

**December 2013**

### **Best Practice Environmental Monitoring:**

Concerns over the environmental impact of Coal Seam Gas (CSG) drilling and the effectiveness of site protection measures, in particular around the emission and migration of methane gas, are being addressed through the implementation of robust continuous site monitoring. This best practice approach utilises best available technology (GasClam® - remote, continuous ground gas monitor) coupled to independent monitoring, throughout the site life cycle, to continuously validate the effectiveness of the site protection and alert for adverse environmental impact.

Every location has a certain amount of naturally occurring methane from organic soils or carboniferous rocks for example, and if ordinary water wells intersect the soils mentioned, methane in water is the result, but it is problematic to create a nexus with deeper exploration or mining, often thousands of metres below.

In the US, no baseline monitoring was required, make claims of groundwater contamination from the onset of mining, impossible to refute.

Currently utilised in the UK, this approach provides data to demonstrate well integrity and report on the environmental impact of CSG drilling and extraction. Through going beyond the current statutory requirements and implementing this as best practice companies are now able to make informed decisions based upon good data and provide transparent, independent reporting to the public and regulators.

### **High Level Best Practice Approach:**

Key aspects:

1. Establish background environment and sources:
  - a. Methane and hydrocarbons are widespread in the environment and can be from both natural and man made sources, it is therefore critical to undertake a near surface geology desk study of the site prior to drilling to identify/map sources and receptors
2. Baseline monitoring:
  - a. Site monitoring design – install gas monitoring wells with response zones to target near surface aquifers outside the protective measures
  - b. Continuous monitoring – GasClam® - as ground gas is highly sensitive to changing environmental conditions, in particular barometric pressure, temperature and ground water level changes - establish perimeter gas monitoring wells with continuous monitoring of methane, carbon dioxide, barometric and borehole pressure, temperature and ground water level using GasClam®

Conventional spot monitoring provides incomplete data and can be very misleading, given ground gasses are fluid and can respond within minutes to changes in atmospheric pressure or the groundwater table.

- c. Gas isotope analysis undertaken to establish and validate gas provenance



cont

- d. Continuous ground gas monitoring data integrated with gas sampling, atmospheric monitoring and ground water monitoring to provide the complete picture
3. Operational monitoring:
  - a. Monitoring to continue providing on going validation of the protection measures and well integrity, allows almost immediate feedback of any issues to a site operator.
4. Close down:
  - a. Monitoring to continue for a period post capping, and facilitates a more complete understanding of the respective emissions life cycle.

### **Best Available Technology: the GasClam® - Ground Gas Monitoring**

GasClam® is a battery powered, continuous ground gas monitor that allows unattended, remote site investigation, alerting and reporting. Particularly suited to CSG site monitoring and investigation, GasClam® is easily deployed by fitting into a standard 2 inch monitoring borehole. Data is collected on a pre-configured frequency, typically hourly, is communicated via GPRS and remotely accessed via the internet.

Manufactured from stainless steel, GasClam® is intrinsically safe, ATEX approved, environmentally sealed and ingress protection rated to IP-68. Battery operated; the GasClam® can be powered for up to 1 month based on hourly sampling.

Parameters that can be measured are:

- methane
- carbon dioxide
- oxygen
- carbon monoxide
- hydrogen sulphide
- total volatile organic compounds
- barometric/ borehole pressure
- temperature / water level



Key Benefits of GasClam® include:

- Monitoring of well integrity / validation of protective measures
- Provides data for transparent site reporting to the public and regulators
- Continuous monitoring for event alerts/ complete site view over time.
- Stand alone system - minimises unnecessary site visits reducing costs
- Demonstrates operator is using best practice above & beyond purely regulatory requirements

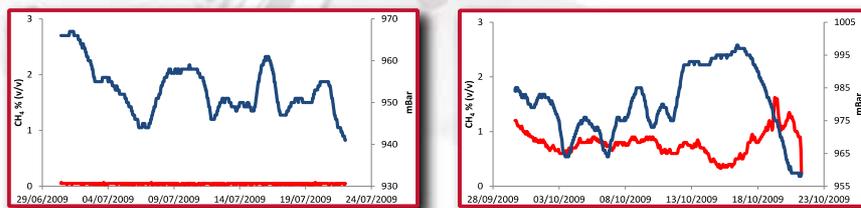
## Monitoring gas levels in Hydrofracking

