Dr Wayne Somerville
PO Box 744
Kyogle NSW 2474
Ph/fax: 02 66333158
Email: waynes@bordernet.com.au

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National Inventory Systems and International Reporting Branch
Land Division
Department of Climate Change and Energy Efficiency
Canberra ACT 2601
nationalgreenhouseaccounts@climatechange.gov.au

Dear Departmental Officers,

RE: Submission on Estimation of Fugitive Methane from Coal Seam Gas Operations.

I am writing in response to the request for comment on the future measurement of methane released into the atmosphere as a result of coal seam gas (CSG) mining operations.

As noted by the Australian Government's Department of Climate Change and Energy Efficiency (2012)[1], emissions from CSG operations:

> "Depend on a range of factors, including the geological properties of the gas basin, the techniques used in gas extraction and processing, emissions during pipeline transportation, further processing and transportation emissions if CSG is converted to LNG for sale to overseas customers, and the efficiency of end use."
>
> "Emissions occur at several stages during the production, supply and use of CSG. Fugitive emissions of methane are a significant source during the production phase. This includes methane released from exploration drilling, production testing and well completion, and gas production activities including processing, venting and flaring."
>
> "Other sources include fugitive emissions during transportation and supply, emissions from fossil fuel use during the development and operation of CSG facilities, and emissions from end-use combustion of CSG."

This submission is specifically concerned with methane emissions associated with the technology employed in CSG vertical well construction and migratory emissions due to the fracturing of rock strata caused by horizontal drilling and the depressurization of coal seams.

CSG Mining Technology and Fugitive Methane Emissions

CSG is touted as a safe, cleaner than coal transitional fuel. The legitimacy of the CSG industry depends on the extent to which their drilling technology allows fugitive methane to rise to the surface, and whether this pollution can be effectively controlled and mitigated.

The United States is committed to massive landscape scale CSG and shale gas mining operations despite limited experience with relatively new drilling technologies and increasing scientific concern about the true nature and extent of fugitive methane emissions.[2,3,4,5]

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[1] Consultation Draft Measurement Determination, National Greenhouse and Energy Reporting Measurement Amendment 2012, Departmental Commentary (30 April 2012).

The Australian CSG industry began only about 15 years ago when new drilling techniques developed by US company Halliburton made it possible to unlock coal bed gases. Up until the development of this technology, the sought after methane had been buried under hundreds of metres of sandstone, safely sequestered from the atmosphere. Australia's coal beds were laid down 90 million years ago in a great dying-off which ended a period of extreme global warming.

