

Fractured landscape
Northeastern BC



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Unconventional shale gas development: challenges for
environmental policy and EA practice

Yap, N.T. (2016). Unconventional shale gas development: challenges for environmental policy and EA Practice. *Impact Assessment and Project Appraisal*. June. DOI: 10.1080/14615517.2016.1176405

Basis of the arguments but with greater focus on Canada

Council of Canadian Academies, (2014) *Environmental Impacts of Shale Gas Extraction in Canada*. Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, Council of Canadian Academies.

Agenda

- 1) Paper Rationale, Methods, Questions
- 2) Profile: Canadian natural gas production, shale gas resources
- 3) 'Fracking' – technologies, process, inputs, concerns
- 4) Summary: what is known, what is not known
- 5) Conclusions
 - 1) Implications for EA policy
 - 2) Implications for EA practice
- 6) Status of CDN provincial and federal government regulations relevant to 'fracking'

Rationale

- Natural gas production to more than triple in the next decade and make up 23% of energy consumption by 2040 ; can lead to energy security in some countries
- Coupled with fuel switching, can be a transition fuel to low carbon economy, BUT
- Dramatic growth of USG development has been accompanied by public protests & civil suits with
 - bans or moratoria in various jurisdictions, e.g., Wales, Scotland, Maryland and New York in the U.S., Quebec, Newfoundland and Labrador, and New Brunswick in Canada, and attempted in
 - several counties in COL, TX, and OH and most recently, by an Indian Band in North Dakota.

'Feds feared another 'Idle No More' after New Brunswick protest'

(MacLeans Aug 17, 2014)



Port Cranford Photo

Review literature (2006-2016) chemistry, geochemistry, environmental S&E, microbiology

- 1) *What is known and not known about the process chemicals and wastewaters generated in shale gas development?*
- 2) *What is known and not known about the release mechanisms and transport pathways by which hydraulic fracturing chemicals and wastewaters enter surface water and groundwater aquifers?*
- 3) *What are the risks posed to human and ecosystem health?*

Focus: water pollution (health impacts) risk, recognising ...

OTHER CONCERNS

- Air quality - Rn
- Water use: high volumes in short periods of time
- DWI & seismicity (OK, TX, PA, ALTA, BC)
- Land- fragmentation of landscape, natural processes, existing land use

ALTERNATIVES

- FRACTURING LIQUIDS - N_2 gas, N_2 - based foam, CO_2 & LPG, non-potable water
- WW DISPOSAL - WW reuse
- CENTRE FOR SUSTAINABLE SD established standards
- NOT MAINSTREAM

Natural gas production in Canada (CCA 2014)

- Started mid 19th century
- 30% of CDN energy consumption
- Producers: British Columbia, Alberta, Saskatchewan, Ontario, New Brunswick, Nova Scotia, Yukon, NWT
- world's 3rd largest producer , 4th largest exporter
- USG drilling boom started 1990s - ENCANA extracted gas from dense rock in northern BC and from shallow coal seams in Alberta in 2000
- USG reserves - largely in traditional territories of Aboriginal peoples

Canadian shale gas resources

- 2009 - 1000 trillion cubic ft (tcf)
- 2012 – 3 times larger
- Recoverable: 5 to 30% (vs 50 to 90% for conventional)

Challenges: best plays are far from markets and infrastructure, very low temperatures; soggy ground slows drilling in spring and summer

- Number of wells drilled in 2011 (Rivard et al 2012 in CCA 2014)

	B.C.*	Alta.	Sask.	Ont.	Que.	N.B.	N.S.
Drilled	1873	190	85**	1***	29	4	5
Fractured	~1873	178	~42	0	18	3****	3
Producing	1354	114	35	0	0	1****	0

Canadian shale gas plays (NEB 2009 in CCA 2014)

	Geological Formation
Geographical Location	Alberta & BC embrace large scale fracking – offer financial incentives and loosen regulatory hurdles BC reduced royalties for deep drilling and credits for building roads and pipelines – has seen most intensive drilling anywhere
Potential Gas in Place (Tcf)	
Depth of Formation (m)	
Shale Thickness (m)	
Well Cost (M \$)	