### The problem

Across the world, plans for shale gas drilling are being assessed and implemented as nations look to secure their fuel supplies. However, there is controversy surrounding the process for extracting shale gas which is known as 'hydrofracking'. The concerns are based on the potential for fracking fluids and shale gas to escape from the well and through fractures contaminating aquifers, creating an explosion hazard and further impacting greenhouse gas levels. The only way to demonstrate hydrofracking is not causing any adverse effects is to monitor the process

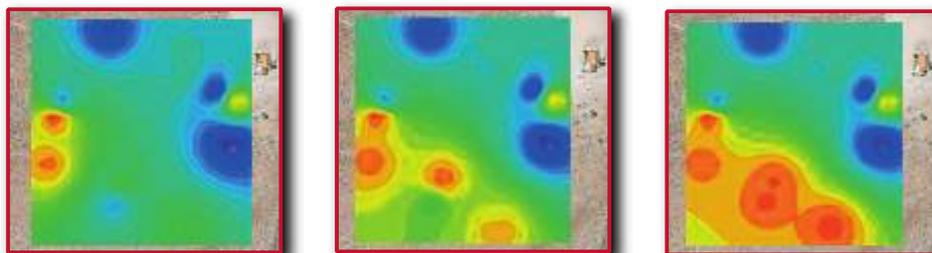
### The solution: GasClam®

As gas naturally seeps from the subsurface to groundwater and atmosphere, operators need to monitor before, during and after shale gas operations to know what the existing gas regime is, and to identify any impact. It is well known that natural gas concentrations in the subsurface change over time, consequently, to establish the true natural base line, continuous measurement is essential.



Continuous data from a proposed fracking site demonstrates how the soil gas regime naturally changes over time. If spot samples had been taken between June and July the site could have been easily characterised as having no natural background levels of methane.

Whilst drilling and fracking, GasClams are located near to the well to demonstrate its integrity and also installed in boreholes located in aquifers to make sure they are safe. The devices are then left in-situ for long term monitoring throughout production and following well closure.