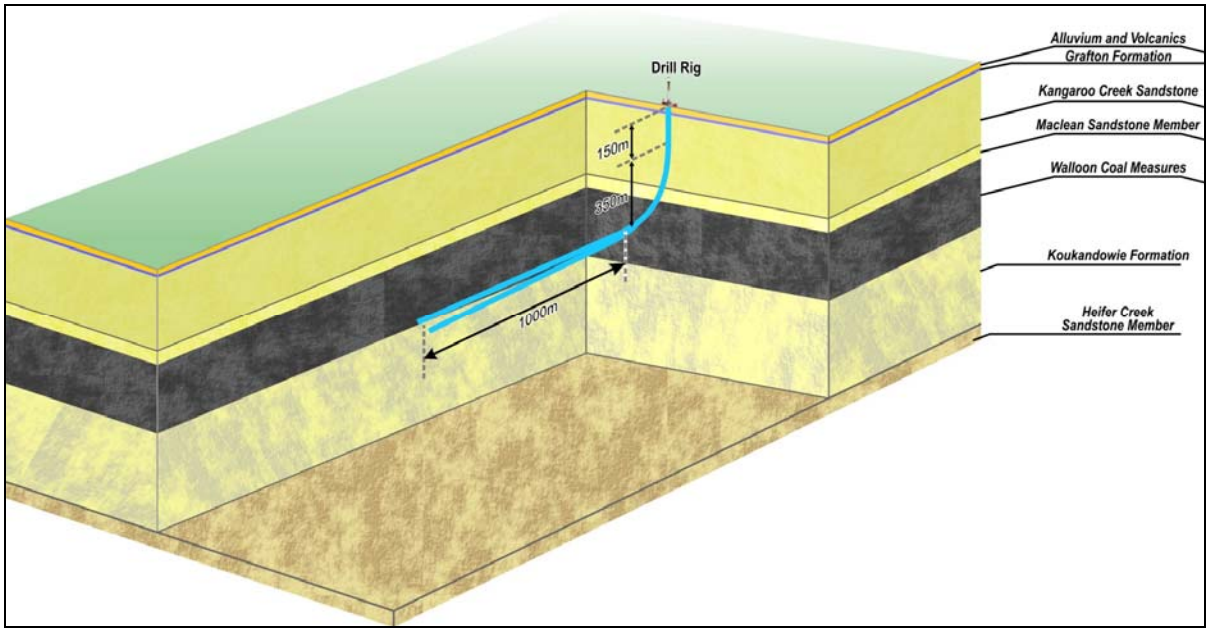

Figure 1: CSG Company Metgasco's Graphic of CSG drilling.[6]

CSG miners drill down 600 to 1,000 metres or more through aquifers and rock to the coal measure. They then drill horizontal shafts, for up to 4 kilometres, through the coal seam. Methane is liberated when water from the coal seam aquifer is pumped to the surface. A mix of water, sand and chemicals is sometimes pumped into the fractured coal to liberate the coal seam gases.

Conventional natural gas is extracted from large reservoirs via a small number of wellheads. Fugitive methane emissions from CSG mining come from thousands of interconnected wells, distributed across landscapes, with each well being connected to a system of shafts drilled horizontally through the coal seam.

A CSG well is essentially a metal pipe inserted into a very deep borehole. 1,000 m is greater than the height measured from the water to the top of the arch of seven Sydney Harbour Bridges stacked one on top of the other.

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[2] Hardisty, P., Clark, T. and Hynes, R. (2012). Life Cycle Greenhouse Gas Emissions from Electricity Generation: A Comparative Analysis of Australian Energy Sources. *Energies* 2012, 5(4), 872-897; doi:10.3390/en5040872. http://www.mdpi.com/1996-1073/5/4/872

[3] Pétron, G., et al. (2012), Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study, *J. Geophys. Res.*, 117, D04304, doi:10.1029/2011JD016360.

[4] Howarth, R., et. al. (2012). Methane Emissions from Natural Gas Systems: Background Paper Prepared for the National Climate Assessment, Reference number 2011-0003, February 25, 2012.

[5] Howarth, R., Santoro, R., and Ingraffea, A. (2011). Methane and the greenhouse gas footprint of natural gas from shale formations. *Climatic Change Letters*, doi:10.1007/s10584-011-0061-5

[6] Metgasco - Large Uncontracted Gas Reserves – Excellent Market, March 2012, International Road Show: Hong Kong, New York, London.

To prevent methane escaping into the atmosphere via the borehole, and to protect aquifers from bleeding into each other, for the entire length of the well the space between pipe and rock has to be sealed for all eternity. As CSG company Metgasco described the process in their submission to the NSW Parliamentary Coal Seam Gas Inquiry[7], this is achieved by pumping concrete into the gap between pipe and rock. This gap is two inches thick at the top, and three-quarters of an inch thick for the deepest 800 metres or so of the vertical borehole. The concrete sleeve ends where the horizontal drilling begins.

