WATER INFORMATICS SCIENCE & ENGINEERING
EPSRC CENTRE FOR DOCTORAL TRAINING

EPSRC
Engineering and Physical Sciences Research Council

Assessing the risks to groundwater contamination from fracking in the UK: A probabilistic modelling approach

Olivia Milton-Thompson [a*], Diego E. Gomez [a], Akbar A. Javadi [a]
[a] Centre for Water Systems, Harrison Building, University of Exeter, EX4 4QF, United Kingdom

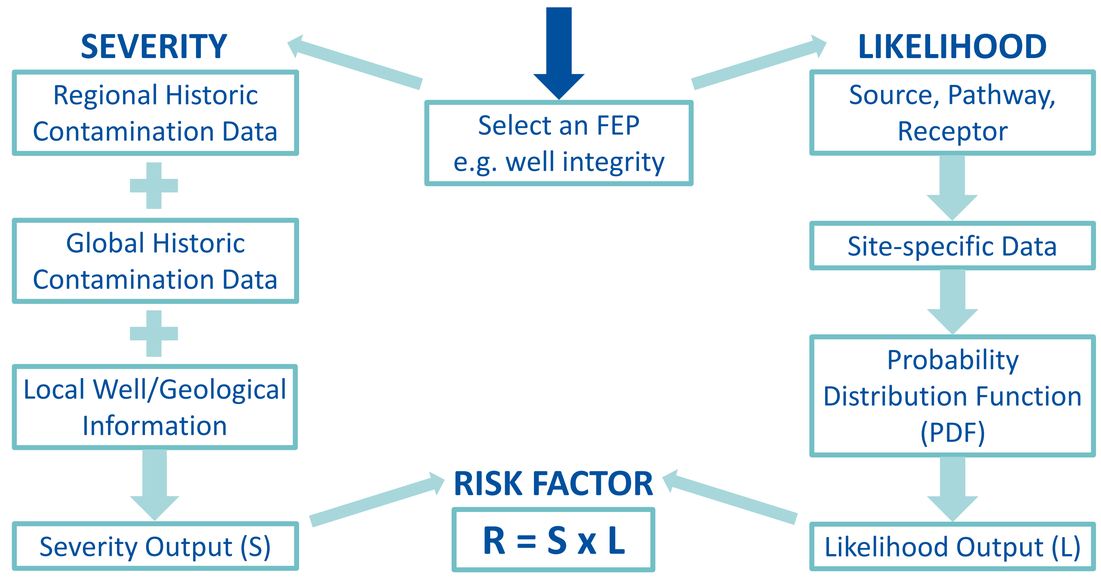
1. Introduction

Hydraulic fracturing is an established technology which has been used across the world and is now considered in the UK as a viable method for extracting natural gas from shale rock. However, the fracturing of shale is a controversial topic due to its uncertainty on the effects of the environment. In the USA, hydraulic fracturing has caused issues regarding groundwater contamination from methane[1-3], flowback[4-5] and chemicals[6] via different potential contaminant pathways during the process[7]. Aquifers are vital groundwater resources for freshwater for the population and the fracturing procedure has elevated concerns over the contamination of these aquifers.

Main Objectives:

- Consider different **contamination pathways** for gas and fluid flow reaching **aquifers**.
- Develop a **Features, Events and Processes (FEP)** method to highlight pathways.
- **Severity and likelihood** of the selected FEP are calculated to obtain a **risk factor** of the FEP occurring[8].
- Vary **geological parameters** to apply to any area in the **UK**.

2. Methodology



3. Conceptual Model

Analysis of **literature** and development of the **conceptual mode**l (Fig. 1) highlighted a **leaking well** to be a large concern during hydraulic fracturing[9].

