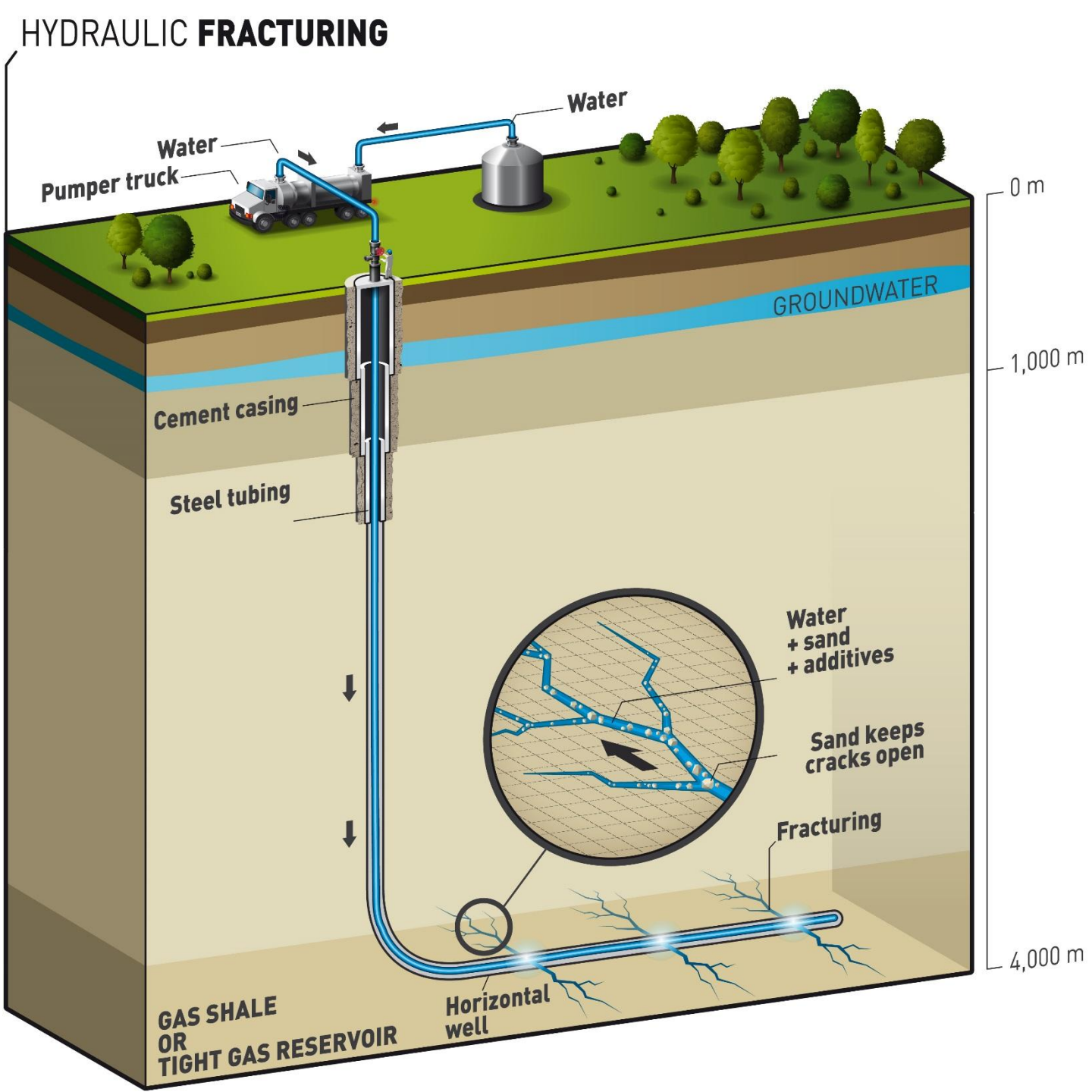
6-5-2014

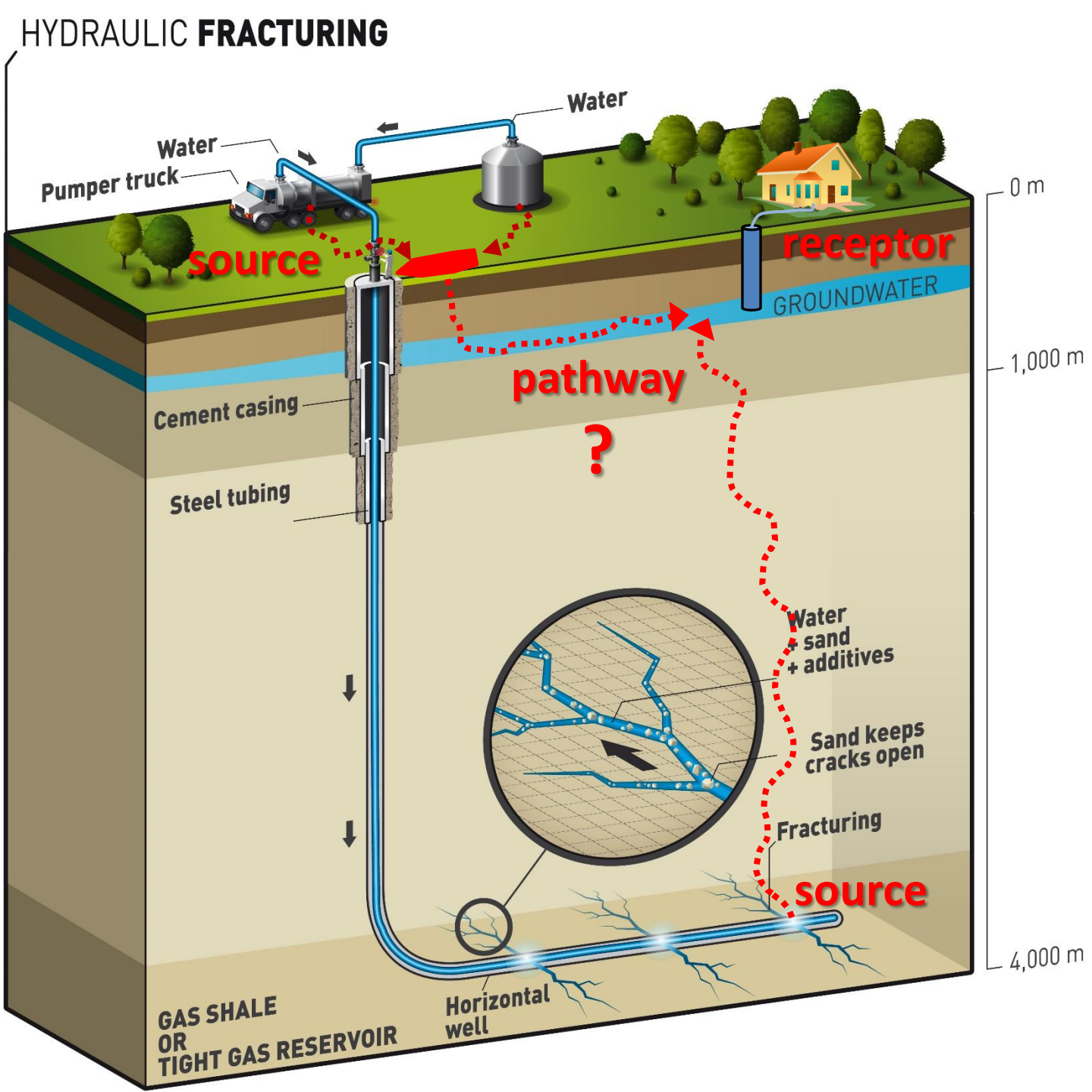
SLIDES: What We Know (and Don't Know) about the Effects of Oil and Gas Development on Water Quality

Joseph N. Ryan

What We Know (and Don't Know) about the Effects of Oil and Gas Development on Water Quality

Prof. Joe Ryan
University of Colorado Boulder
Environmental Engineering
AirWaterGas
Sustainability Research Network
www.airwatergas.org


HYDRAULIC FRACTURING
Water
Water
Pumper truck
0 m
GROUNDWATER
1,000 m
Cement casing
Steel tubing
Water
+ sand
+ additives
Sand keeps
cracks open
Fracturing
4,000 m
GAS SHALE
OR
TIGHT GAS RESERVOIR
Horizontal
well

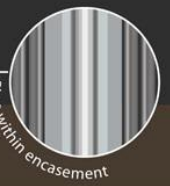

HYDRAULIC FRACTURING
Water
Water
Pumper truck
source
receptor
GROUNDWATER
pathway
?
Cement casing
Steel tubing
Water
+ sand
+ additives
Sand keeps
cracks open
Fracturing
source
0 m
1,000 m
4,000 m
GAS SHALE
OR
TIGHT GAS RESERVOIR
Horizontal
well

Shielding ensures safety

In the hydraulic fracturing process, there are about

10 inches of steel and concrete **SHIELDING** underground aquifers.

That's comparable to an armored door on a bank vault.



Hydraulic fracturing wells go **far below** underground aquifers.

