Submission to the Senate Select Committee on Unconventional Gas Mining

Terms of Reference 1.b:

"The health, social, business, agricultural, environmental, landholder and economic impacts of unconventional gas mining"

A Darling Downs CSG Gasfield

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7 February 2016

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Dear Committee Members,

My submission addresses Terms of Reference 1.b - "The health, social, business, agricultural, environmental, landholder and economic impacts of unconventional gas mining".

References

The references for, and links to, statements and research cited in this submission can be found in the following three downloadable reports:

a) Dr Wayne Somerville (2013) Self-help Risk Management Tools: A Report on the Health Impacts of CSG and Shale Gas Mining. This document reviews the literature on unconventional gas mining impacts on health.
http://www.creeksbend.com/CSG%20Health%20Risk%20Management%20Tools%20-%20Dr%20W%20Somerville.pdf.

b) Dr Wayne Somerville (2014) Is CSG Safe? A Failed Public Debate in the Interests of Community Health. This report analyses information that gas mining company Metgasco CEO Mr Peter Henderson put forward as "evidence" to support his claims that the CSG industry has been proven to be safe.
http://creeksbend.com/Dr%20W%20Somerville%20(2014)%20Is%20CSG%20Safe%20-%20A%20Failed%20Debate.pdf

c) Dr Wayne Somerville (2015) How Could CSG Air Pollution in the Darling Downs Be an "Acceptable" Risk to Health? This report reviews and discusses the significance for policy and community health of National Pollutant Inventory (NPI) data for air pollution created by the industrial processing of Coal Seam Gas (CSG) in Queensland's Darling Downs in the reporting year 2013-2014. The report and recommendations of the NSW Chief Scientist and Engineer Prof Mary O'Kane are also analysed and discussed.
http://creeksbend.com/CSG%20Air%20Pollution.pdf

Summary

This submission discusses the impacts from developing and operating unconventional gasfields in populated areas of rural Australia.

Specifically, the submission addresses issues associated with the Unconventional Gas industry and gasfield industrialisation, including the:

- Nature of the profit motive and speculative investment in unconventional gas infrastructure in Australia;
- Influence of "Cargo Cult" mentality and irrational economic thinking that drives investment in the unconventional gas industry;
- Two forms of Risk Management - characterised as "Profit Procurer" Vs "People Protector" - evident in debate about the merits and impacts of the unconventional gas industry;
- Role and use of propaganda and scientific information regarding the costs and benefits of gasfield industrialisation;
- Significance of the lack of baseline health and environmental data;
- "Presumption of innocence" and "burden of proof" in claims regarding the health impacts of gasfield industrialisation and pollution;
- Misrepresentation of scientific research by gas industry representatives and their political supporters;
- Implications of the investigation of CSG risks prepared by Prof Mary O'Kane, the NSW Chief Scientist and Engineer;
- Risks to aquifers and water systems;
- Implications associated with the management of CSG wastewater;
- Review of the physical reality - the "nuts and bolts" - of Unconventional Gas mining, including wells, bore pipes, cement, composition of gas, substances in gas-bearing seams, substances and particulates, public disclosure of chemicals, CSG wastewater, reverse osmosis filtration, produced salt, air pollution produced in the Darling Downs, and the effects of aquifer depressurisation on water tables and fugitive emissions;
- Psychological and mental health impacts of gasfield industrialisation, including economic benefit and loss, reduction in land values, damage to extant agricultural and tourist industries, the social impacts of compelling people to live in gas fields, stress and symptoms of psychopathology;
- Risk to human and animal health, including exposure to dangerous substances, endocrine (hormone) disrupting chemicals, the health of children, and specific pollutants being released in the Darling Downs, and;
- A plea for the better protection of Australian communities and country.

Introduction

The gasfield industrialisation of populated rural areas creates an array of complex, interrelated threats to the health of communities and the environment. The large-scale implementation of a largely untested, unstudied, and poorly understood gas mining technology puts at risk people alive now as well as generations to come.

Australians have never before had to live and raise children in landscapes dominated by gas wells, pipes, flares, wastewater ponds, and pumping and compression stations. Communities are being exposed to a myriad of psychological and social stresses, and a witch's brew of air, water, and soil contaminants.

Nature's great life-support systems are in peril, compromised by an invasive technology that fractures the Earth, destroys precious water systems, pollutes soil and air, and degrades our long term ability to grow healthy food.

People tend to be dismayed when they first fall down the "CSG rabbit hole" and learn what unconventional gas mining actually involves. The industry has developed rapidly with little or no oversight or scientific study despite a plethora of apparent risks to community and country. For many, it seems obvious that any informed, sane person of good heart and intent would see that the industry poses risks that require stringent assessment and management. These citizens cannot understand how the industry and its supporters can claim that operating gas fields where people live is "proven safe" and poses no risk at all.

To make sense of the gasfield threat to rural Australia, we need to understand the motivation and risk management philosophies of the key players.

The Money Motive - Risky Economics

Why would anyone think that turning Australia's best farming country into gasfields was a good idea? The answer is, of course, to make a lot of money. But if the CSG/LNG industry does not turn a profit, and a good one at that, the billions of dollars invested and the damage done will all be for nothing.

As far back as May 2011, Don Voelte, the former CEO of Woodside, Australia's largest petroleum producer, warned of the risks. Mr Voelte said that he wanted to be remembered for his decision not to pursue CSG, and he would be "sleeping easier because of it". "Come back and check four or five years from now", "I think one of the greatest things I will have achieved is not taking my company into coalbed methane", he predicted.