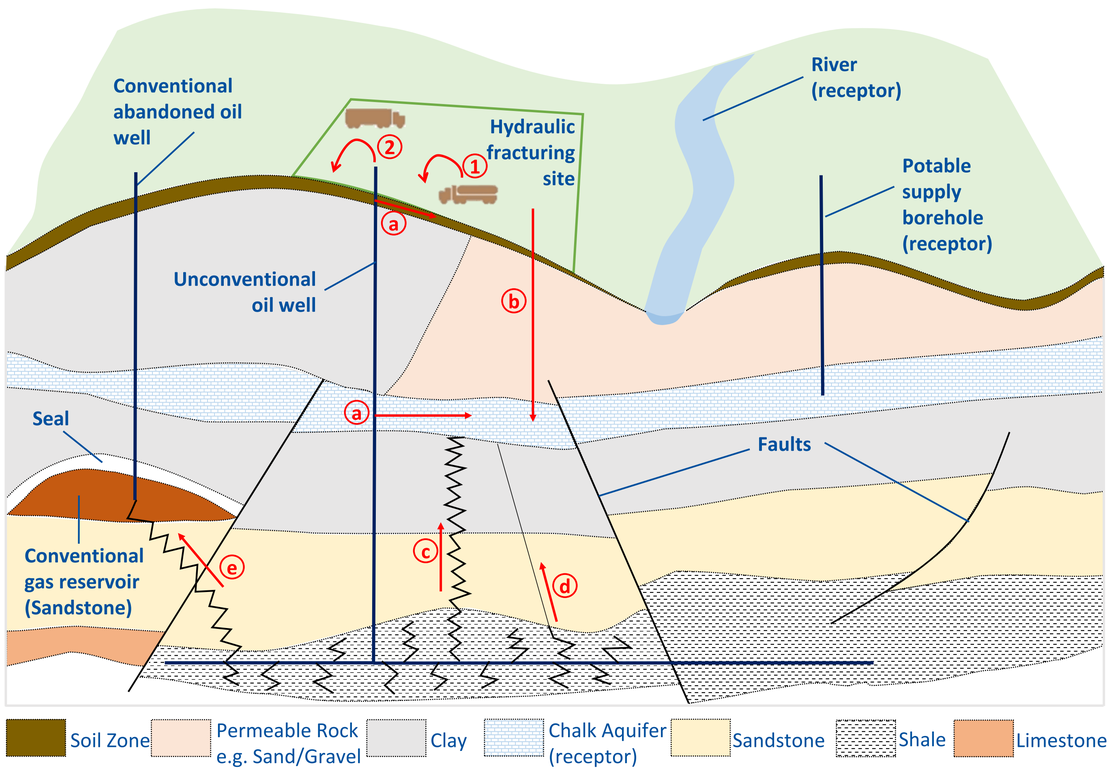
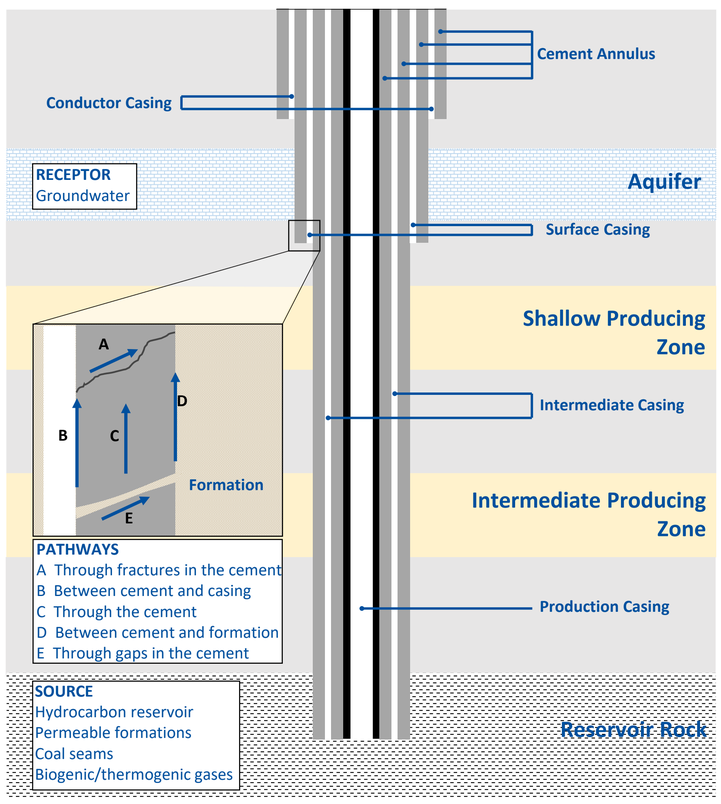


Fig. 1 A conceptual model indicating the main potential contaminant pathways reaching groundwater from a hydraulic fracturing site. The letters correspond to individual contaminant pathways: a) well casing failure, b) infiltration, c) fracture propagation, d) natural fracture connection, e) connection with old oil wells. The numbers correspond to spills on site: 1) chemicals spills, 2) returned flowback/produced water spills from wells.

4. Well Integrity



- **Well integrity** was selected as the first FEP to assess risk to groundwater.
- **Source**, **pathways** and **receptors** were highlighted (Fig. 2).

Fig. 2 A standard well construction for hydraulic fracturing. A-E represent potential pathways for gas migration from different sources to groundwater due to poor well integrity[10].