2000ft

3000ft

4000ft

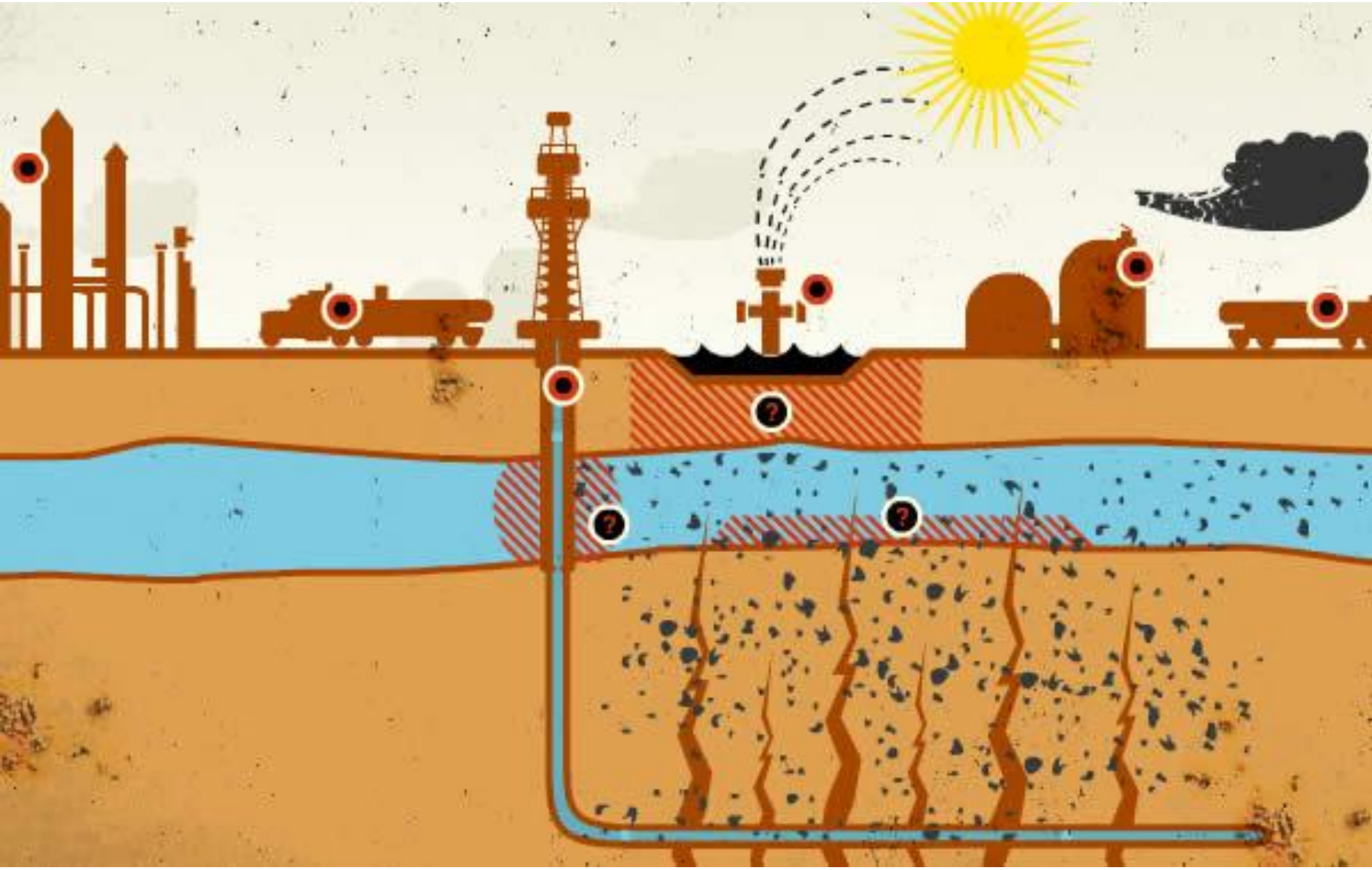
5000ft

6000ft

They reach approximately **6,000 feet** or more under the earth's surface - almost the distance of **4** Empire State buildings stacked on top of each other.

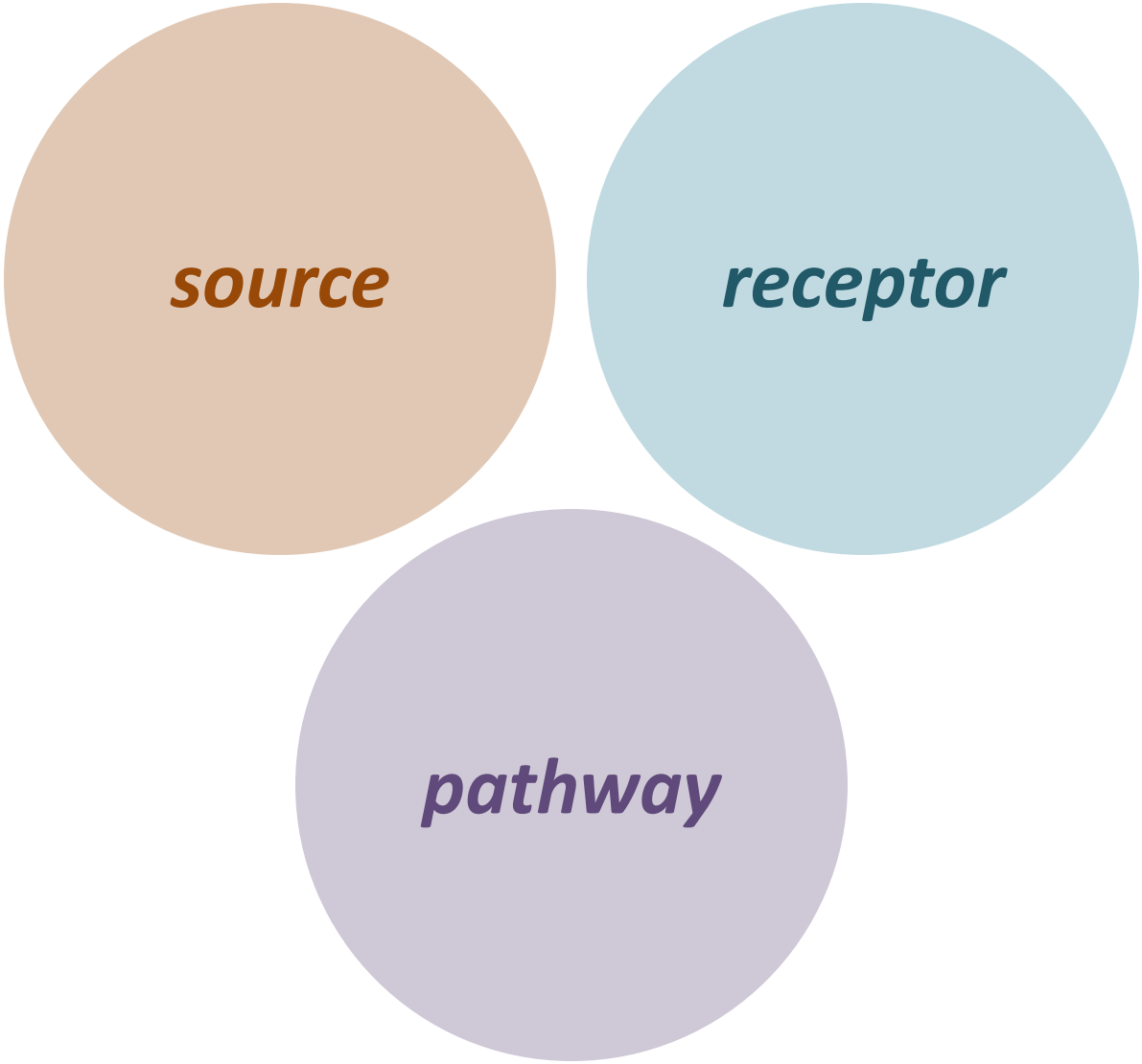
Ten inches of steel and concrete; that's the shield protecting Mother Nature as rigs extract much-needed clean-burning natural gas from deep beneath shale formations from Pennsylvania to Texas.

This vault-thick armor isn't just on a few of the natural gas wells, it's the industry standard. Hydraulically fractured wells have multiple layers of steel and concrete to protect underground aquifers and isolate the wellbore. On top of this protection, state regulators and the industry are also making sure that well construction meets an additional host of rigorous safety standards.