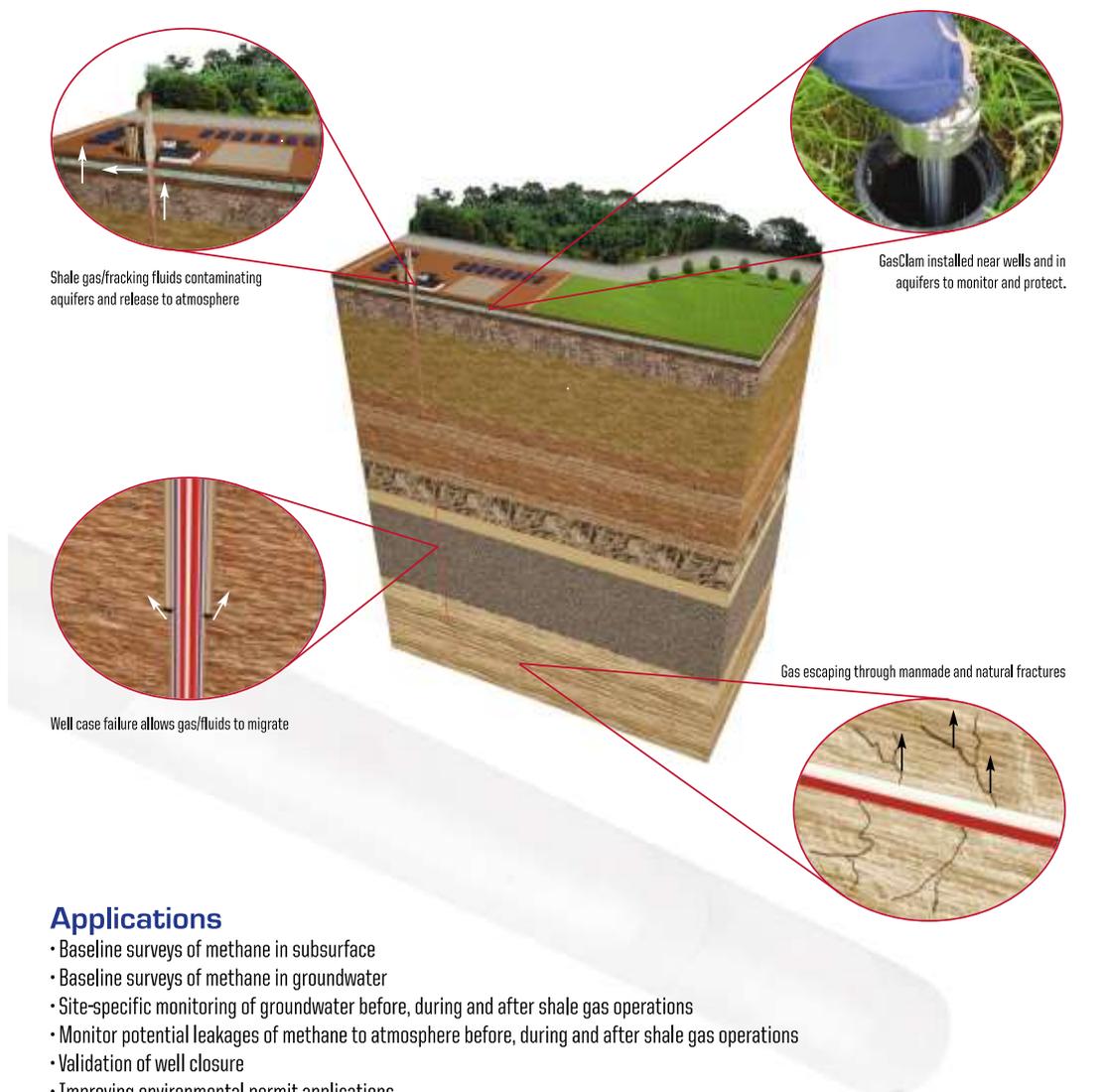


Networks of devices can be deployed and real time modelling of the ground-gas regime over the whole site is possible.

GasClam is the only product that can collect in-situ continuous ground gas data and is becoming adopted as best available technology by the industry.

Unrivalled Detection.

## Continuous ground gas monitoring



## GasClam Specification

Sensor	Method/Type	Range	Resolution	Accuracy	Linearity
CH <sub>4</sub> CO <sub>2</sub>	Infrared	0 - 5% 0 - 100%	1% of measuring range above 50%, 0.5% below 50%	± 2% FSD	± 2% FSD or 10% reading
O <sub>2</sub>	Electrochemical	0 - 25%	0.1%	± 5% of reading ± 1 digit	>1% O <sub>2</sub> deviations @ 10% O <sub>2</sub>
CO*	Electrochemical	0 - 500 ppm	1 ppm	<± 3 ppm at 0, ± 5% at 250 ppm	±5%
H <sub>2</sub> S*	Electrochemical	0 - 200 ppm	1 ppm	<± 1 ppm at 0, ± 2.5% at 50 ppm	±5%
VOC	PID	0 - 4000 ppm	1 ppm	± 5% of reading ± 1 digit	±5% to 100 ppm

\*Other range CO & H<sub>2</sub>S sensors are available on request.

Environmental	Method/Type	Range	Resolution
Barometric Pressure	Piezoelectric	800 - 1200 mbar	1 mbar
Borehole Pressure	Piezoelectric	800 - 1200 mbar	1 mbar
Temperature	Internal Chip	-5 °C to +50 °C or 41 °F to 122 °F	0.1 °C or 1 °F
Water Depth*	Piezoelectric	0 - 25 m	0.01 m

\*Optional

<b>Memory</b>	65000 time / date stamped readings	<b>Developed by:</b> 
<b>Power</b>	Internal x 2 Alkaline D-cells or rechargeable battery pack	
<b>Battery Life</b>	Approximately 1 month (hourly sampling with rechargeable battery)	
<b>Case</b>	High Quality Stainless Steel, 316s	
<b>Weight</b>	6KG or 13.2lb	
<b>Protection</b>	IP-68 (continuous submersion, 1 meter for 7 days)	
<b>Operation</b>	-20 °C to +50 °C or 41 °F to 122 °F (alkaline batteries), -10 °C to +40 °C or 50 °F to 104 °F (NiMH batteries)	
<b>Approvals</b>	CE, EMC, ATEX, IECEx, UL/CSA	
<b>Certification Rating</b>	 2G Ex d'ib (Ib) IIb T4 Gb	
<b>Certification number</b>	FTZU 07 ATEX 0105 X	
<b>Patents</b>	Worldwide (US Pat. 8186211, EP Pat. 2027363)	

Unrivalled Detect**ion**.

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