# Diesel Cave Pollution Data Logging

***Stuart France**, the Cambrian Caving Council's Conservation & Access Officer since 2014, has been data logging hydrocarbon fume levels in a cave. This follows a series of pollution incidents spanning more than eight years at a remote site in the hills of South Wales. An appraisal of all the evidence, including Winter 2015 cave gas data, now points to these being deliberate nature crimes.*

## Background

Cavers first reported very unpleasant vomit-inducing levels of road fuel pollution in Little Neath River Cave (LNRC) in April 2008 [1]. This is a very pretty and sporting but little-visited active river cave situated close to a narrow remote dead-end road in the central hills of the Brecon Beacons National Park [2]. The cave has 7km of passages of which the first 1km or so are easily accessible to non-divers. It is a conservation site with SSSI legal protection and worthy of that status.

Unfortunately, these incidents continued at the rate of about one per year: June and August 2009, October 2011, October 2012, October 2013 and September 2014. There was also an incident in November 2015 detected by the data logger, which went unreported because no cavers visited the cave between November 2015 and February 2016 due to flooding during the winter months. This hidden 2015 incident and the data logger that recorded it, is the main subject of this paper.

The 2014 incident [3] was the first in my time on the Cambrian Caving Council. My predecessors had reported earlier incidents to the authorities who then failed to discover anything conclusive. I informed Natural Resources Wales, the new public body incorporating the former Environment Agency Wales, that investigates pollution incidents. NRW went to the cave and claimed nothing untoward there – which was absurd since the cave was still heavily polluted with a terrible fuel smell at the entrance and oil scum all over the place underground, such as in the river pools.

NRW stood by their result and claimed to have no more budget for laboratory chemical analyses. But I persuaded NRW to visit the cave again with myself as a guide and the assurance that nothing other than their noses would be needed. As it happened, the investigators did not know where the entrance used by cavers was actually located. Having smelled the cave fumes, we then checked the downstream sinks and found nothing else was affected. NRW then had to agree with me that the only way that the top sink but none of the lower sinks on the same river could be polluted was if fuel, assumed to be diesel, had been poured directly into the influent water of that top sink. The fuel was definitely not carried by the main river water, which absolved local farmers and leisure 4×4 drivers who sometimes cross the main river at upstream fords and might have been remarkably careless to spill road fuel there every October, give or take the odd month.

The question is: why should anyone deliberately harm a cave in such a bizarre way? They clearly had expert knowledge that only a local person or a caver or indeed a local caver would possess, and curious persistence too. I am struggling to find a compelling motive for this series of actions, but I regard them as an act of spite on the part of one unusual person who resents others gaining access to a beautiful cave that they cannot see for personal reasons such as age, health or body size, because the cave entrance is a confined and tricky wet place to get oneself through.

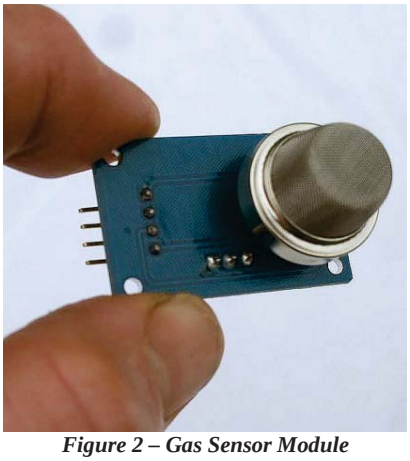

***Figure 2 – Gas Sensor Module***

## Data Logging Results

I have been counting cavers visiting LNRC from December 2014 following that September's fuel incident using the counter equipment described in [4]. In 20 months there have only been 44 visiting groups, mainly from spring to autumn. I ran the fume logging system in the spring of 2015 for three months. For the hourly rainfall and air temperature I had to rely on loggers at my home about 20 miles away, also in the National Park mountains. I was surprised to observe small peaks in the cave fume levels, but most peaks also corresponded to high rainfall events. There were no more reports from cavers about pollution in the 2015 summer so I thought no more of it and attributed the results to methane from biological decay or the remnants of the September 2014 pollution being churned up by more recent floods, see *Figure 1*.