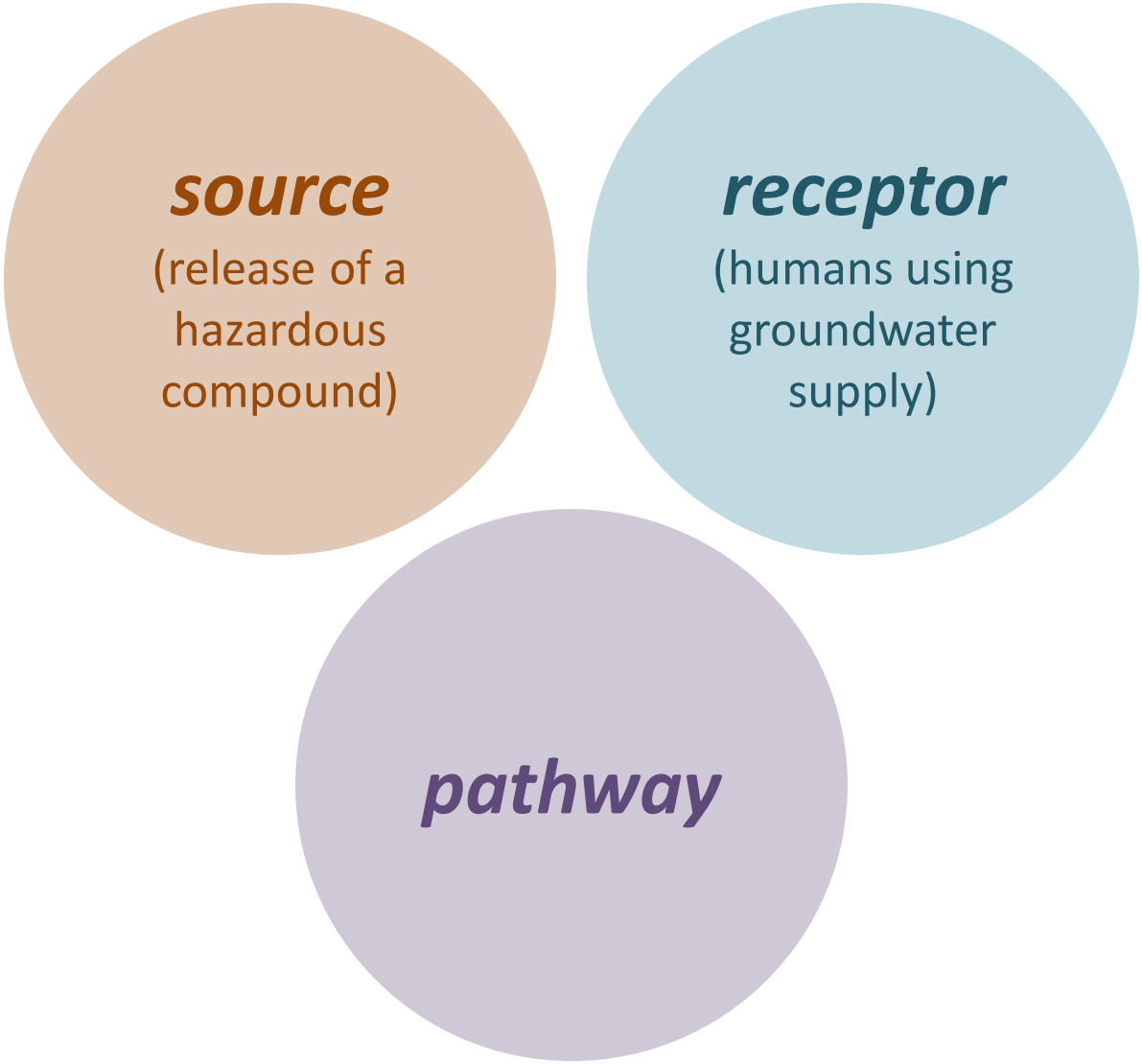


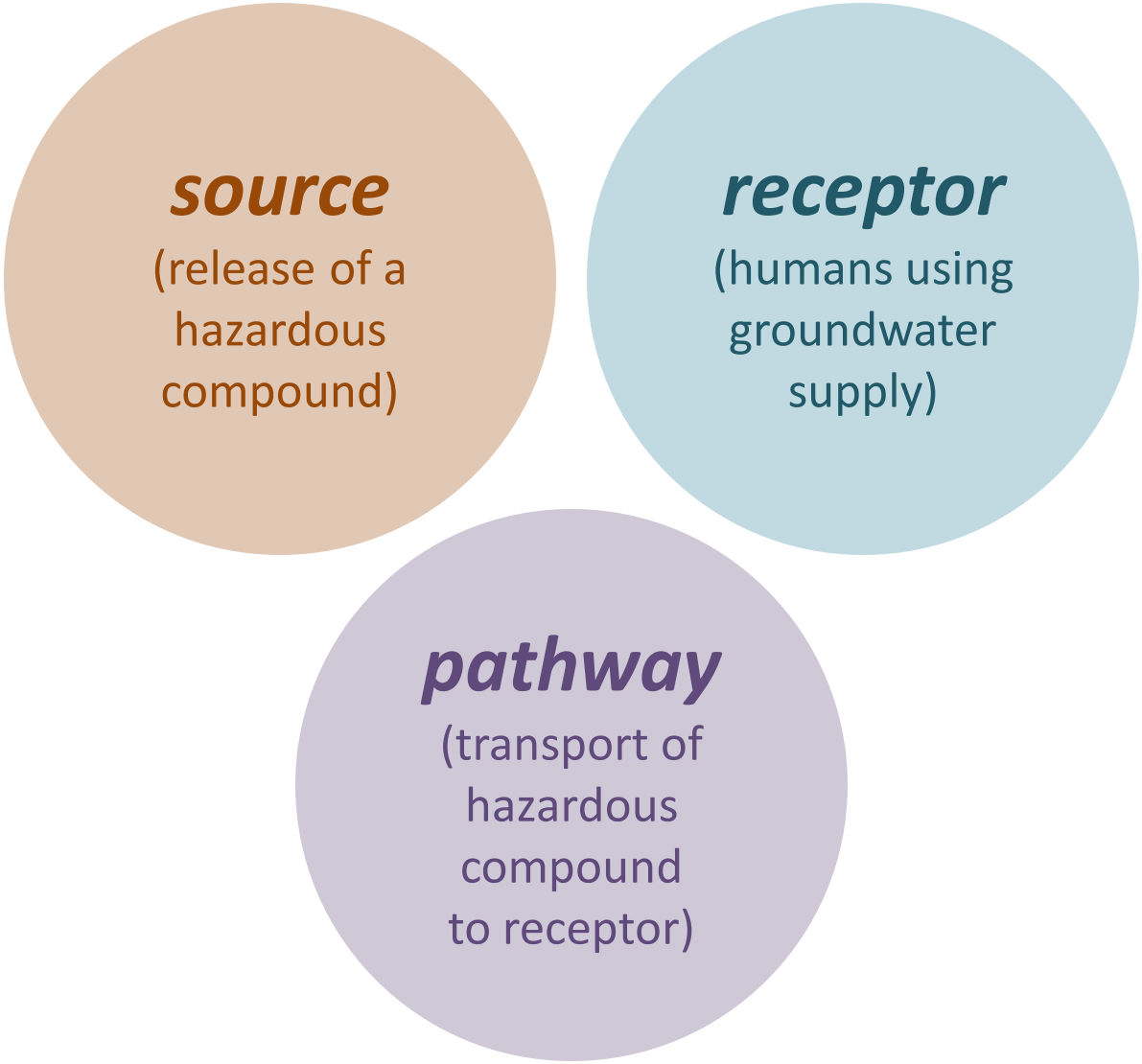
http://www.propublica.org/article/epa-chemicals-found-in-wyo.-drinking-water-might-be-from-fracking-825

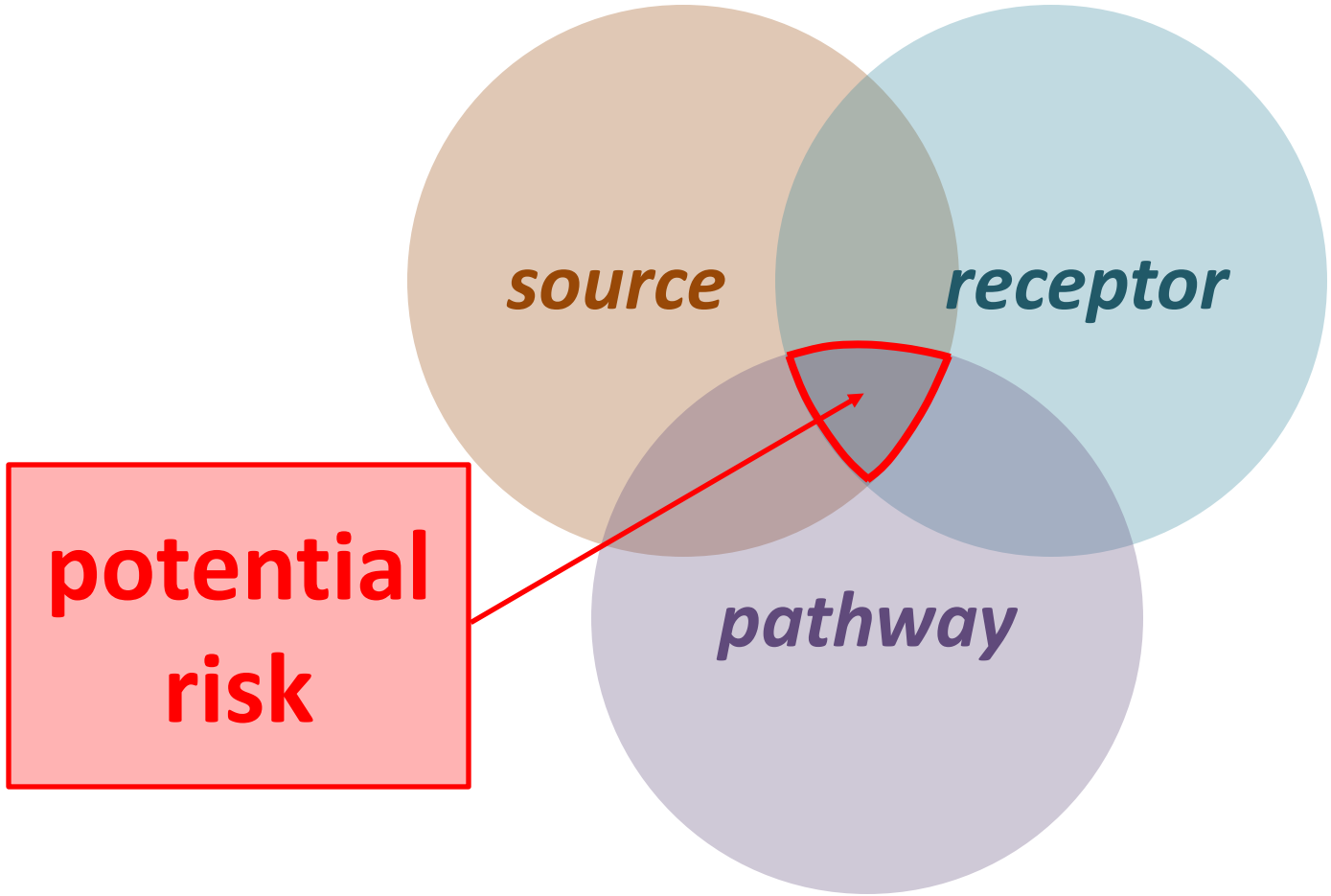
Is water quality at risk?




