Shale Gas

North West - Monitoring of Flow back water

3rd November 2011

Results

The Bowland Shale rock formation in Lancashire is a potential source of unconventional shale gas and is described by the British Geological Society as offering the best potential in the UK.

Cuadrilla Resources are licensed by the Department of Energy and Climate Change to explore in this area. They have permission to drill up to five exploratory wells. They have drilled two and are currently drilling a third. One of these has progressed to hydraulic fracturing - Preese Hall.

Environmental regulation

Our role is to help ensure that the environment is protected from the potential impacts of exploration and this includes ensuring that the disposal of the “flow back” water from the exploratory wells is managed properly.

What is flow back water?

Some of the water that is injected in to the shale rock during hydraulic fracturing returns to the surface through the drilled well. This is often called the “flow back” water. Typically around a quarter of the water injected will return to the surface over a period of weeks to a few months. This flow back water is very saline, and contains minerals dissolved from the rocks as well as small particles of the rock.

Because the water has a high mineral content it has to be disposed of carefully, with the appropriate permits granted, where necessary, for the chosen disposal route.

What analysis did we do and what did we find?

We took samples of the flowback fluid and sent them to our own laboratories for analysis.

All of the chemicals found are those which we would expect to find in shale rock and are naturally occurring.

There are notably high levels of sodium, chloride, bromide and iron, as well as higher values of lead, magnesium and zinc compared with the local mains water that is used for injecting into the shale.

Analysis for us by other laboratories showed that they also contained very low levels of naturally radioactive minerals - similar to the levels found in granite rock.

Where does the flow back water go?

The flow back water produced to date from the Preese Hall exploration site has been stored in double skinned tanks on site. It was then transported to a waste water treatment works at Davyhulme .

The waste water treatment works already treats many other industrial effluents from the Manchester area and holds a permit from the Environment Agency to discharge to the Manchester Ship Canal. It is capable of dealing with the levels of minerals contained in the flow back water.

Do they need a permit?

On 1 October 2011, new limits were specified in Schedule 23 of the Environmental Permitting Regulations 2010. This supersedes previous limits. Cuadrilla want to continue disposing of these fluids to the waste water treatment works. A permit is now required as the levels measured combined with the expected quantities of flow back water exceed new limits. We have told them that they need to apply to us for a permit and provide us with more information so we can assess their proposal.

What is happening to the flow back fluid now?

Currently the flow back water is being stored in double skinned tanks on site pending a permit application.

Appendix 1 A comparison of the mineralisation of this water with other waters

Different water sources have different levels of these chemicals. Below is a table to give an indication of how the maximum levels in the flow back waters compare to those in other water sources.

	Sea Water (grams per litre)	The Dead Sea (grams per litre)	Flow Back Water (grams per litre)
Sodium	10.1	36.3	28.4
Chloride	19.4	230.4 (for chloride plus bromide)	75.0
Bromide			0.9
Magnesium	1.3	45.9	0.6
Potassium	0.4	7.8	0.05

Appendix 2: Table of Environment Agency dissolved salts sample analysis

Notes to support table

- Mains water with small amounts of additives are injected into the exploratory well - this is the fracking fluid.

- As a comparison we are using the figures for the water from United Utilities in the detailed table (below). It is a typical analysis for mains tap water in the Singleton area. (sourced from United Utilities web pages).

- The variation between this and the flow back analysis indicates the minerals which have been taken from the shale formation during the fracking process.

- The analysis of the flowback water is reported in either micrograms per litre (µg/l), or milligrams per litre (mg/l). (Note 1 mg/l = 1000 µg/l). Filtered means filtered to remove solids.

SITE	**Cuadrilla Drill Rig**	**Cuadrilla Drill Rig**	**Cuadrilla Drill Rig**	**Cuadrilla Drill Rig**	**Cuadrilla Drill Rig**	**Mains water (from United Utilities web data) average concentration**
DATE	07/04/11	14/04/11	28/04/11	18/05/11	14/06/11	
TIME	13:20	13:30	11:10	14:00	09:55	
Conductivity at 25oC µs/cm	–	–	–	150614	133730	299
pH	–	–	–	6.35	7.06	7.54
Lead (filtered) µg/l	179	<20	<2	<40	<40	
Lead - as Pb µg/l	600	<10	<10	<40	44.9	<0.417
Mercury (filtered) µg/l	0.01	<0.01	0.013	<0.01	<0.01	
Mercury - Hg µg/l	0.024	<0.01	<0.01	<0.01	0.012	<0.0127
Cadmium (filtered) µg/l	0.674	<1	1.47	<2	<2	
Cadmium - Cd µg/l	1.29	<0.5	<0.5	<2	<1	<0.04
Bromide mg/l	–	–	242	854	608	<0.444
Chloride Ion mg/l	15400	34400	22200	75000	64300	13.5

Sodium (filtered) mg/l	7950	15100	9330	28400	>200	
Sodium - Na mg/l	no bottle	15100	9380	28400	23600	22.9
Potassium (filtered) mg/l	23.2	46.4	37.8	82.1	>20	
Potassium - K mg/l	28.8	52.3	40.6	–	–	
Magnesium (filtered) mg/l	177	>50	397	–	–	
Magnesium - Mg mg/l	no bottle	586	401	1470	1350	9.21
Phosphorus - P mg/l	1.28	0.0771	<0.02	<0.1	<0.5	
Chromium (filtered) µg/l	< 3	<5	0.565	28	<10	
Chromium - Cr µg/l	25	4.03	<3	20.5	53.9	<0.349
Zinc – (filtered) µg/l	297	<50	53.6	142	411	
Zinc - as Zn µg/l	565	51.5	<30	173	435	
Nickel – (filtered) µg/l	13.8	<10	21.5	<20	<20	
Nickel - Ni µg/l	20.3	<5	<5	<20	<20	1.20
Silver (filtered) µg/l	< 10	<5	<10	<20	<10	
Silver µg/l	–	–	<1	<20	<10	
Aluminium (filtered) µg/l	< 50	<100	<10	<200	<200	
Aluminium-Al µg/l	596	<50	<50	<200	<100	<8.04
Arsenic (filtered) µg/l	5.1	<1	<1	<1	<1	
Arsenic – As µg/l	6.2	<1	<1	1.2	2.6	0.309
Iron (filtered) µg/l	36600	82800	35800	70700	106000	
Iron - as Fe µg/l	66600	80700	51800	78600	112000	<7.62