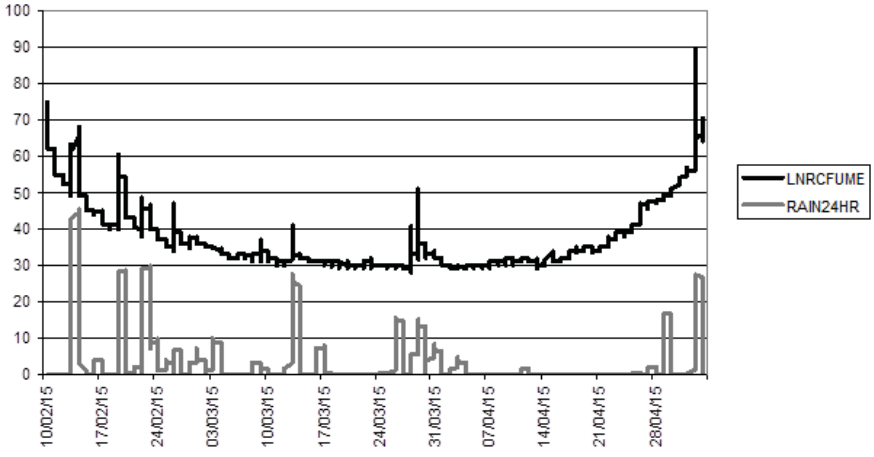


***Figure 1 – Fume Level versus 24hr Rain (arbitrary units)***

I ran the logger again for almost six months over the Autumn and Winter of 2015. This time there was no correlation between the weather and the fume level in the cave, as shown in *Figures 4 and 5*. However, the cave fume level built rapidly in just two hours on Tuesday 17th November from 2AM and then exponentially decayed over the following week to its normal level, despite many more rainy days and external temperatures heading down, while oscillating somewhat. The strange onset time for a pollution event (in the middle of the night) points once again to a deliberate act by a person whom is becoming more careful in getting a thrill from contaminating this particular cave.

## The Hardware

The data logger and sensor controller boards are essentially the same hardware as was used for the water depth logging project in the nearby OFD cave [5], but with some firmware changes. It was necessary to add a standard 5V regulator to the controller board that is capable of delivering 150mA at 5V to the gas sensor module when commanded to by the logger. The gas sensor is a cheap Arduino hobby module bought on eBay, intended to detect methane escapes in indoors settings. Initial lab tests were done by measuring the hydrocarbon gas level inside a plastic bag, which was near to zero, and then inserting a tissue wiped on a vehicle fuel cap or introducing butane gas traces, which both produced very dramatic effects.

For use in the cave, this gas sensor was housed in a small IP65 box external to the 1150-size Pelicase that housed the rest. The sensor needs three wires for power supply and returning the analog gas level to the controller which in turn digitizes it for the logger at 1 AD unit per 2mV. The metal gauze dome part of the gas module must be exposed to the cave air. I positioned it on a large flat rock area about 2m above maximum river level about 100m into the cave with the sensor element between two brick-size rocks, with a similar rock on top spanning them, creating a small alcove that could not be dripped on whilst letting the cave air circulate freely.

The data logger also runs at 5V via its own always-on microwatt power regulator IC, sharing the same pack of eight D-size alkaline batteries with the gas sensor and its controller board. This power pack is connected by a well-greased HeyPhone-style power lead.

The 15Ah capacity will only power the whole system for one year because of the warm-up time needed for the gas sensor, when it is run intermittently. The gas sensor, drawing 150mA, is warmed up for