source
(a release of a hazardous compound)
receptor
pathway


source
(release of a hazardous compound)
receptor
(humans using groundwater supply)
pathway


source
(release of a hazardous compound)
receptor
(humans using groundwater supply)
pathway
(transport of hazardous compound to receptor)


source
receptor
pathway
potential risk

Possible and Probable Pathways

- Surface spills
  - possible surface water contamination
  - possible groundwater contamination
  - remediation – sometimes prompt, sometimes not
  - Weld County, July 2010-June 2011
    - 77 spills involving benzene, toluene, ethylbenzene, xylenes
    - 84% remediated by May 2012

Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations

Sherilyn A. Gross,[1,*] Heather J. Avens,[1] Amber M. Banducci,[1] Jennifer Sahmel,[1] Julie M. Panko,[2] and Brooke E. Tvermoes[1]
[1]*ChemRisk LLC, Boulder, Colorado, USA*
[2]*ChemRisk LLC, Pittsburgh, Pennsylvania, USA*

Journal of the Air & Waste Management Association, 63(4):424–432, 2013. ISSN: 1096-2247 print
DOI: 10.1080/10962247.2012.759166

Possible and Probable Pathways

- Probability of surface spills

$$V_{spill} = P_{spill} \times f_{fluids\,spilled} \times V_{fluids\,on\,site}$$

  - P_{spill} : probability of a spill – 0.1 to 0.5
    - frequency of spills (all known and reported?)
    - number of sites (active or total?)
  - $f_{fluids\,spilled}$: fraction of fluid spilled – 0.0001 to 1
    - reported volume of spills

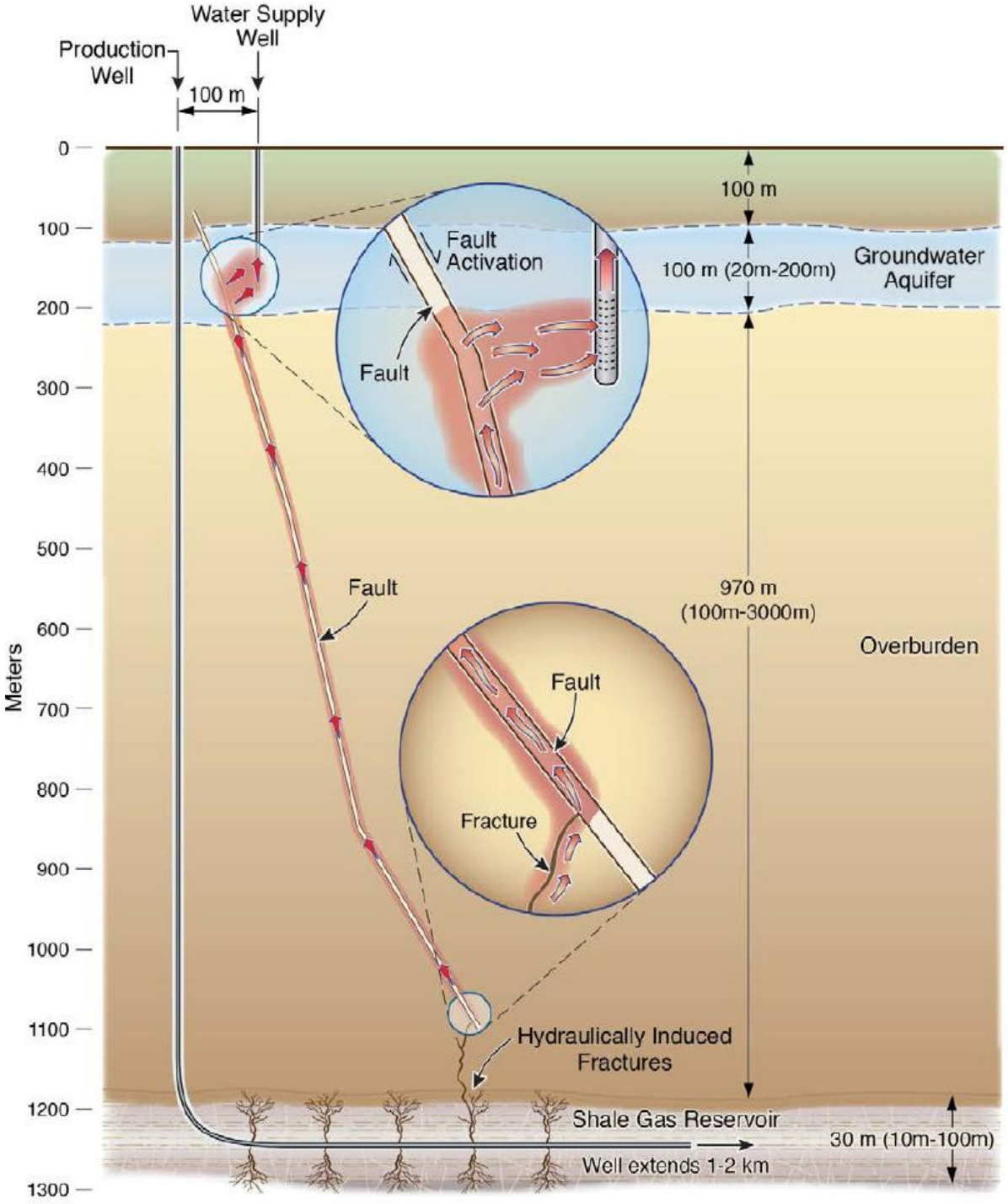
Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale