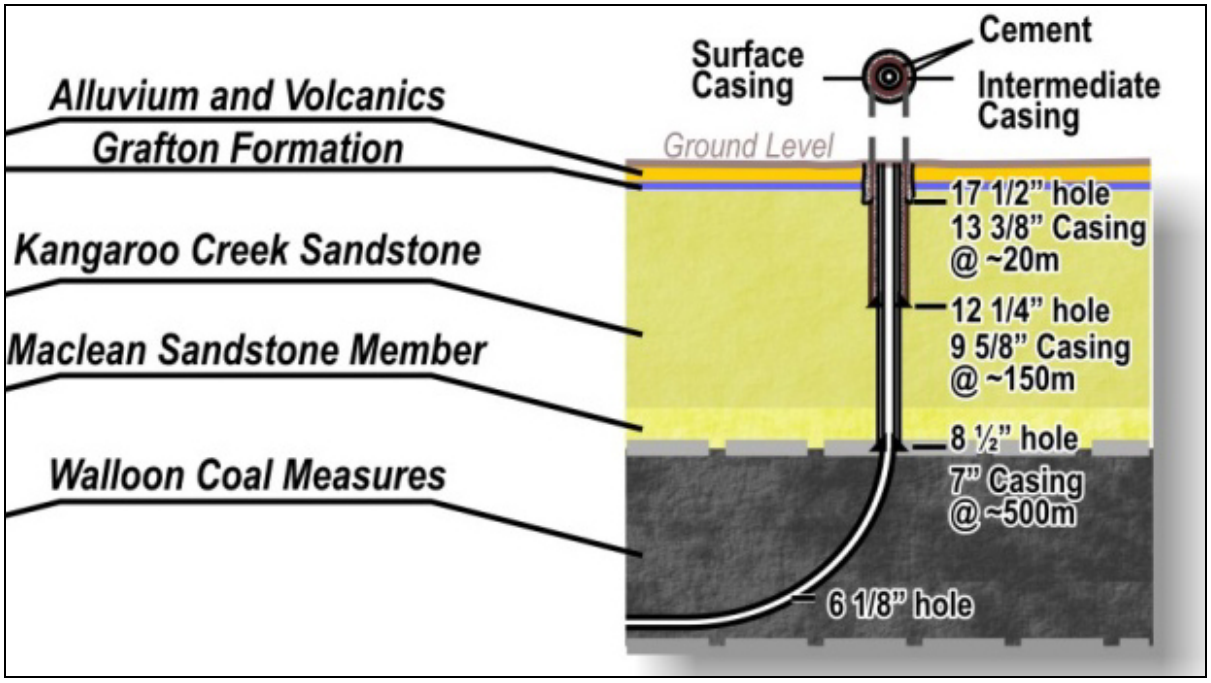

Figure 2: CSG Company Metgasco's Graphic of CSG Well Casing and Concrete Barrier.[8]

I know of no imaging or other kind of technology which would enable an accurate scientific assessment of the continuity and integrity of concrete barriers in deep underground CSG well casings.

Nonetheless, the notion that concrete can be routinely poured in thousands of wells to effectively seal ¾ inch gaps between pipe and rock, hundreds of metres underground, defies commonsense and contradicts practical experience. I am aware of no evidence that would suggest that the concreting techniques used in CSG well construction represent a technological wonder rather than a dangerous fantasy. And of course, with time, concrete inevitably breaks down, steel corrodes and CSG wells will blow out.[9]

But not even concrete can prevent greenhouse methane rising through overlaying sandstone strata that have been fractured as a result of vertical and horizontal drilling processes.

Methane escaping though fissures that open up in the ground or via pre-existing boreholes and mines are a potentially massive source of migratory emissions that have yet to be properly assessed.