Case Study Data:

- Data outside the UK can be used to calibrate the model provided practices are similar.
- Conventional and unconventional well data between **2009-2014** in **Pennsylvania**, USA was analysed.
- Code violations linked to **well integrity violations** were filtered and combined to give **seven categories** based on poor drilling practices (Fig. 3).

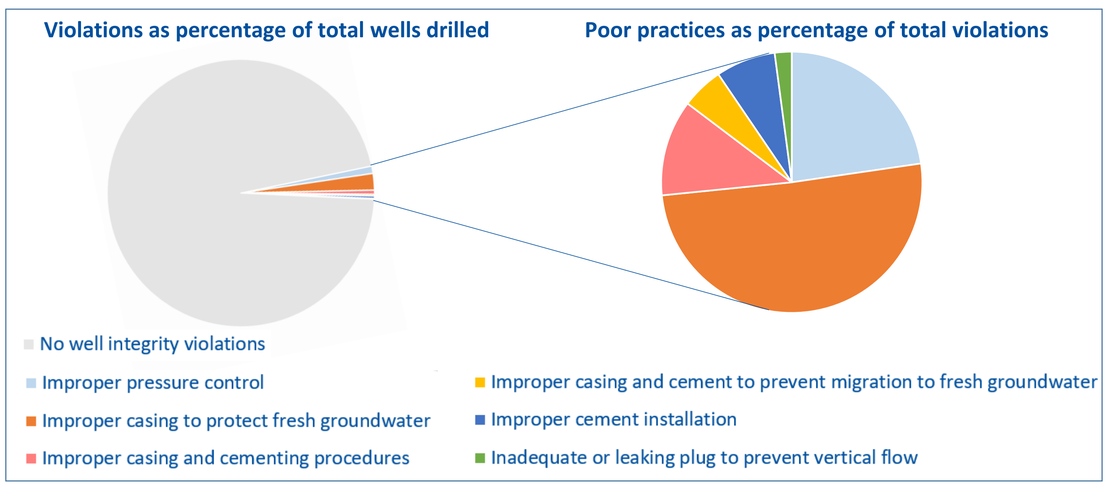


Fig. 3 Data illustrating well violations occurring in Pennsylvania between 2009-2014.

5. Future Work

- Collect **data** on well integrity and **well violations** in the **UK**.
- Obtain **regional** and **global historic data** on well integrity in the **UK** for severity calculations.
- Develop a simple **numerical model** to quantify the **severity** of well violations.
- Create a **probability distribution function** on the frequency of **gas migration pathways** occurring in wells.
- Develop an **integrated assessment model** to quantify all FEPs to obtain an **overall risk to contamination** in varying geological conditions of the **UK**.

References

[1] Jackson, R.B. et al., 2013. Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *Proc. Natl. Acad. Sci. USA*, 110(28), pp.11250–11255.
[2] Molofsky, L.J. et al., 2013. Evaluation of Methane Sources in Groundwater in Northeastern Pennsylvania. *Ground Water*, 51(3), pp.333–349.
[3] Osborn, S.G. et al., 2011. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc. Natl. Acad. Sci. USA,* 108(20), pp.8172–8176.
[4] Haluszczak, L.O., Rose, A.W. & Kump, L.R., 2013. Geochemical evaluation of flowback brine from Marcellus gas wells in Pennsylvania, USA. *Applied Geochemistry*, 28, pp.55–61.
[5] Warner, N.R. et al., 2012. From the Cover: Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania. *Proc. Natl. Acad. Sci.*, 109(30), pp.11961–11966.
[6] Gordalla, B.C., Ewers, U. & Frimmel, F.H., 2013. Hydraulic fracturing: A toxicological threat for groundwater and drinking-water? *Environmental Earth Sciences*, 70(8), pp.3875–3893.
[7] Ward, R.S., Stuart, M.E. & Bloomfield, J.P., 2015. The hydrogeological aspects of shale gas extraction in the UK. In R. M. Hester, R.E.; Harrison, ed. *Fracking*. RSC, pp. 137–141.
[8] Ayash, S.C. et al., 2009. Probabilistic approach to evaluating seismicity in CO_2 storage risk assessment. *Energy Procedia*, 1, pp. 2487-2494.
[9] Davies, R.J. et al., 2014. Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation. *Marine and Petroleum Geology*, 56, pp. 239-254.
[10] Vidic, R.D. et al., 2013. Impact of Shale Gas Development on Regional Water Quality. *Science*, 340, pp. 1235009.

*Corresponding author
Olivia Milton-Thompson
PhD Researcher
University of Exeter
om271@exeter.ac.uk

www.wisecdt.org