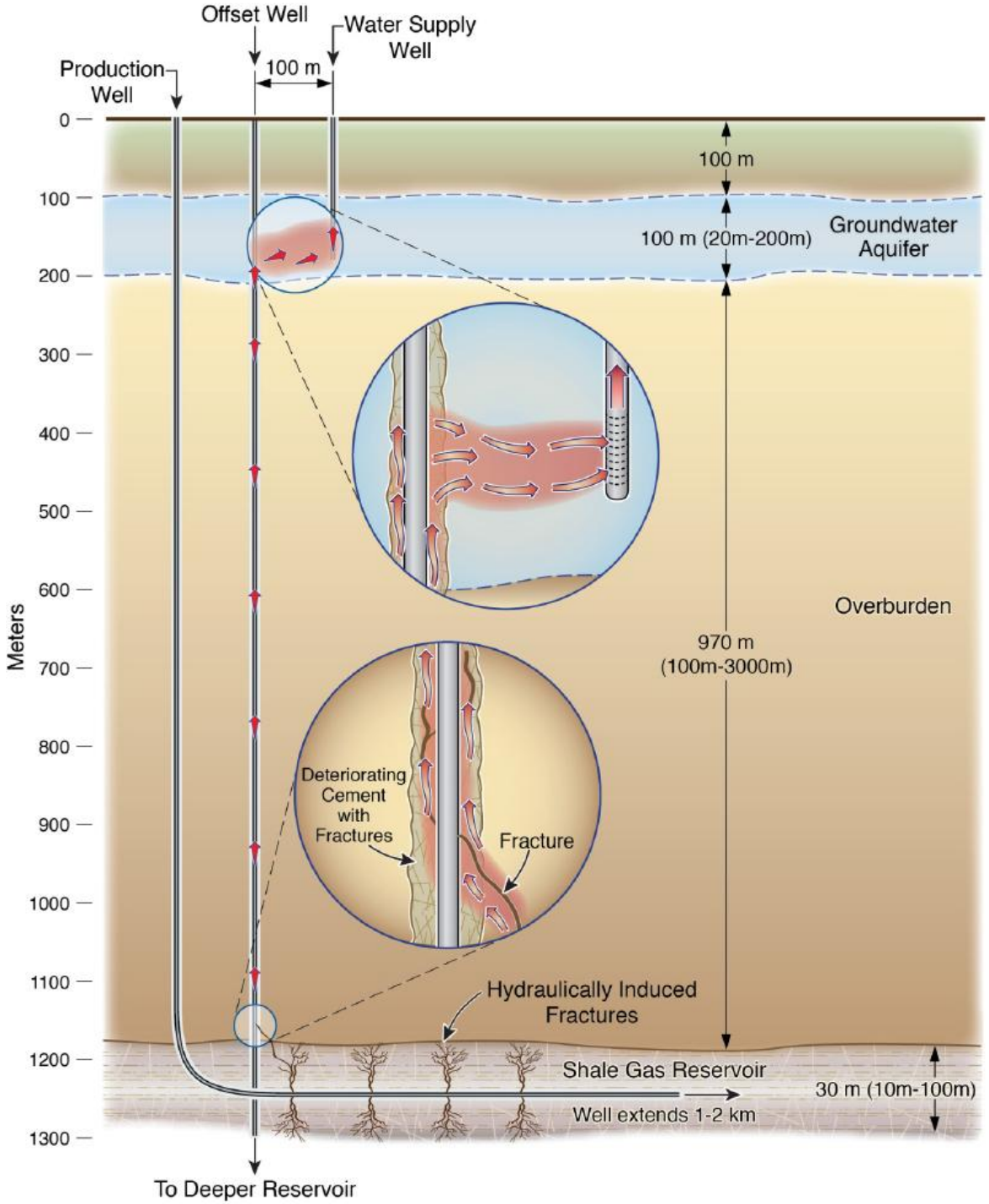
Risk Analysis, Vol. 32, No. 8, 2012

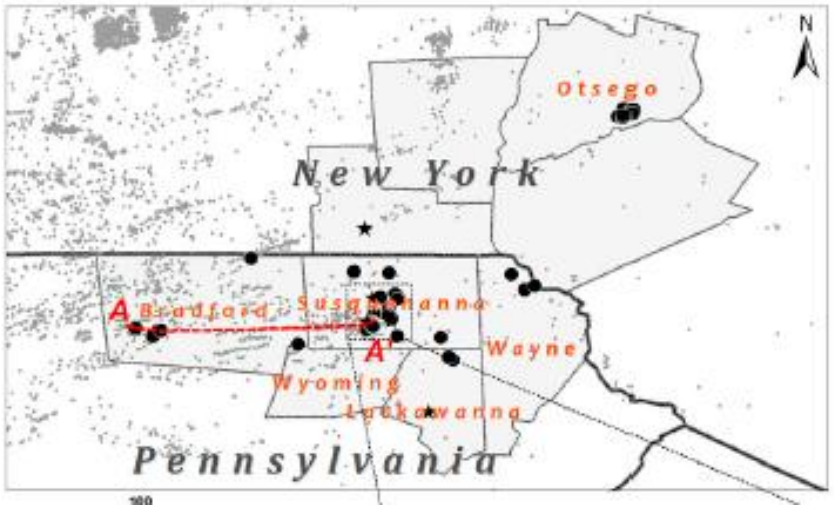
Daniel J. Rozell* and Sheldon J. Reaven[1]

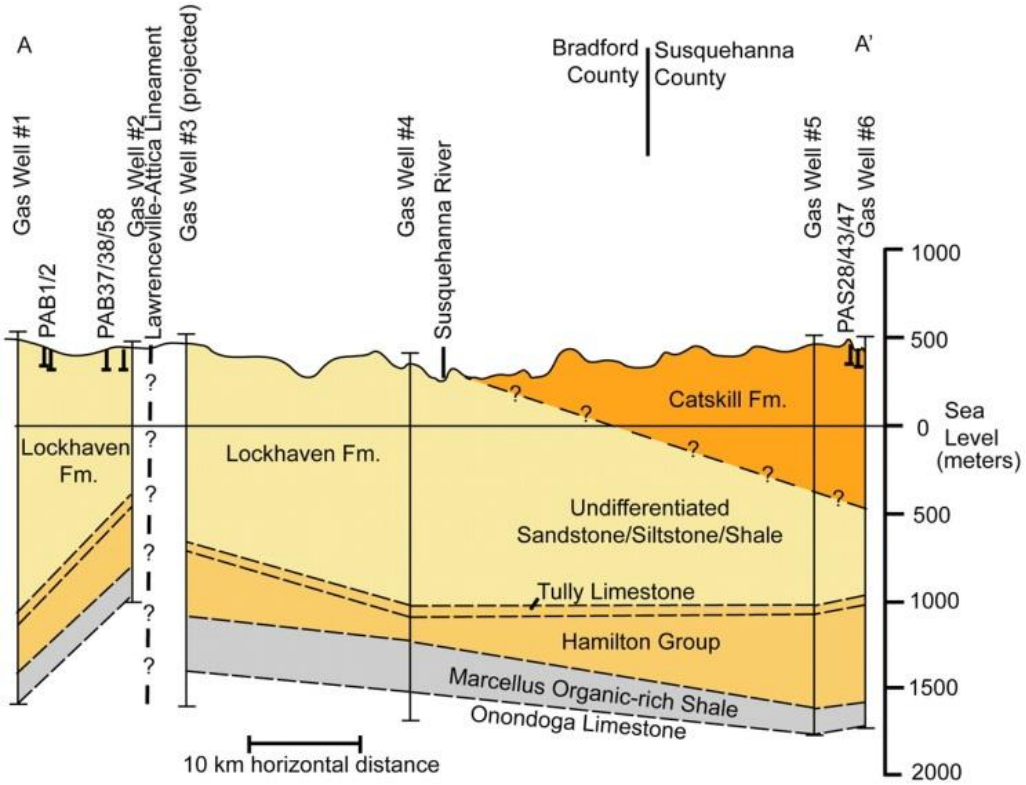
Possible and Probable Pathways

- Subsurface releases
  - possible groundwater contamination
  - scenarios
    - well casing integrity
    - abandoned wells
    - existing faults and fractures
    - etc.
  - groundwater flow and transport modeling
    - EPA
    - AWG SRN
  - groundwater sampling


Water Supply Well
Production Well
100 m
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Meters
100 m
100 m (20m-200m)
Groundwater Aquifer
Fault Activation
Fault
Fault
970 m (100m-3000m)
Overburden
Fault
Fracture
Hydraulically Induced Fractures
Shale Gas Reservoir
Well extends 1-2 km
30 m (10m-100m)


Offset Well
Water Supply Well
Production Well
100 m
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Meters
100 m
100 m (20m-200m)
Groundwater Aquifer
Overburden
970 m
(100m-3000m)
Deteriorating Cement with Fractures
Fracture
Hydraulically Induced Fractures
Shale Gas Reservoir
30 m (10m-100m)
Well extends 1-2 km
To Deeper Reservoir