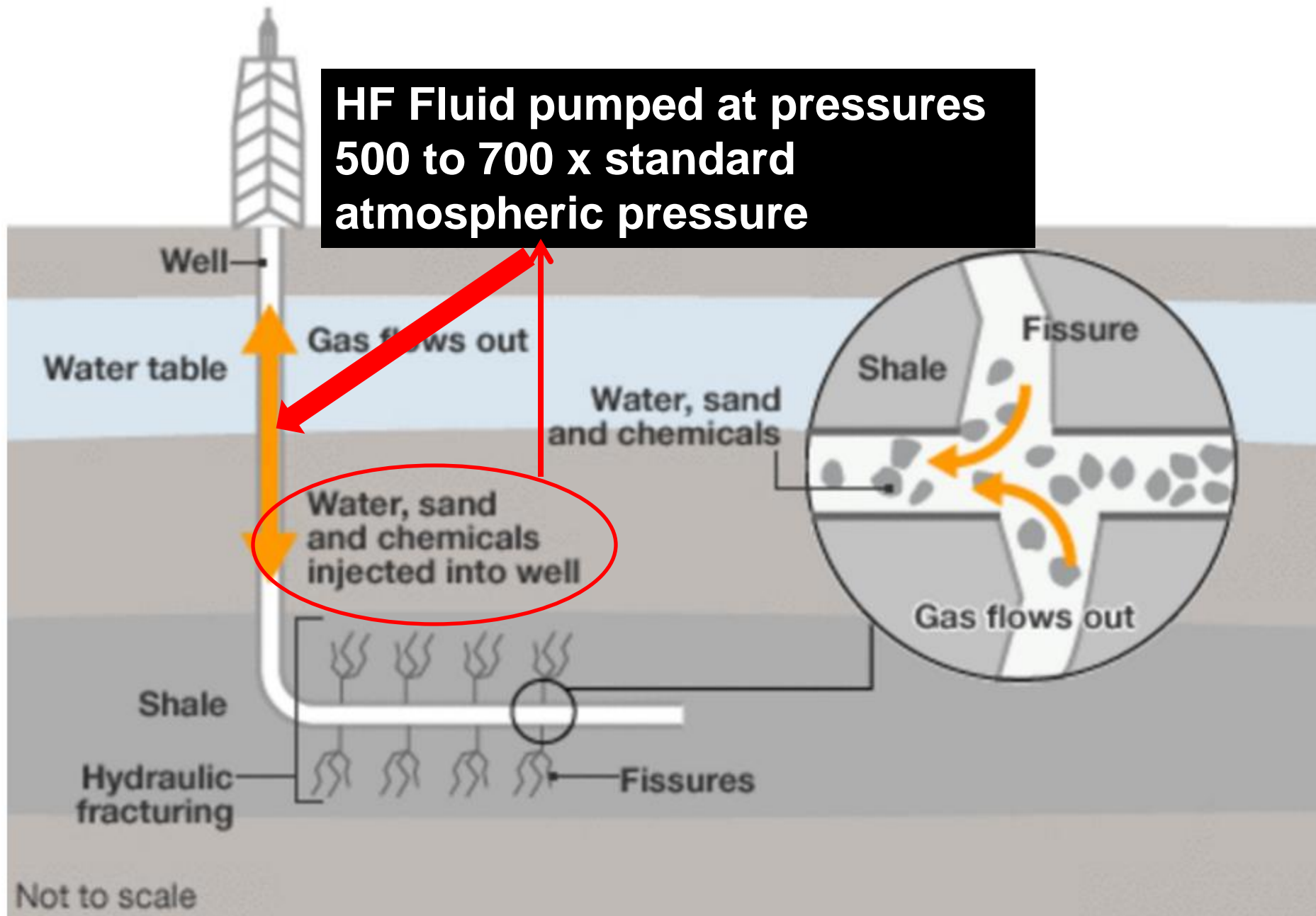
'Fracking' - a combination of

- 1) ***Horizontal drilling*** - enables a downward-plodding drill bit to bend as much as 90 degrees and continue drilling for several kilometres
 - 2) ***Hydraulic fracturing*** - high pressure solutions to create & maintain fissures allowing easy flow of gas, oil & water
- ❑ Separately used since the 40's , now applied together in shale gas deposits, tight oil deposits, shale oil, tight gas strata

