

From: Paul Younger
Sent: 14 November 2014 16:10
To: Robert Westaway
Subject: RE: fracking

Excellent Rob

I just corrected one typo in the first sentence and added a few words here or there. I presume you will send it to her?

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From: Robert Westaway
Sent: 14 November 2014 15:59
To: Paul Younger
Subject: RE: fracking

Paul

How is this for a reply?

Our paper was primarily about the strength of induced ground vibrations caused by fracking. The two issues that you raise are rather peripheral to this central aim. We shall, however, deal with these issues individually.

First, Greenpeace have claimed on their website that there is an error in our paper insofar as we stated that disposal of wastewater underground is illegal in the UK (and, indeed, throughout the EU). They argue that injection of water into boreholes for the purpose of enhanced oil recovery is the same thing as subsurface disposal of wastewater. Greenpeace in fact put this point to us on Tuesday and I spent part of Wednesday morning composing a response, which the University Press Officer sent back to Greenpeace (pasted in below). This reply covers the legal situation in a way that is completely correct. It is disingenuous of them to propagate this misrepresentation, to say the least. It is apparent that Greenpeace have taken no notice of this reply whatsoever. Please feel free to quote from it, as you wish.

The second issue is the effect of induced seismicity on well integrity. We did not cover this topic explicitly in our paper, although there is implied coverage in the section that reports the fact that fracking should not be undertaken in places where faults are present that are larger than a specified size threshold. The formulae we have presented should make it easy for any developer – or objector – to calculate the maximum possible vibration at any point up the well resulting from induced earthquakes of a given magnitude. For example, the paper indicates that an induced earthquake circa magnitude 3 will produce ground vibrations at the Earth's surface that are comparable to the 10 mm/s limit allowable for quarry blasting. Working through the various equations in the paper, an earthquake of this size will involve slip on a fault plane with a radius of ~200 m, and the maximum slip at the midpoint of this fault will therefore be something like 20 cm. In order for the earthquake to be induced, this fault must lie within the region reached by the fracking fluid, and so can be no more than a few hundred metres from any of the fracking clusters where fluid is forced into the surrounding rock. The resulting 20 cm maximum offset of the borehole that might result might well be a problem for the shale gas developer, as it would impair production. However, it should be noted that casing and cement seals have to be pressure-tested to ensure they equal or exceed the surface gas containment devices (which in turn are rated according to worst-case-scenario 'gas kicks' in the well – which are far more relevant to conventional gas reservoirs than to unconventional ones). Thus damage to a low part of the casing does not mean that the cement seal will be compromised throughout the well depth: the higher reaches of the borehole within the required exclusion zone with respect to aquifers would be highly unlikely to be compromised, so no harm to the public would be likely to result.

It should be clear that we consider it essential that potential fracking sites are surveyed in advance (using seismic reflection) to exclude the possibility that any large faults are present, which might reach to much shallower depths than the depth at which the fracking would take place. We did not make any recommendation as to what is the critical size limit of fault that is allowable within any fracking project area, because this is not our field of expertise; however, it is clear that it should be no greater than a few hundred metres at most. A specialist who knows more about this topic than we do is [REDACTED] Strathclyde University, who works specifically on this aspect; some of her publications have been cited. As we stated in our paper, there is a trade-off between the cost of carrying out more detailed seismic surveys to exclude the presence of faults down to smaller sizes and the potential cost of the risk of not spotting them, such as the occurrence of induced earthquakes that might be a significant nuisance to the public and/or might damage parts of boreholes close to the depth of fracking.

I hope this e-mail clarifies the situation. As always, I am happy to answer any further questions that you might have.

Best wishes, Rob Westaway

Dr Rob Westaway
Senior Research Fellow

From: Ross Barker
Sent: 12 November 2014 09:37
To: [REDACTED]
Subject: RE: Re-injection

Hi [REDACTED] –

Please find below a joint response from Dr Westaway and Professor Younger.

Hope it helps – let me know if there's anything else you need.

The enquirer is mixing up injection of water into the ground for the purpose of hydraulic fracturing and subsurface disposal of wastewater.

Disposal of wastewater is regulated by the EU Water framework directive (European Union, 2000. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF) which has been incorporated into law for the various UK legal jurisdictions. Among other things, it forbids subsurface disposal of wastewater. This point has been noted before, for example here: Mair, R., Bickle, M., Goodman, D., Koppelman, B., Roberts, J., Selley, R., Shipton, Z., Thomas, H., Walker, A., Woods, E., & Younger, P.L., 2012, Shale gas extraction in the UK: a review of hydraulic fracturing. Report to the UK Government Chief Scientist. Royal Society and Royal Academy of Engineering, London. 76 pp. Available online: http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/projects/shale-gas/2012-06-28-Shale-gas.pdf

As the enquirer has indicated, hydraulic fracturing (as has indeed been carried out at Wytch Farm for enhanced oil recovery and at many other sites in the UK, both onshore and offshore, on many occasions over the past three decades or so) is permitted, subject to the granting of appropriate environmental permits. After a typical hydraulic fracturing operation, most of the water that was injected returns to the surface. Some of it does not, which is why this water must be 'clean', containing only substances permitted for use in hydraulic fracturing. There is thus a fundamental difference here compared with the deliberate disposal of wastewater in the subsurface.

DECC recently issued regulatory guidance to cover this aspect of fracking for shale gas (DECC 2014. Fracking UK shale: water. Department of Energy and Climate Change, 8 pp. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/277211/Water.pdf). This explains that when the used fracking fluid returns to the surface it must be stored temporarily in closed tanks before treatment. Once treated, it can be reused for more fracking operations or disposed of in a limited number of permitted ways that are listed individually.

When reading UK legal guidance documents such as this, it should always be kept in mind that options that are not permitted, such as subsurface disposal in this case, are not mentioned at all. It would possibly be clearer if options that were not permitted were listed explicitly, but that would be against precedent in this country.

The summary of this topic in our recent paper is therefore correct. I hope this note helps to clarify the situation.

Best regards,
Ross

Ross Barker
Media Relations Officer

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From: Paul Younger
Sent: 13 November 2014 19:19
To: [REDACTED]
Cc: Robert Westaway
Subject: RE: fracking

Dear [REDACTED]

Rob and I have been busy all day with visitors, but we would hope to get some comments to you tomorrow.

Best wishes

Paul Younger

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Professor of Energy Engineering
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From: [REDACTED] [[mailto:\[REDACTED\]@telegraph.co.uk](mailto:[REDACTED]@telegraph.co.uk)]
Sent: 13 November 2014 13:46
To: Paul Younger
Subject: fracking

Dear Paul,

This Greenpeace blog (<http://www.greenpeace.org.uk/newsdesk/energy/news/factcheck-are-uk-fracking-regulations-earthquakes-ridiculous>) raises a couple of interesting points, and I wondered your response?

- 1) that the magnitude of the tremor matters because of potential to affect well integrity rather than surface effects
- 2) that re-injection processes may take place that cause greater tremors.

Would love to hear your thoughts if you have time

thanks and best wishes

[REDACTED]

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