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[7] Shields, R. (2011). Metgasco's Submission to the NSW Parliamentary inquiry into Coal Seam Gas (CSG), Submission 287.
[8] Metgasco - Large Uncontracted Gas Reserves – Excellent Market, March 2012, International Road Show: Hong Kong, New York, London.
[9] Dr Tina Hunter (2012). Bond University, interview in *Echonetdaily*, http://echonetdaily.echo.net.au/csg-where-the-frack-to-next/

The CSG miner Santos noted that "the drawdown of ground water heads within coal seam gas aquifers is a necessary process and an unavoidable impact associated with the depressurisation of the coal seam."[10]

Further, Santos stated that;

> "There can be significant losses in pressure both within the aquifer, and/or in the overlying and underlying aquifers. Industry predicts groundwater drawdown for the Arcadia Valley and Fairview CSG fields within the Bowen Basin, Queensland of up to 15 metres by 2013 and 65 metres by 2028. For the four bore wells situated in and around the fields, it was estimated they would experience 7 to 25 metres drawdown in the groundwater level by 2028."[11]

If a depressurised coal seam many hundreds of metres down inevitably causes a drop in aquifer water levels close to the surface, it follows that CSG mining has to cause deep fracturing of sandstone rock layers. These fractures provide a potential conduit for methane from deep coal seams to vent into the atmosphere.

CSG Methane Emissions: Implications for Assessment and Policy

Many CSG wells in the Queensland gas fields have been reported to be leaking methane[12], but three recent cases of migratory methane emissions warrant particular consideration. These examples of methane releases in CSG gasfields demonstrate the potential significance of this source of atmospheric pollution, and also highlight important issues bearing on the future scientific assessment of fugitive emissions.

The reader is directed to the video, "Dr W Somerville CSG Fugitive Emissions Submission" which can be downloaded at the following links:

FLV Format (Smaller You Tube file, but requires a .flv reader)

https://dl.dropbox.com/u/99105418/Dr%20W%20Somerville%20-%20CSG%20Fugitive%20Emissions%20Submission.flv

MP4 Format (Larger file, higher resolution)

https://dl.dropbox.com/u/99105418/Dr%20W%20Somerville%20-%20CSG%20Fugitive%20Emissions%20Submission.mpg

These videos show significant migratory methane emissions around CSG wells on a Queensland farming property and in the Condamine River. Such examples illustrate characteristics of migratory CSG emissions which have implications for thinking about the scientific assessment of methane pollution.

The video of leaking CSG wells was edited from the ABC 4 Corners program, "The Gas Rush"[13] and the 60 Minutes program, "Undermined"[14]. The scenes of the Condamine River were edited from video filmed by Dayne Pratsky on 28 May 2012.[15]

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[10] Groundwater (Deep Aquifer Modelling) for Santos GLNG Project – EIS, 31/3/2009.
[11] Groundwater (Deep Aquifer Modelling) for Santos GLNG Project – EIS, 31/3/2009.
[12] National Toxics Network (2011). Coal Seam Gas Briefing Update.
[13] Four Corners program on CSG, "The Gas Rush" aired 21/02/2011. www.abc.net.au/4corners/content/2011/s3141787.htm
[14] 60 Minutes program, "Undermined", aired 14 May 2010. www.youtube.com/watch?v=eZwWGlhqkbE
[15] www.youtube.com/watch?v=Di8cCrlyW6k29

In his interview for the ABC Four Corners program[16], Scott Lloyd, a Queensland farmer with a CSG gas field on his property, reported that QGC wells on his property had been leaking since 2006. Mr Lloyd said that attempts to plug the leaks with concrete had been unsuccessful, and the gas that was originally coming from the well head was now "coming straight out of the ground all around the site". Further, the methane escaping from bores on the Lloyd's and other farms in the area can now be set alight.

Dayne Pratsky's video of a stretch of the Condamine River surging like a spa bath with venting methane should trouble anyone who is concerned about the dangers posed by uncontrolled CSG methane emissions into the atmosphere.

Incredibly, shortly after this video was released the Queensland Minister for Mining announced that the CSG miners had assured him that this was a natural phenomenon. Of course, no one has ever before witnessed Australian rivers seething with methane. There is no rational or scientific basis for the Minister's implied belief that vast quantities of methane have been freely venting, presumably for millions of years, into the atmosphere from coal seams hundreds of metres below the Condamine River.

