9%	4.8%	16.7%
1-2%	0	2	14	18	5	39
	0.0%	1.1%	7.5%	9.7%	2.7%	21.0%
3-5%	0	2	17	20	3	42
	0.0%	1.1%	9.1%	10.8%	1.6%	22.6%
6-10%	0	1	5	5	10	21
	0.0%	0.5%	2.7%	2.7%	5.4%	11.3%
11-15%	0	1	6	3	1	11
	0.0%	0.5%	3.2%	1.6%	0.5%	5.9%
26-50%	0	0	2	12	6	20
	0.0%	0.0%	1.1%	6.5%	3.2%	10.8%
>50%	0	0	1	0	5	6
	0.0%	0.0%	0.5%	0.0%	2.7%	3.2%
Total	0	7	62	72	45	186
	0.0%	3.8%	33.3%	38.7%	24.2%	100.0%

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Industry

	Severity					
Probability	Very Low	Low	Medium	High	Very High	Total
<0.1	10	9	24	23	12	78
	3.8%	3.4%	9.2%	8.8%	4.6%	29.8%
0.1-1	9	17	19	25	11	81
	3.4%	6.5%	7.3%	9.5%	4.2%	30.9%
1-2%	1	9	13	8	4	35
	0.4%	3.4%	5.0%	3.1%	1.5%	13.4%
3-5%	0	6	12	8	2	28
	0.0%	2.3%	4.6%	3.1%	0.8%	10.7%
6-10%	1	5	7	4	3	20
	0.4%	1.9%	2.7%	1.5%	1.1%	7.6%
11-15%	0	0	2	4	1	7
	0.0%	0.0%	0.8%	1.5%	0.4%	2.7%
26-50%	1	0	1	4	4	10
	0.4%	0.0%	0.4%	1.5%	1.5%	3.8%
>50%	0	1	1	1	0	3
	0.0%	0.4%	0.4%	0.4%	0.0%	1.1%
Total	22	47	79	77	37	262
	8.4%	17.9%	30.2%	29.4%	14.1%	100.0%

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Academics

	Severity					
Probability	Very Low	Low	Medium	High	Very High	Total
<0.1	4	19	27	27	21	98
	1.5%	7.1%	10.1%	10.1%	7.8%	36.6%
0.1-1	1	12	33	18	3	67
	0.4%	4.5%	12.3%	6.7%	1.1%	25.0%
1-2%	1	3	13	17	7	41
	0.4%	1.1%	4.9%	6.3%	2.6%	15.3%
3-5%	0	6	8	12	2	28
	0.0%	2.2%	3.0%	4.5%	0.7%	10.4%
6-10%	1	2	15	4	0	22
	0.4%	0.7%	5.6%	1.5%	0.0%	8.2%
11-15%	0	0	1	3	1	5
	0.0%	0.0%	0.4%	1.1%	0.4%	1.9%
26-50%	0	0	0	1	1	2
	0.0%	0.0%	0.0%	0.4%	0.4%	0.7%
>50%	0	0	3	1	1	5
	0.0%	0.0%	1.1%	0.4%	0.4%	1.9%
Total	7	42	100	83	36	268
	2.6%	15.7%	37.3%	31.0%	13.4%	100.0%

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Routine Priorities: Who takes the lead?

Prior to Risk Matrix

Group	Gov.'t	Industry	Shared
NGO	74%	4%	22%
Industry	14%	38%	48%
Academics	37%	14%	49%
Government	16%	13%	71%

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If you have to choose one

	All Activities				
	NGO	Industry	Academics	Government	All Groups
Government Responsible	94.5%	58.9%	75.0%	77.0%	74.9%
Industry Responsible	5.5%	41.1%	25.0%	23.0%	25.1%

- No sharing option
- If sharing an option, all agree to sharing responsibility; all except industry clearly favor government in the lead role
- Industry support for government regulation is about10% greater for the consensus pathways than for all pathways

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Communicating the Findings

How did RFF communicate this work?

- A written report
- One-on-one briefings, including on the Hill
- Two webinars, one offered specifically for industry representatives
- Conference/workshop presentations
- Special project website on www.rff.org
- RFF's blog, magazine, social media
- *RFF Connection* newsletter

Impact

- The risk matrix was used by many groups to help them think through priorities and was quoted in a number of publications
- High degree of consensus helped depoliticize and focus attention on previously underappreciated problems
  - Habitat fragmentation
  - Community impacts
  - Pits and tanks
- Turned down the heat on certain issues
  - Groundwater pollution from the fracking process itself

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Thank you!

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Who is included

Confidentiality

- **NGOs (35)**: Most national environmental groups, some local
- **Academics (63)**: Universities/think tanks
- **Government (42)**: Key federal agencies; about half the relevant states; river basin commissions
- **Industry (75)**: Many operating and support companies, trade associations, consulting firms, law firms

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The Survey

1. About respondent
2. Key concepts
3. Filling out the risk matrix
4. Accidents
5. Burden priorities, opportunities for comment

Results

- Routine priorities
- Accident priorities
- Burden priorities

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Number of Routine Priorities

	Total	NGO	Industry	Academia	Government
10th Percentile	5	38	3	12	2
50th Percentile	39	100	28	42	27
90th Percentile	125	218	72	117	80
Mean	55	**105**	**39**	54	**40**
Observations	215	35	75	63	42

➔ NGO's are the outlier in number of high priorities identified

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Top consensus categories (out of top 20)

7 surface water

2 groundwater

2 air quality (both methane)

1 habitat (from site/infrastructure development)

Industry priority for community impacts

Fluids priorities

Six Fluid Burdens Identified by All Expert Groups as "High Priority" for Further Action Out of Top 10

WHERE THE FLUID IS FOUND	FLUID BURDEN
Flowback and produced water	Naturally occurring radioactive materials (NORMs)
	Aromatic hydrocarbons (e.g. BTEX)
	Hydrogen sulfide
Drilling fluids and cuttings	Diesel oil
	Naturally occurring radioactive materials (NORMs)
Fracturing fluids	Oils (including diesel)

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Other

- Boom towns net effect
  - Industry: net positive
  - NGO's: net negative
  - Overall: 2/3 net positive
- Plays
  - Very little difference in priorities
- Do other personal characteristics matter? Are they more fundamental than group affiliation? Regression analysis

Bottom Line

- Top priorities for action
  - What is their state of play?
  - Do they need more research?
  - Who should be responsible?
    - Theory
    - What experts say
  - Costs
- Top priorities for research
- What not to worry about