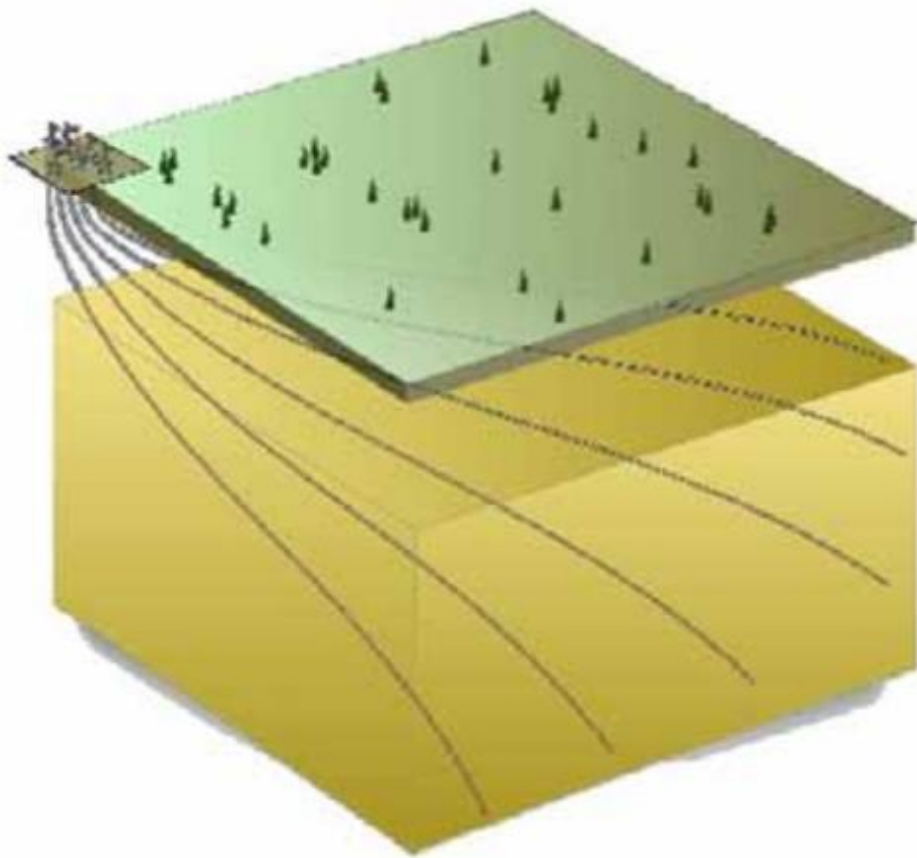
Shale gas - > 90% methane

Shale gas extraction

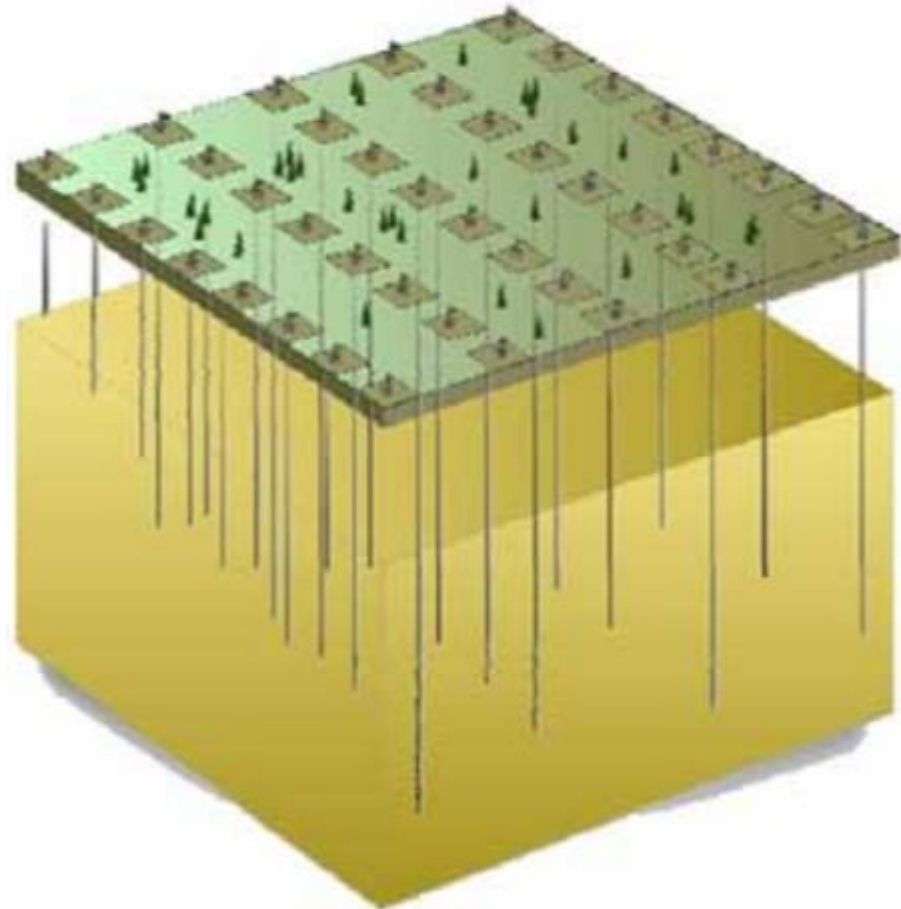
(Source :<http://www.bbc.com/news/uk-14432401>)



Smaller environmental footprint, greater operational efficiencies of multiwell pads



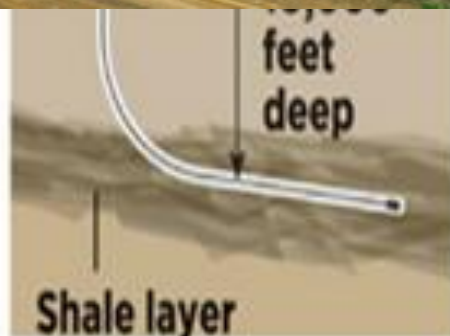
6 Horizontal wells (8 fracs/well) = 48 total
fracs per section