On 18 August 2012, a mining exploration hole in the Daandine coal seam gas field, west of Dalby, was found to be alight with leaking methane.[17] An Arrow Energy spokesman claimed that the methane did not come from their three CSG wells, which were located between 750m and 1km away, and Arrow attributed the leak to a 30-year-old coal mining exploration hole. Presumably, the Arrow Energy spokesman believed that this old hole had been freely venting large quantities of methane for 30 years, but had not been detected or ignited until recently.

The above three examples of methane leaking on Queensland gasfields illustrate the need for CSG methane emissions to be measured across landscapes, and not just at the well head.

Methane is a colourless, odourless gas. Leaking around the wells on the Lloyd's property and in the Condamine River can only be seen because the gas is bubbling through water. The Daandine CSG field methane leak was only detected because it ignited. It makes no sense to assume that the leaking methane is somehow narrowly confined to the Condamine River, to puddles on Scott Lloyd's farm, or to where it has been ignited. It is reasonable to assume that the methane is also venting across the countryside around the Condamine and the CSG wells on the Lloyd's property.

Aquifer systems can extend underground for many kilometres. Finding methane in bores at ignitable concentrations indicates that aquifers can potentially transport methane across great distances before it is discharged into the atmosphere.

In my opinion, the emphasis on measuring CSG fugitive emissions "at the CSG wellhead", as recommended in The Australia Institute's recent report[18], runs the risk of obscuring the potentially massive contribution of fugitive emissions that are likely to be occurring across the landscape, sometimes kilometres away from the well head. The above examples suggest that CSG methane emissions need to be scientifically assessed across landscapes and entire gasfields.

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[16] Four Corners program on CSG, "The Gas Rush" aired 21/02/2011. www.abc.net.au/4corners/content/2011/s3141787.htm

[17] http://www.couriermail.com.au/news/coal-gas-stream-blaze-still-alight-west-of-dalby/... 20/08/2012

[18] Grudnoff, M. (2012). "Measuring Fugitive Emissions: Is coal seam gas a viable bridging fuel? The Australia Institute, Policy Brief No. 41, August 2012 ISSN 1836-9014.

Self-assessment and self-reporting by the CSG mining companies will not work. The demonstrated first response of mining companies is to promptly deny that methane emissions have anything to do with their operations; even when such denials lead them to make patently ridiculous claims about the "naturalness" of methane agitated rivers.

In my opinion, when assessing migratory methane emissions from CSG operations it would be reasonable to assume that methane can potentially vent into the atmosphere via fractures in rock strata created by both vertical and horizontal CSG drilling.

A reasonable working hypothesis would be that methane venting will tend to be densest around lines corresponding to the direction of horizontal drillings, but no one yet knows how far fracturing is likely to radiate away from the vertical and horizontal drill shafts.

Future scientific research and assessment of migratory methane emissions in CSG gasfields due to fracturing of rock strata and transporting of the gas via aquifers would be greatly enhanced if miners provided government agencies with maps of the direction and length of horizontal shafts that radiate out from each wellhead. This data could inform future understanding of how far from the well head venting of such migratory emissions can take place.

It is not known how long migratory emissions due to venting via fractured rock strata and aquifers will continue into the future. Consequently, an accurate assessment of atmospheric pollution due to CSG operations would require long-term monitoring.

As recent events demonstrate, current CSG mining activity may activate emissions in older abandoned and capped wells and water bores. Mining companies need to be required to assume responsibility for methane emissions from an agreed area extending outwards from their operations for an agreed period of time into the future.