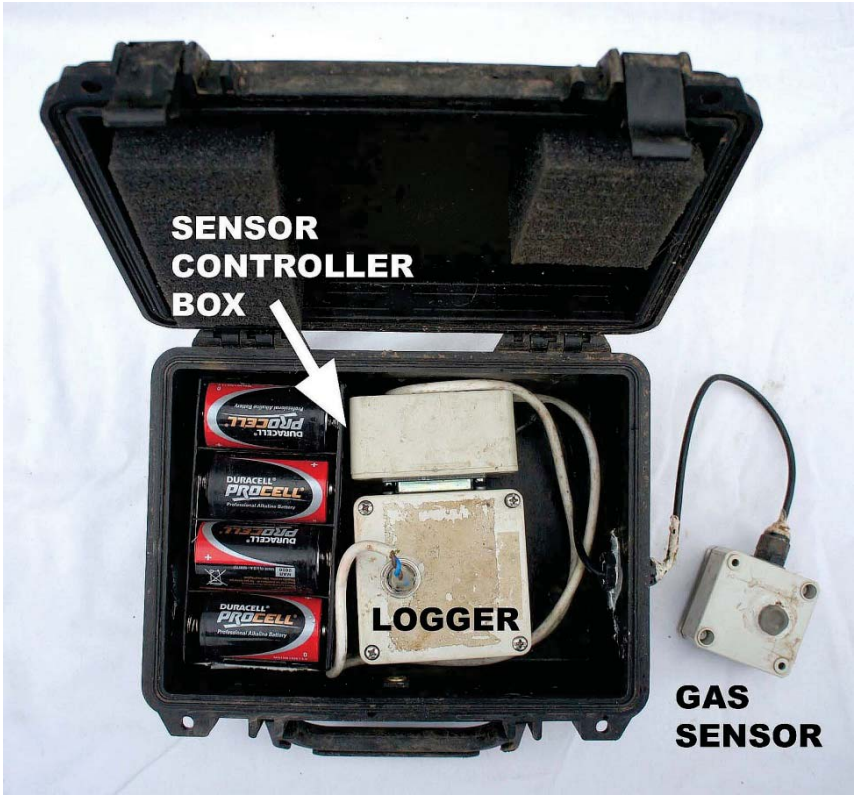


*Figure 3 – The Equipment*

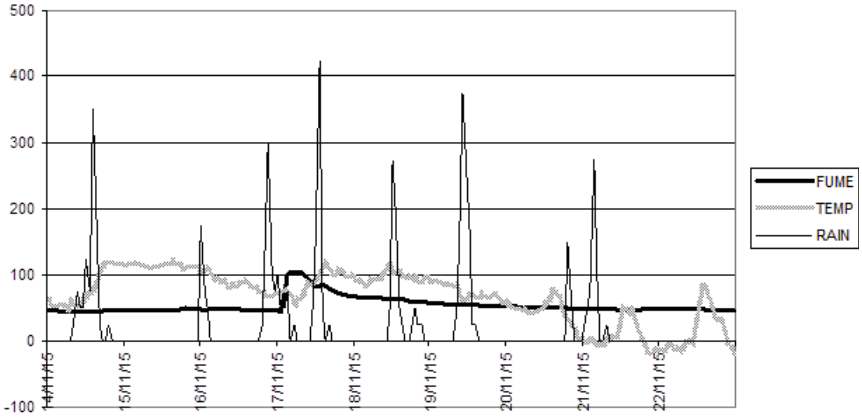


*Figure 4 – Hourly Fume Level versus Hourly Temperature (C×10) and Hourly Rain (mm×100)*

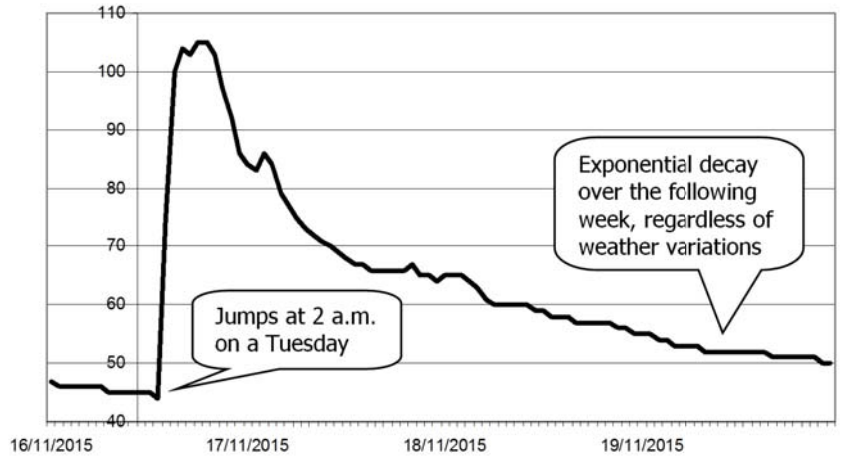


*Figure 5 – Expanded Detail of Hourly Fume Level*

40 seconds prior to taking each reading on every hour change.

By contrast, the OFD system utilised a separate 9V PP3 battery inside the logger box to power the logger at 5V, again via a microwatt regulator, whilst the water depth sensor was powered up by its controller board from a block of 12 AA-size batteries without any regulator, whenever the logger commanded the controller board to deliver a reading.

The OFD water depth sensor needs only a couple of seconds warm-up time drawing 20mA, so AA-size batteries will last for years.

On reflection, the OFD system is a more resilient design because of its twin batteries, but I was in bit of a hurry to get LNRC fume monitoring underway last year, using parts that were to hand.