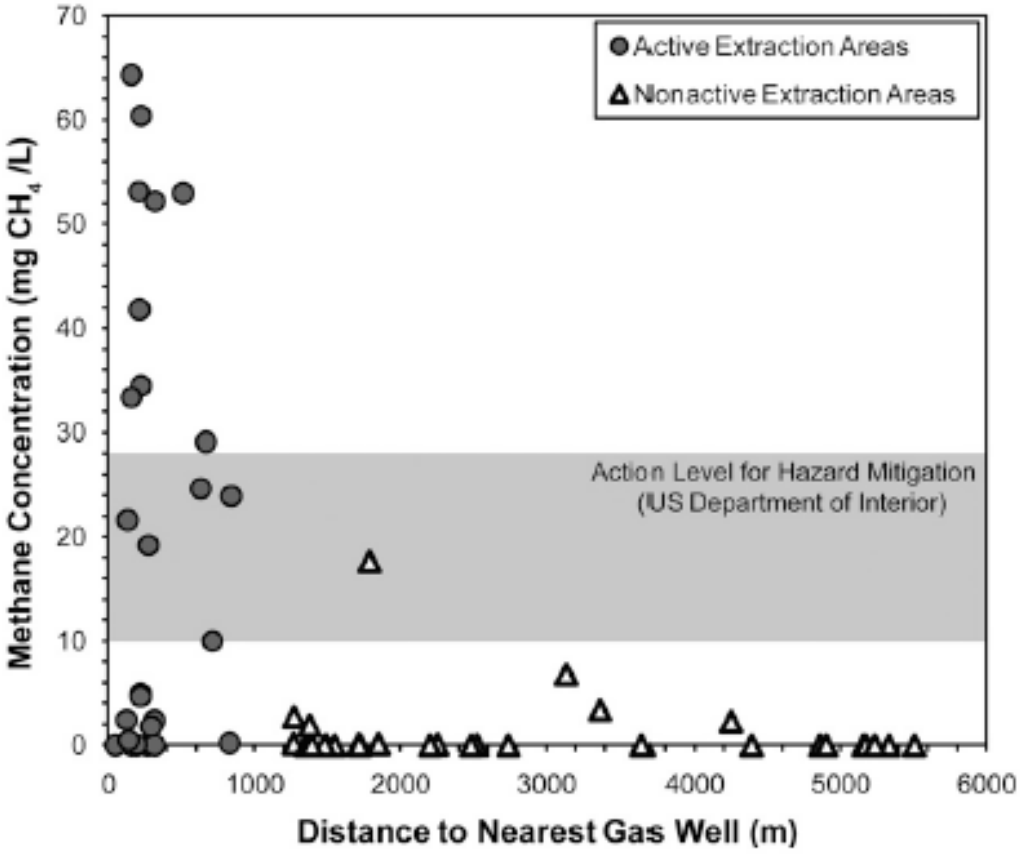


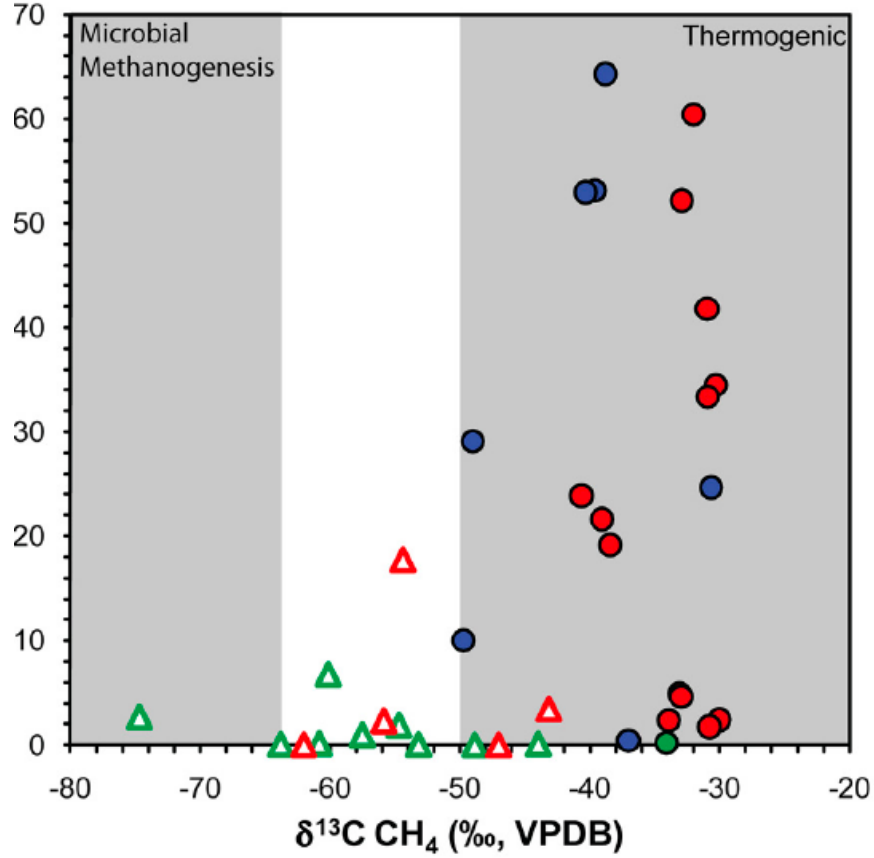


Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing

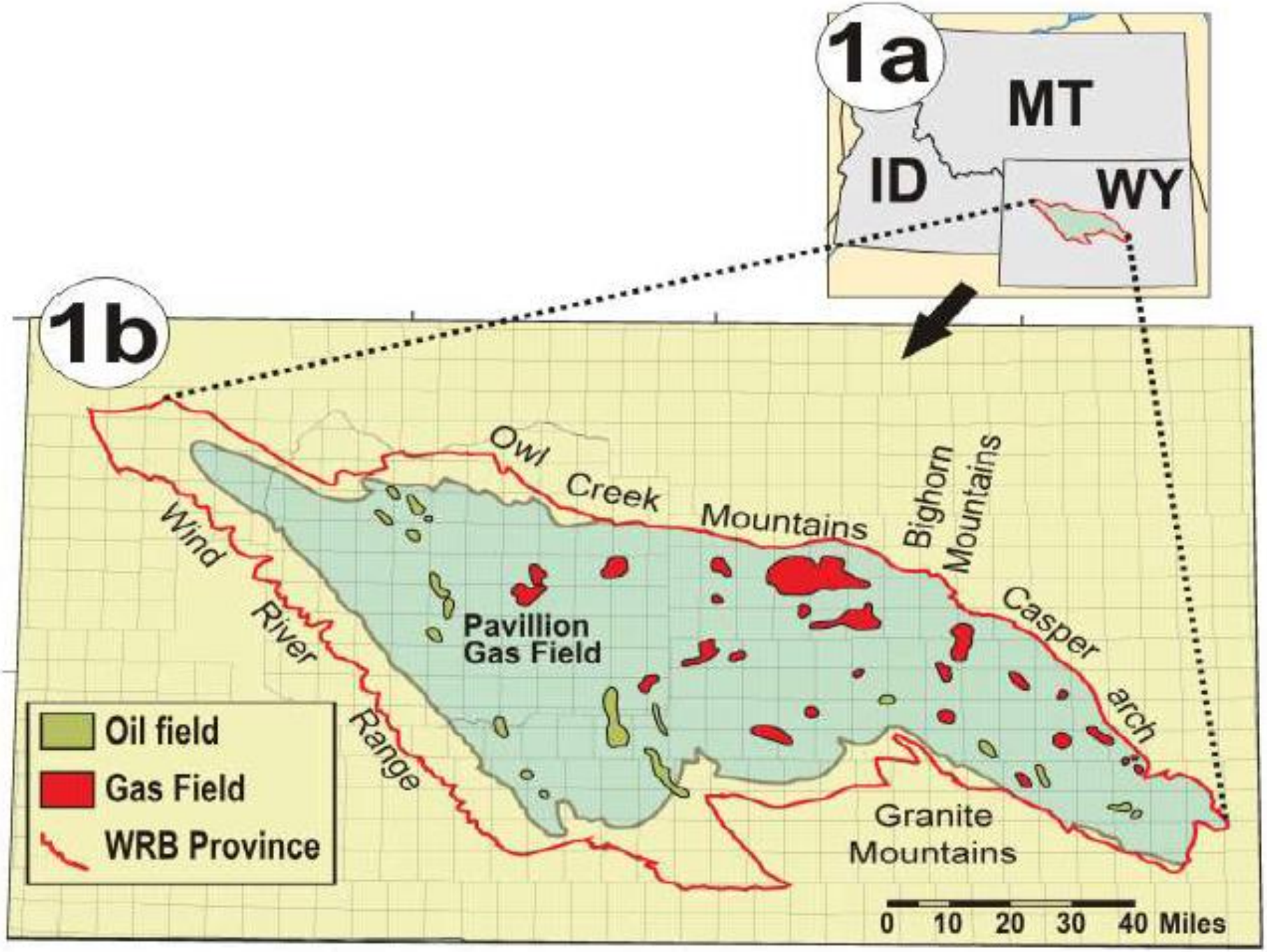
Stephen G. Osborn[a], Avner Vengosh[b], Nathaniel R. Warner[b], and Robert B. Jackson[a,b,c,1]

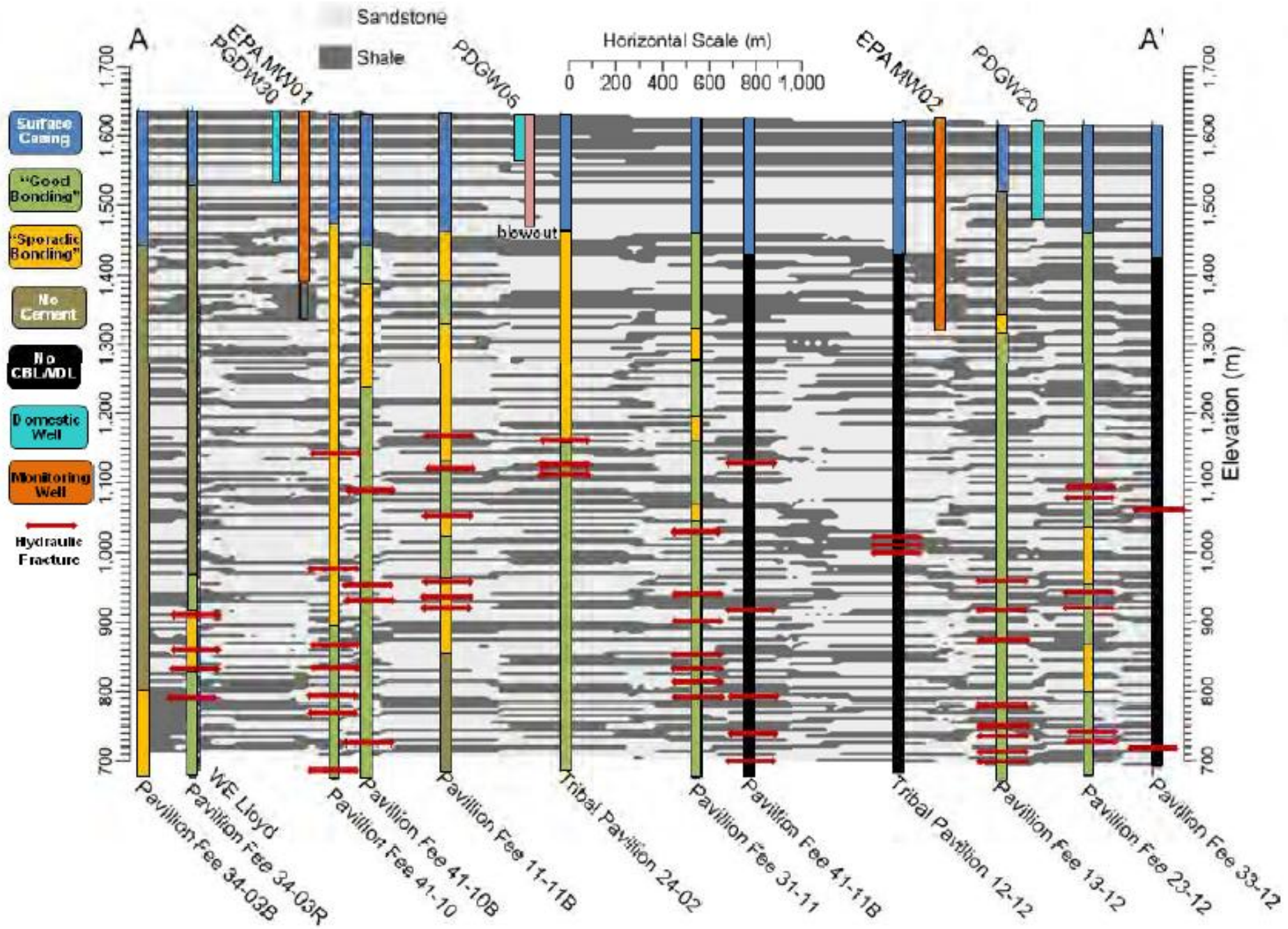
[a]Center on Global Change, Nicholas School of the Environment, [b]Division of Earth and Ocean Sciences, Nicholas School of the Environment, and [c]Biology Department, Duke University, Durham, NC 27708