In my opinion, the appropriate assessment of fugitive methane emissions from CSG operations can only be achieved by the "Method 4: Direct monitoring of emissions systems, either on a continuous or periodic basis", as described in the Consultation Draft Measurement Determination, National Greenhouse and Energy Reporting Measurement Amendment 2012, Departmental Commentary (30 April 2012).[19]

I note that Petron (2012)[20] described the use of a motor vehicle fitted with methane detecting instruments to locate a specific gasfield responsible for a high level of methane pollution identified in an atmosphere testing tower. Petron also referred to ongoing research collaboration with other scientists who were using aircraft to measure methane in the atmosphere over gasfields. Petron (2012) recommended that air pollution be measured over entire gas fields in addition to monitoring at well sites and compressor stations.

A Google search for "methane monitoring equipment" indicated that various handheld, stationery, vehicle mounted, and aircraft mounted instruments are available for assessing methane pollution on a landscape scale.

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[19] Consultation Draft Measurement Determination, National Greenhouse and Energy Reporting Measurement Amendment 2012, Departmental Commentary (30 April 2012).

[20] Pétron, G., et al. (2012), Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study, *J. Geophys. Res.*, 117, D04304, doi:10.1029/2011JD016360.

Unfortunately, the CSG industry in Australia, and particularly in south-east Queensland, has gone ahead without any assessment of methane emissions prior to widespread drilling operations. Consequently, for gasfields that have already been developed, the total amount of methane emissions due to CSG drilling can not be assessed by a comparison of pre-drilling to post-drilling emission data.

An alternative approach would be for landscape scale assessment of methane emissions to be made for a "control/comparison" area that is matched to the gasfield to be assessed on such variables as geology, previous mining activity, agricultural operations, and other relevant factors.

Even though CSG operations have impacted widely across some regions, the same coal seam underlies large areas, so identifying an appropriate control/comparison area should be practical.

Atmospheric assessment of methane in the control/comparison area, with an appropriate adjustment for natural variability established by research, would provide a baseline for likely natural emissions above which any methane present could be attributed to current mining operations.

I note that even in south-east Queensland the CSG industry is far from maturity, and massive further development is planned. Consequently, the accurate future assessment of methane emissions will require repeated assessments over time to accurately gauge the pollution due to specific mining operations.

Summary and Recommendations

- Due to its very nature, the recently developed drilling technology employed by the CSG industry is likely to produce significant fugitive and migratory methane emissions across landscapes.

- It is reasonable to assume that methane can potentially vent into the atmosphere via: a) fractures in rock strata created by both vertical and horizontal CSG drilling; b) contaminated aquifers, and c) faulty concrete well casings.

- Self-assessment and self-reporting by the CSG mining companies will not be viable.

- CSG methane emissions need to be measured across landscapes and entire gasfields, and not just at the well head.

- To facilitate research and assessment of migratory methane emissions, miners need to provide government agencies with maps of the direction and length of horizontal shafts that radiate out from wellheads.

- Given the possible long term persistence of migratory emissions due to venting via fractured rock strata and aquifers, an accurate assessment of atmospheric pollution will require long-term monitoring.

- Given the potential for CSG mining activity to activate emissions in older abandoned and capped wells and water bores, mining companies need to be required to assume responsibility for methane emissions from an agreed area extending outwards from their operations for an agreed period of time into the future.

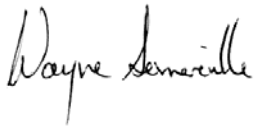
- Methane venting might tend to be densest along lines corresponding to the direction of the horizontal drilling, but the likely extent and range of venting is currently unknown.

- The appropriate assessment of fugitive methane emissions from CSG operations can only be achieved by the "Method 4: Direct monitoring of emissions systems, either on a continuous or periodic basis".[21]

- In proposed gas fields, pre-drilling assessment of emissions across the landscape would enable comparison with post-drilling emission data.

- In already developed gasfields, the total amount of methane emissions due to CSG drilling can be assessed by a comparison to a matched control/comparison area.

Yours faithfully,



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[21] Consultation Draft Measurement Determination, National Greenhouse and Energy Reporting Measurement Amendment 2012, Departmental Commentary, (30 April 2012).