Same development would require 48
vertical wells each on a separate wellsite



Upstream development area



UNIVERSITY
OF GUELPH

SOURCE:
Los Angeles Times

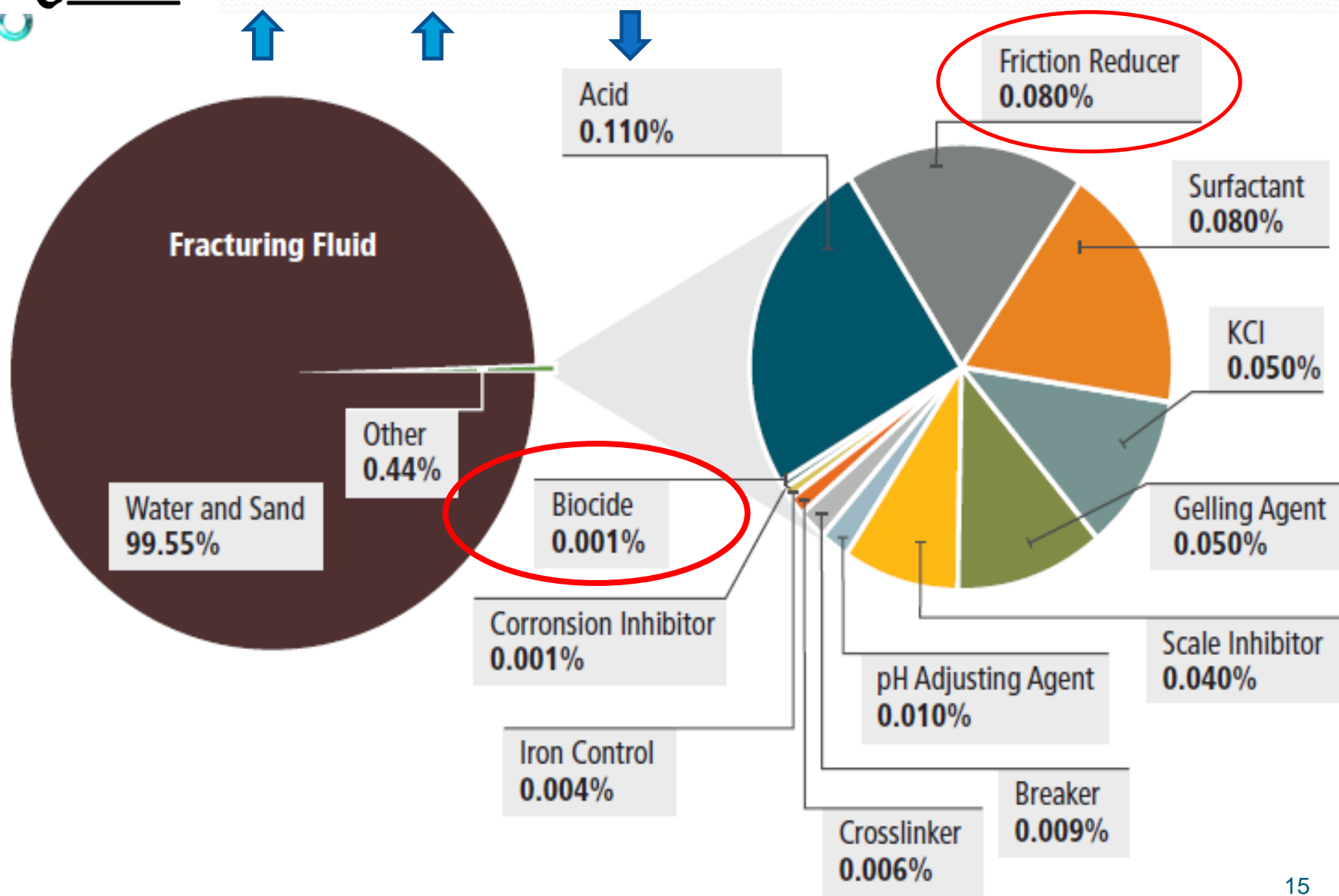
McClatchy Tribune

Well is bored using directional drilling, a method that allows drilling in vertical and horizontal directions to depths of more than 10,000 feet.

Large amounts of water, sand and chemicals are injected into the well at high pressure, causing fissures in the shale.

Sand flows into the fissures, keeping them open so the oil or natural gas from the shale can flow up and out of the well.

2 - 12 – 752 consisting of:



Why the concern?

Fracturing fluid required for each fractured well
ca 8x water in Olympic swimming pool [2.5M
gallons TX to 15M gallons in Horn River BC]
containing on average ...