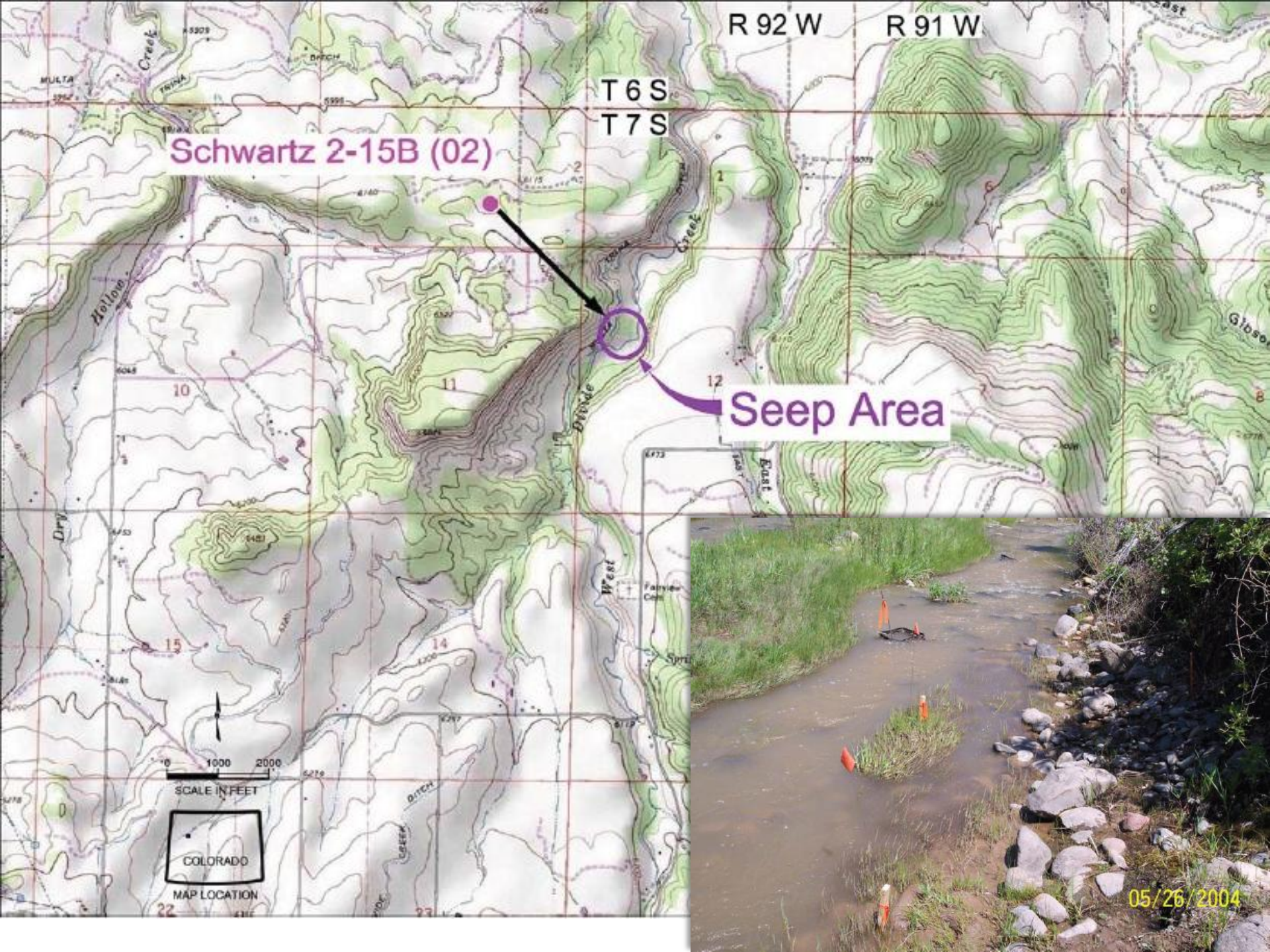


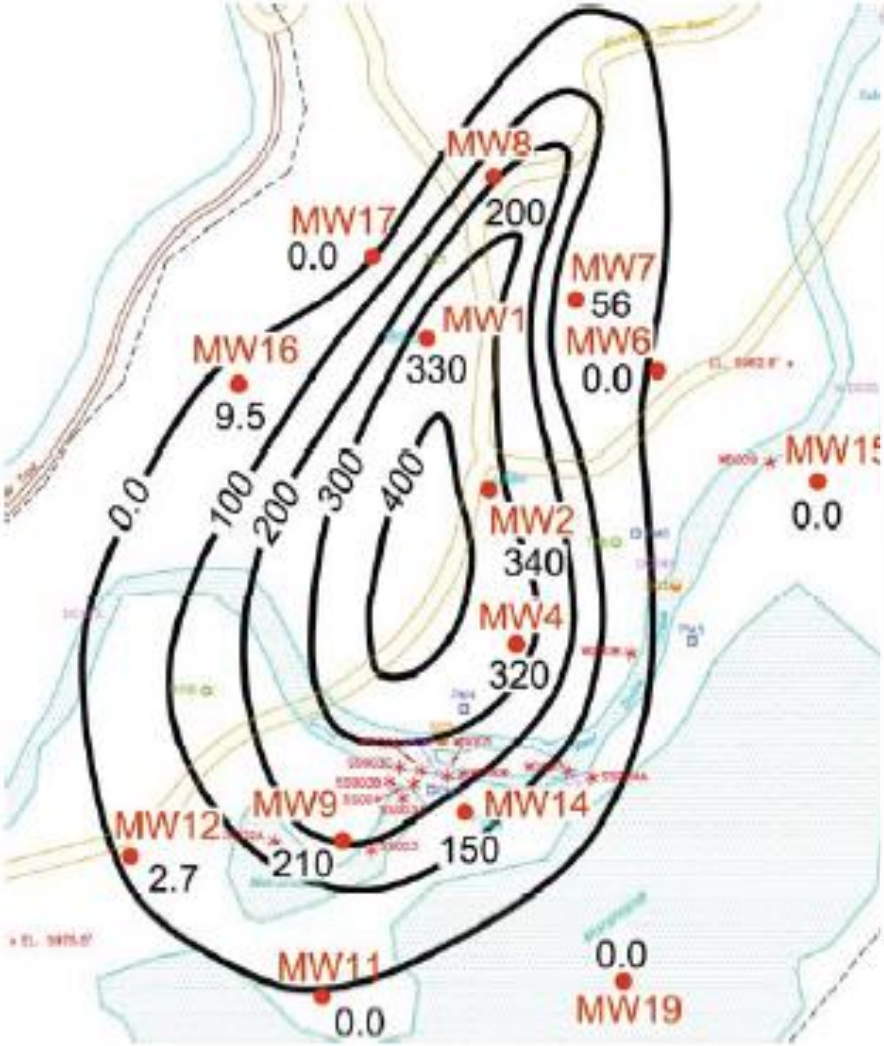


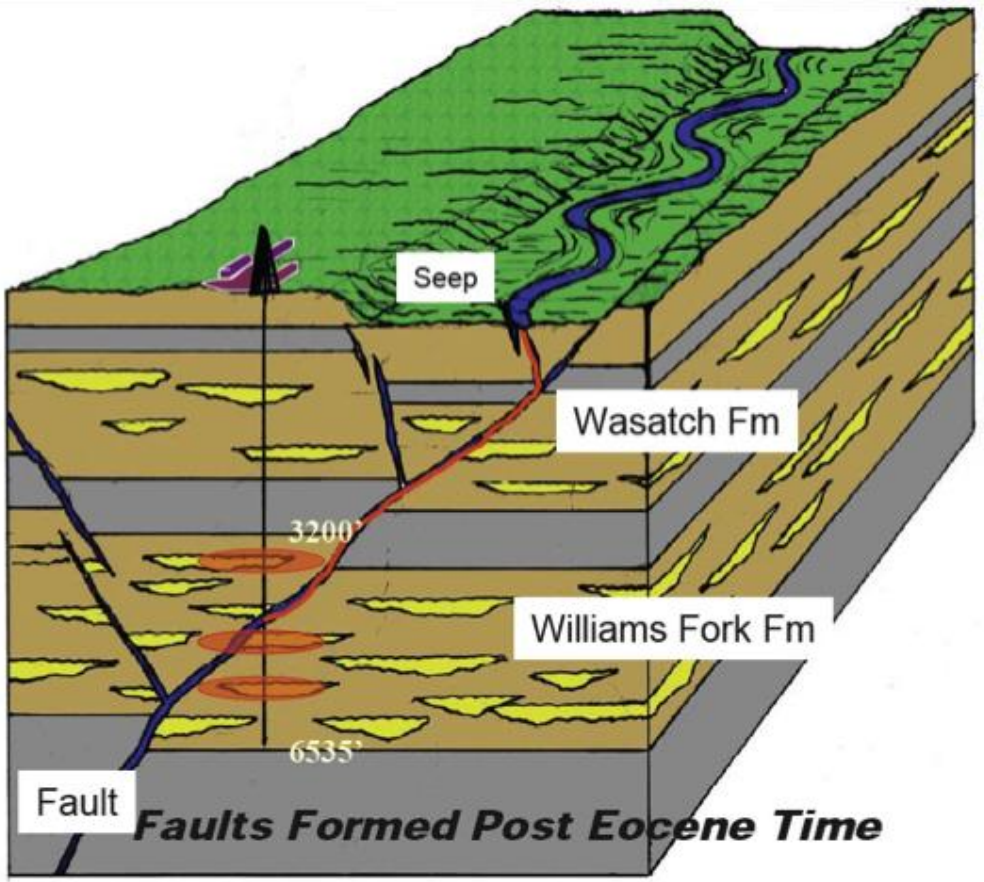
Osborn et al., 2011. *Proc. Natl. Acad. Sci.* **108**(20), 8172-8176

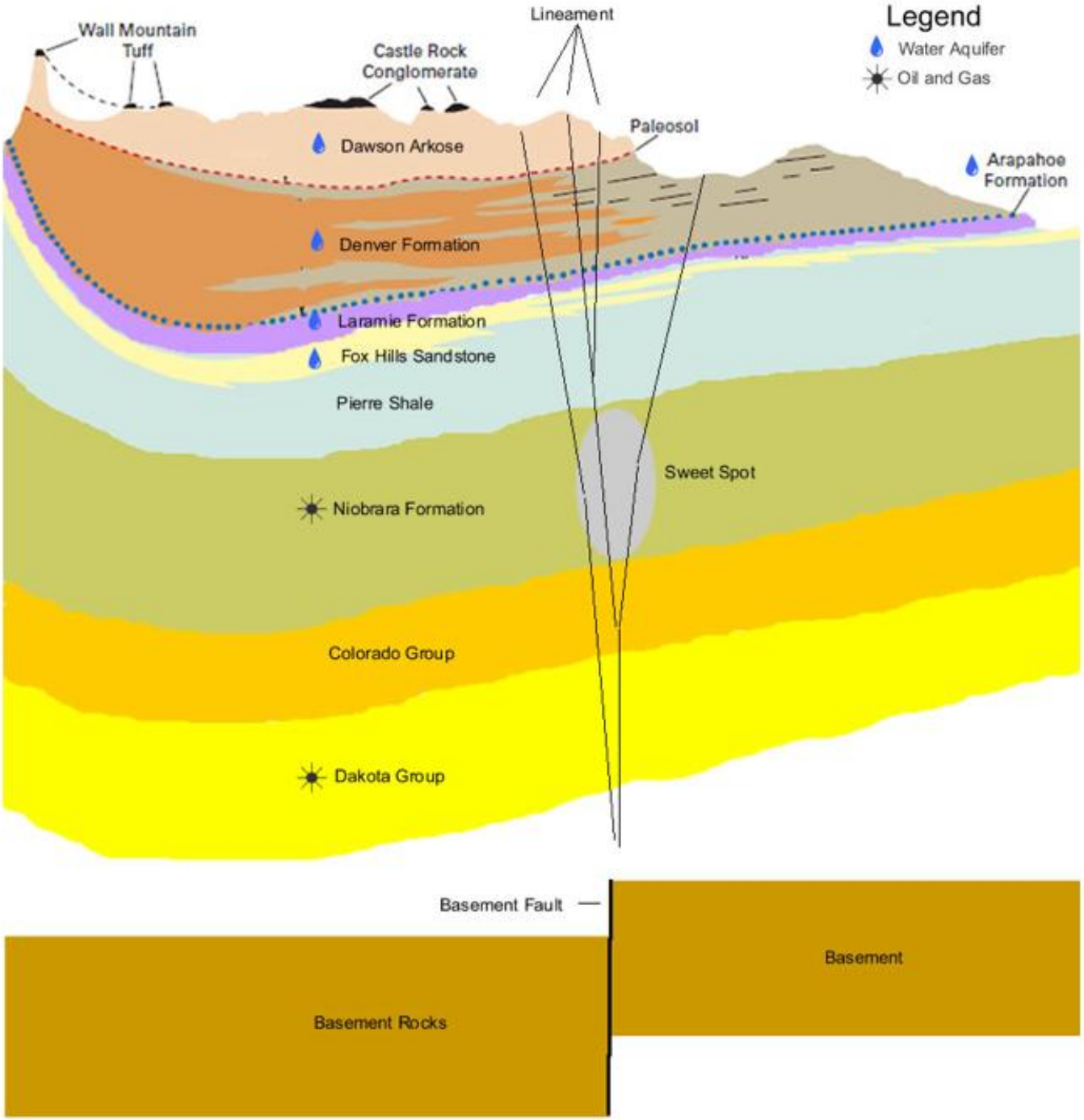

1a
MT
ID
WY
1b
Owl Creek Mountains
Bighorn Mountains
Casper arch
Wind River Range
Pavillion Gas Field
Granite Mountains
Oil field
Gas Field
WRB Province
0 10 20 30 40 Miles


A
A'
Sandstone
Shale
Horizontal Scale (m)
0 200 400 600 800 1,000
Elevation (m)
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
Surface Casing
"Good Bonding"
"Sporadic Bonding"
No Cement
No CBL/MDL
Domestic Well
Monitoring Well
Hydraulic Fracture
EPA MW01
PGDW30
PDGW05
EPA MW02
PDGW20
blowout
Pavillion Fee 34-03B
WE Lloyd
Pavillion Fee 34-03R
Pavillion Fee 41-10
Pavillion Fee 41-10B
Pavillion Fee 11-11B
Tribal Pavillion 24-02
Pavillion Fee 31-11
Pavillion Fee 41-11B
Tribal Pavillion 12-12
Pavillion Fee 13-12
Pavillion Fee 23-12
Pavillion Fee 33-12


R 92 W
R 91 W
T 6 S
T 7 S
Schwartz 2-15B (02)
Seep Area
SCALE IN FEET
0
1000
2000
COLORADO
MAP LOCATION
05/26/2004


MW8
200
MW17
0.0
MW7
56
MW1
330
MW6
0.0
MW16
9.5
MW15
0.0
0.0
100
200
300
400
MW2
340
MW4
320
MW12
2.7
MW9
210
MW14
150
MW11
0.0
0.0
MW19


Seep
Wasatch Fm
3200'
Williams Fork Fm
6535'
Fault
Faults Formed Post Eocene Time