Cobalt (filtered) µg/l	< 10	<5	<10	<20	13.3	
Cobalt µg/l	–	–	4.96	<20	<50	
Copper (filtered) µg/l	27.5	<10	12.4	36	<20	
Copper - Cu µg/l	936	8.04	<5	37.6	34.4	0.025
Nitrogen - N mg/l	10.7	52.5	33.4	98.8	77.8	
Vanadium - Filtered µg/l	< 20	<10	<20	<40	<20	
Vanadium - V µg/l	< 4	<10	<2	<40	<100	

Appendix 3: Environment Agency low level naturally occurring radioactivity sample analysis

We also sent samples to an external laboratory for an analysis of any radioactivity. The analysis showed the presence of naturally occurring radioactive materials (commonly called NORM) at levels similar to that in many rocks throughout the UK, granite being a common example.

Naturally occurring radioactive materials have been present in rocks since their formation, perhaps billions of years ago. All radioactive materials undergo decay to become more stable, eventually ceasing to be radioactive. Some radioactive materials decay over very long time periods and others more quickly, and so naturally occurring radioactive materials will contain many different radioactive isotopes in differing amounts. The radioactive materials with very long decay times are usually present in larger amounts. Commonly this is Radium 226.

The initial analysis of the flowback fluid has shown Radium 226 as the radioactive material present at the highest levels, between 14 and 90 Becquerel per litre. Other naturally occurring isotopes present included potassium-40 and Radium-228.

On 1 October 2011, revised levels for naturally occurring radioactive materials were introduced into Schedule 23 of the Environmental Permitting Regulations 2010. Based on initial analysis of the radioactivity in the flowback fluid Cuadrilla will require an Environmental Permit to store and dispose of the flowback fluid.

The results of this preliminary analysis have to be viewed with caution, they are only indicative of the radioactivity present. As part of Cuadrilla's application for a permit a radiological impact assessment will be required. In determining the application we will review the radiological impact assessment with regard to public dose constraints as set out in legislation.

Results of Analysis

Gross Alpha and Beta Activity

LGC Reference	Sample	Count Date	Gross Alpha Activity as ^{241}Pu (Bq/kg)	Gross Beta Activity as ^{40}K (Bq/kg)
L3004800	Water Sample "14/04/11" A	03-05-11	10.4 ± 3.5	2.7 ± 0.47
	Solids from Sample L3004800	03-05-11	1.1 ± 0.3	0.33 ± 0.05
L3005183	Water Sample "03/05/11" A	16-05-11	12.1 ± 4.0	6.2 ± 1.0
	Solids from Sample L3005183	16-05-11	2.2 ± 0.6	1.5 ± 0.1
L3005770	Bottle A Received 23/05/11	31-05-11	15.8 ± 5.3	12.1 ± 2.0
	Solids from Sample L3005770	31-05-11	10.1 ± 2.8	3.4 ± 0.5

Gamma Spectrometry (Bq / kg or Bq / kg equivalent for solids)

LGC Ref.	L3004801		L3005184		L3005769	
Sample Ref	Water Sample B 14/04/11	Solids from Sample L3004801	Water Sample B 03/05/11	Solids from Sample L3005184	Bottle A Rec'd 23/05/11	Solids from Sample L3005769
Analysis Date	21-04-11	21-04-11	09-05-11	18-05-11	24-05-11	31-05-11
^{40}Potassium	< 1.0	< 1.0	3.5 ± 1.1	< 1.0	3.3 ± 1.9	< 1.0
^{60}Cobalt	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
^{137}Caesium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
^{228}Actinium	1.7 ± 0.4	< 0.1	2.6 ± 0.5	0.4 ± 0.1	2.9 ± 0.6	1.4 ± 0.3
^{228}Thorium	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
^{224}Radium	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
^{212}Lead	0.4 ± 0.1	< 0.5	0.9 ± 0.1	< 0.5	0.7 ± 0.1	< 0.5
^{212}Bismuth	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
^{208}Thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
^{234}Thorium	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
^{226}Radium	14 ± 2.1	< 0.2	16 ± 2.1	2.5 ± 0.4	17 ± 2.3	7.2 ± 1.5
^{214}Lead	1.4 ± 0.2	< 0.5	6.0 ± 0.7	1.6 ± 0.2	2.3 ± 0.3	2.6 ± 3.3
^{214}Bismuth	0.9 ± 0.2	< 0.5	5.1 ± 0.6	1.3 ± 0.2	2.1 ± 0.3	2.3 ± 0.3
^{235}Uranium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
^{227}Thorium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
^{223}Radium	< 0.5	< 0.5	2.1 ± 0.6	< 0.5	< 0.5	< 0.5
^{241}Americium	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2

Glossary

- Fracking fluid - fluid injected in to the exploration well
- Flow back water - water that comes back out of a exploratory well (this can also be called return fluid, or return fracking fluid)