- 1.5M kg of proppant, 100,000 l acid, 1,000 kg of friction reducer, 900 kg of disinfectant, 300 l corrosion inhibitor.
- Wastewater -> *Flowback* – 20 to 40% of original volume plus *formation* water with minerals from the shale formation – TDS, chlorides, bromides, arsenic, barium, NORM [Th-90, Ra-226, Rn-222 > Po-210, Pb-210]

Contamination pathways (Rozell & Reaven 2011)

- Improper placement, formulation
- Deterioration from repeated fracturing
- Cement crack, shrinkage, deformation

Long recognised but unresolved problem

HWTP

Reuse

MSTP dilution

DW Injection

Unknown

Injection

1
Fracturing fluids
Transport to site

2
Well casing failure

3
Migration through rock fractures

4 ON SITE SPILLS
AND LEAKS

5
Wastewater disposal

➤ Drilling

In winter 2010 in northern Canada, the “world’s largest fracking project”

- A company boasted of having completed 274 fractures in 16 wells from a single well pad over a 111-day period.
- used 5.7 M gallons of water, 50.3 M kilograms of sand and an estimated quarter of a million gallons of chemical additives (Kusnetz 2011).
- Record exceeded by 50% in neighbouring site by end of the year

Process chemicals and wastewaters generated	<ul style="list-style-type: none"> 73% of HF fluid products with CAS numbers associated with 6 to 14 adverse effects on skin, eye, sensory organ and reproduction Marcellus shale region - Flowback and produced water contain TDS, toxic chemicals and NORM above regulatory thresholds Wyoming - high levels of polycyclic aromatic hydrocarbons 	<ul style="list-style-type: none"> Identity of over half of ca 750 HF chemicals outcomes of possibly synergistic interaction between HFF and formation chemicals
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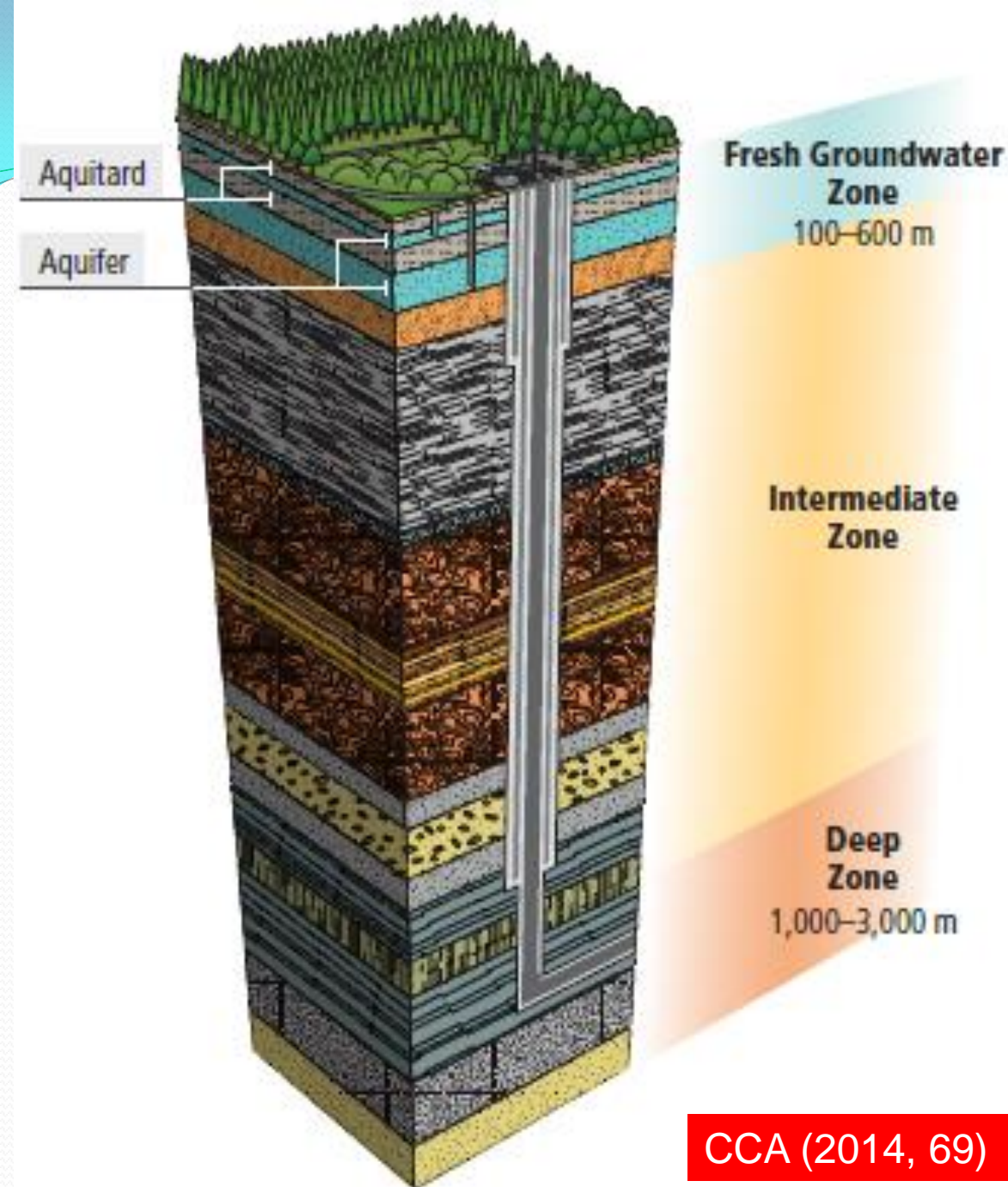
Concern: what is known not known