www.niobraranews.net/geology/

Possible and Probable Pathways

- Probability of subsurface release by well failure

$$V_{release} = P_{well\ failure} \times f_{fluids\ released} \times V_{fluids\ injected}$$

  - $P_{well\ failure}$: probability of casing failure – 10^{-8} to 0.02
    - what is failure?
    - how to measure failure?
  - $f_{fluids\ released}$: fraction of fluid released – 10^{-6} to 0.1
    - what is the severity of the failure?

Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale

Risk Analysis, Vol. 32, No. 8, 2012

Daniel J. Rozell* and Sheldon J. Reaven[1]

Possible and Probable Pathways

- Probability of subsurface release by fractures

$$V_{release} = P_{fractures} \times f_{fluids\,released} \times V_{fluids\,injected} \left(1 - f_{returned}\right)$$

  - $P_{fractures}$: probability of fractures as pathway
    - 10^{-6} to 0.1
      - need more data, field and modeling!

Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale

Risk Analysis, Vol. 32, No. 8, 2012

Daniel J. Rozell* and Sheldon J. Reaven[1]

“Will I be able to drink the water from my well?”

“Will I be able to drink the water from my well?”

“The probability that your well will be contaminated is somewhere between 0.55 and 10,350 in a million.”

“Will I be able to drink the water from my well?”

“Maybe.”