The logger has removable flash memory rather than a download data link or swapping logger boxes in the field. It is very inconvenient if one has to take a laptop, tablet or phone down a river cave to interact with a logger there, so I have a robust plug-in control box with an LCD screen and a couple of buttons to set up the logger with the date/time and run-time parameters, akin to setting up a Casio digital wristwatch.

The logger also plugs into the sensor system by the same DB25 (old-school PC serial port) socket which has 25 gold-plated pins. In my experience these are very reliable and near indestructible connectors. When designing equipment for caves; simplicity, modularity and toughness are a much higher priority than including the latest features, such as BLE.

## What Next?

I had hoped that explaining all these incidents as crimes in 2014 might have been enough to stop them. But it seems that is not so. Autumn 2016 is knocking at the door as I write this article, so I am all set to digitally record the dynamics of the next nasty event in this near annual series.

I can be contacted via the Cambrian Caving Council website by anyone with insight or expertise to offer.

## References


[1] **ukcaving.com/board/index.php?topic=6254.0**

[2] **www.ogof.org.uk/little-neath-river-cave.html**

[3] **ukcaving.com/board/index.php?topic=17037.0**

[4] France, Stuart (2014), *Caver Counting – Why and How*, CREGJ **86** pp7-11

[5] France, Stuart (2016), *Cave Flood Pulse Data Logging in OFD1*, CREGJ **93** pp10-12t


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# Letters and Notes

*Please send contributions to the editor at* ***creg-editor@bcra.org.uk***

## Autumn Field Meeting

We would like to organise a CREG Field Meeting in the Yorkshire Dales, probably during the weekend of 5th/6th November 2016. Please note that this date is subject to confirmation.

To stay informed, please subscribe to the CREG-Announce mailing list at **CREG-announce@list.bcra.org.uk** or check the CREG forum at **bcra.org.uk/cregf**

The meeting will follow the usual pattern, including demonstrations and trials of whatever people bring along. We are keen to encourage anyone to bring anything they are working on across the broad spectrum of cave radio and electronics.

We hope to be trialling various forms of data transmission and extending the range of our series of tests of HF radio from the underground station to more remote surface stations, plus, of course, much more.

We are likely to use more than one cave for the field meeting, so be sure to have the latest information to be able to find us.

***Mike Bedford***

## Thanks

I'd like to record my thanks, particularly to Mike Bedford, for organising the very interesting CREG Field Trip as part of EuroSpeleo 2016.

In particular it was very good to see both the Nicola 3 radio and the Cave Link system in operation in a realistic setting. It was also fun to try radiolocation with Black Meg.

Reading about such developments is fine, but nothing beats hands-on experience. Maybe a similar CREG hands-on session can be organised at Hidden Earth?

***Bob South***

## Cave Link at EuroSpeleo

Thanks very much for allowing us to bring Cave Link along to the CREG Field Meet. Gareth, Jo and I very much enjoyed ourselves and it was a great opportunity to wave the Cave Link flag and get a few more people aware of what it can do. The results from the demo were good and although probably many did not realise what we had done with the one unit and how it was operating, hopefully some did.

If you would like another demo of Cave Link for a future CREG Meeting, I would be pleased to facilitate whatever we can.

***Paul Taylor, Chairman,***
***Gloucester Cave Rescue Group***

## References

We are considering a change to the way that references are identified in the text of articles in the CREG Journal.

We currently use an identifier of the form: (Gill, 2016), which then marries up with an item in the Reference section of the article such as:

Gill, Rob (2016) *Article title*, CREGJ **95**, pp25-26

This normally works well and reflects the practice of many academic journals. However, it doesn't work so well when there is a mix of references to articles and to online addresses or similar resources.

We propose to standardise on simple numbered references, enclosed in square brackets, such as [1], and as used in the article on pages 14 to 16 of this issue.

I'd value feedback before making this change.

***Rob Gill***

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## Diary Dates

*22 OCTOBER 2016 – OXFORD*
*BCRA Cave Science Symposium and BCRA AGM*
Further details to be made available online.

*23 OCTOBER 2016 – BOX STONE MINES, WILTSHIRE*
*BCRA Field Meeting*
Further details to be made available online.

*5-6 NOVEMBER 2016 – YORSHIRE DALES*
*CREG Field Meeting*
Date to be confirmed – subscribe to **CREG-announce@list.bcra.org.uk** or contact Mike Bedford **bedfordmd@aol.com** for further details

Caving diaries and further information about events can be found in the BCA Newsletter, Speleology and Descent magazines and on the web at **bcra.org.uk/forum** and **wildplaces.co.uk**.