	<ul style="list-style-type: none"> do not effectively remove high levels of TDS and NORM Minor earthquakes observed in Marcellus and Barnett shale regions attributed to reinjection of wastewater, not fracturing process; Two events observed in Alberta attributed to fracturing treatment 	<ul style="list-style-type: none"> Whether frequent and successive minor seismic events eventually trigger a big one
Release mechanisms & transport pathways to chemical contamination of water resources	<ul style="list-style-type: none"> Major routes for toxic chemicals and NORM include spills, well casing leaks, leaks through fractured rock, drilling site discharge and wastewater disposal Canada - 'fracture communication', between wells > 600m apart - 25 cases in BC since 2009 & court case in Alberta vs ENCANA, ERCB 	<ul style="list-style-type: none"> Baseline information on groundwater quality for different sites Extent of well integrity failure Extent of inter wellbore communication

Risks posed to human and ecosystem health	<ul style="list-style-type: none"> ○ Positive association between density and proximity of pregnant mothers to SGD and congenital heart defects and possibly neural tube defects in newborns ○ Colorado - water samples from areas 	<ul style="list-style-type: none"> ○ Level, duration and source of exposure to water and air pollutants ○ Confounding variables in existing
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Concern : what is known and not known

	<ul style="list-style-type: none"> ○ Endocrine disruption activity than samples from sites with fewer or no operations ○ High levels of iodide and bromide in HFW react with disinfection chemicals to form known mutagens and carcinogens ○ Pennsylvania - Increased radon readings in buildings after SGD above MCLs ○ Arkansas - individual gas wells fully changed about 2.5 ha of land, modified an additional 0.5 ha of natural forest. 	<ul style="list-style-type: none"> ○ Occupational health hazards posed by NORM in HFW ○ Source of radon emissions increase ○ Long term impacts of land use changes on species diversity, composition, dynamics, ecosystem functioning
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CCA (2014, 69)

Summary

Crucial unknowns

- 1) Reaction of diverse chemicals in IZ : ca 60-70 C & 18MPa (1.8 tonnes/ thnail [6]
- 2) Pathways of fracturing chemicals in the environment
- 3) Human exposure routes & duration
- 4) Baseline information on key variables

Conclusion 1: Evidence based policy

NOT feasible, NOR credible

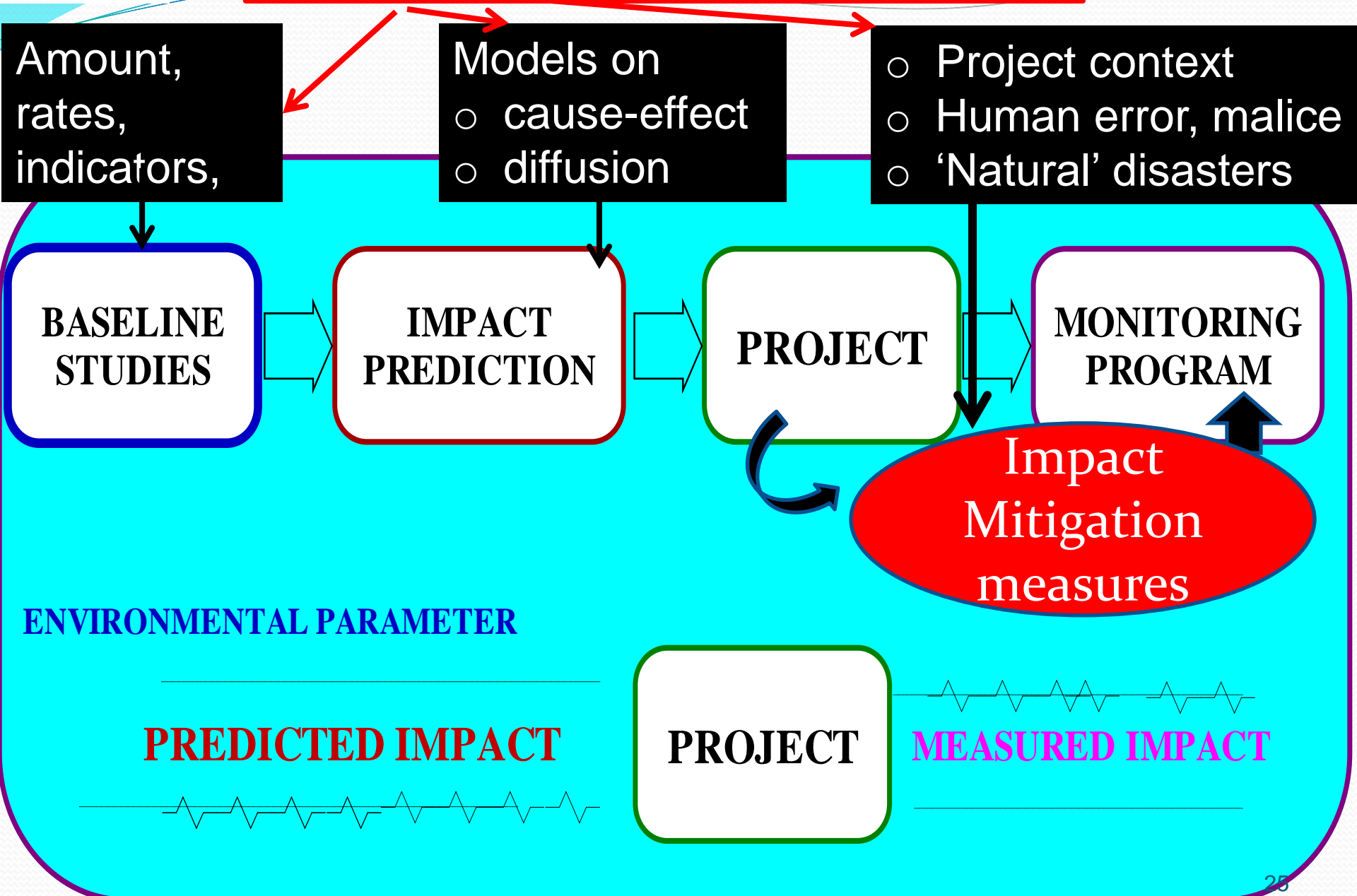
- **Insufficient baseline information on key geological and environmental variables**
- **most jurisdictions - information on process inputs is proprietary**
- **Water contamination studies, health impact studies complicated - multiplicity of potential sources, pathways, confidentiality agreements in damage claims settlement, rapid evolution of technology, lack of tracers to monitor contaminant migration into shallow aquifers**

NEEDED

Regulate

- ☐ siting and design
- ☐ transparency and accountability

Sources of uncertainties in EA



Conclusion 2: EA practice...

- Even with risk analysis, EA not a reliable tool for establishing environmental security in fracking
- Chemical disclosure important but not sufficient
- **NEEDED**

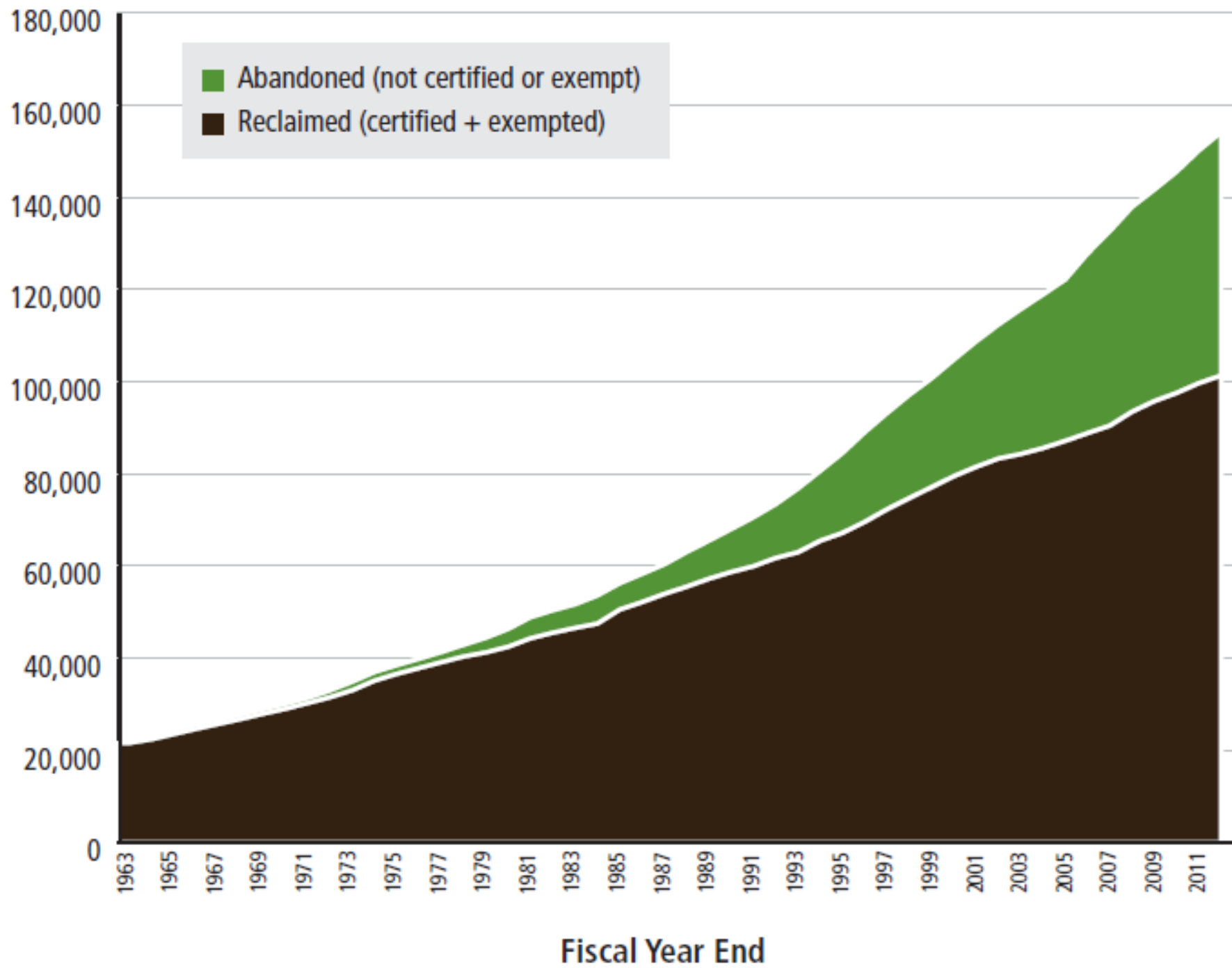
The precautionary principle “denotes a duty to prevent harm, when it is within our power to do so, *even when all the evidence is not in*” (CELA, n.d.)

CUMULATIVE EFFECTS ASSESSMENT

- allows linking of the different scales of impact assessment but maintains the focus on an agreed upon receptor, the community ... BUT
- rather than *forecasting* - “projecting trends and identifying desirable futures from a range of competing possibilities”
- *Backcast* - work “backwards from a particular desired future end-point or set of goals to the present” to determine the feasibility of that desired future and policy measures required to reach it
- *Backcasting* is particularly useful “when
 - the problem studied is complex...
 - dominant trends are part of the problem,
 - the problem to a great extent is a matter of externalities, and
 - the scope is wide enough and time horizon long enough to leave considerable room for deliberate choice”
- More amenable to participation of “non experts” from the community, hence more democratic.

**How are governments
dealing with these
challenges?**

Cumulative Number of Wells



At the federal level

- Aug 2016 – Expert Panel established to review *CEAA* 2012
- Goal: “introduce new processes that are *robust, incorporate science, protect the environment, respect the rights of Indigenous people, and support economic growth*”
- Sept 2016 – Nationwide consultation
- 2017 – Expert Panel recommendations

Ground for optimism but...
much remains to be seen.

THANK YOU!
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Partial list of references used

- 1) Council of Canadian Academies, (2014) *Environmental Impacts of Shale Gas Extraction in Canada*. Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, Council of Canadian Academies.
- 2) Jackson, R B, A Vengosh, J W Carey, R J Davies, T H Darrah, F O'Sullivan and G Pétron. 2014. Environmental Costs and Benefits of Hydraulic fracturing. *Annu. Rev. Environ. Resour.*, **39**: 327-362.
- 3) Jackson, R B, E R Lowry, A Pickle, M Kany, D DiGiulio and K Zhao. 2015. The Depths of Hydraulic Fracturing and Water Use across the United States. *Environ. Sci. & Technol*, **49** (15): 8969–8976.
- 4) King, J C, J K Bryan and M Clarke. 2012. Factual Causation: The Missing Link in Hydraulic Fracture-Groundwater Contamination Litigation. *Duke Envtl. Law & Policy Forum*, **22**: 341-360.
- 5) Rozell, D.J. and Reaven, S.J. (2011) Water Pollution Risk Associated with Natural Gas Extraction in the Marcellus Shale, *Risk Analysis* DOI: 10.1111/j.1539-6924.2011.01757
- 6) Suter II, Barnhouse, L.W., and R.V.O' Neill (1983). ``Treatment of Risk in Environmental Impact Assessment`. *Environmental Management*, 11(3) :295-303. http://www.earthlearningidea.com/PDF/189_Pressure_rock.pdf