Three years later, in September 2014, Don Voelte revisited the issue. "Queensland LNG doesn't add up", he said, "I made an opinion early on I wouldn't take my (then) company into it. I would make the same decision today." Mr Voelte questioned the viability of $70 billion worth of gas export plants in Gladstone, and warned that the economics had become tougher, and CSG remained difficult to extract. He described the Queensland LNG industry as "a big bet" and a process "with no pilot and no test".

The Australian people might hope that the players in this high stakes game were mindful of their responsibilities and acted with due diligence before they signed export contracts and started drilling, but they did not.

Thanks to Don Voelte, we have an insider's perspective on the rapid rise and impending demise of the Unconventional Gas industry in Australia. It was a gamble, a "big bet". There was no testing, no pilot trial. This industry was not built up incrementally. This was an all or nothing, "bet the farm on black" kind of game. How could executives and politicians not carry out the basic SWOT (strengths/weaknesses/opportunities/threats) analyses familiar to anyone who starts up a new business? What happened to duty of care, due diligence, and risk management?

As oil prices stabilise closer to long term averages, the Australian CSG/LNG industry confronts an existential crisis. Tens of billions of dollars were invested on the hope that historically high oil and gas prices would last forever. Economic theory does not account for what happened, but you can find clues in psychology.

You might remember the ostrich investment bubble of the early 1990s. I know a couple who mortgaged their house to pay thousands of dollars for a breeding pair of ostriches. They were not alone. People everywhere were caught up in the frenzy. The market for ostrich feathers, meat, and oil seemed so strong investors could not lose - but lose they did.

Like all economic bubbles, the ostrich boom to bust story illustrates the dangers of assuming that a high price for a commodity will continue forever. As hard as it is to believe, a Reserve Bank official predicted that China would drive Australia's resource boom for 100 years.

The gas bubble goes beyond executives and politicians succumbing to greed inspired "irrational exuberance". The Unconventional Gas industry is better understood as a Cargo Cult.

The Gas Cargo Cult

Cargo Cults sprang up in the South Pacific during World War II when Islanders saw the incredible wealth - the clothing, medicine, food, and other goods - that airplanes delivered for the Japanese and Americans. Their thinking was based on accurate observation. When the foreigners built runways and did certain things, treasures arrived from the sky. What the Islanders lacked was an understanding of what was really going on.

The Islanders abandoned their gardens - why work to be poor when cargo from the sky makes you rich - and set about building crude landing strips and planes made out of straw. They paraded with rifle shaped sticks, wore replicas of headphones carved from wood, and made airplane sounds. They lit fires to mark runways.

Australian CSG Cargo Cultists did not look to the sky for wealth; they knew the cargo comes from underground. Their religion was also founded on a true enough observation. They saw what they took to be great wealth issuing from shale gas and oil wells in the United States. But they were mistaken. They decided to take a short cut. Not for them the time it takes to carefully build up a genuinely safe, effective, and profitable business.

The gas cargo cultists sacrificed their country's best agricultural land - why farm when drilling for gas will make us billionaires? They set about building replicas of what they had seen in the United States. They knew that only one LNG export facility was needed in Gladstone Harbour, but they wanted to build four replicas to be sure of getting their fair share of the treasured cargo. In the end they built three, one for each company.

The gas cargo cultists drilled and drilled, built pipelines and factories. They chanted magical mantras, "We want CSG", "rivers of gold", "jobs, jobs, jobs", and paraded around at conferences and on television. Politicians crafted spells they called "legislation" hoping to replicate the magic of the Halliburton Loophole.

And then, as they looked for the cargo to arrive, the oil price fell with worldwide increasing supply and decreasing demand. China's economy slowed and the world looked towards a decarbonised future. Politicians did not like the U.S. Fracking and the Australian CSG/LNG ventures being likened to a Ponzi scheme. In the U.S., the investment bubble was inflated with billions of newly printed dollars looking for somewhere to go.

In 2011 the New York Times quoted gas industry sources, "The word in the world of independents is that the shale plays are just giant Ponzi schemes and the economics just do not work". "This is an industry that is caught in the grip of magical thinking".

Fast forward to 2016. The export LNG industry has expanded massively and by 2018 Australia will become the world's biggest exporter of LNG. But revenues from the Petroleum Resource Rent Tax (PRRT) will remain stuck at 2003 levels for decades to come as companies avail themselves of generous tax deductions and conditions negotiated by former Resources Minister Martin Ferguson and former Prime Minister Julia Gillard.

The economics is more secure for the Labor, Liberal, and National ex-politicians who take the "revolving door" from their "public service" careers to lucrative work for fossil fuel companies. Martin Ferguson, the man responsible for Queensland LNG export contracts, left parliament to immediately work for the Australian Petroleum Production and Exploration Association (APPEA).

Too many politicians bought the hype peddled by gas bubble spruikers, and now there is a real risk of the Australian people suffering serious harm. What are we to make of the spectacle of an Australian Prime Minister and Treasurer ridiculing the Australian National University for divesting themselves of shares in the gas miner Santos? And Santos shares were worth a lot more then.

The gas gamblers and their political operatives formed a Cargo Cult, gambled with Australia's future, "doubled down on black", and it looks like we are all going to lose. Where were the politicians and regulators who understood the dangers, had the power to change things, and were responsible for protecting the Australian people? What kind of "risk management" and "cost benefit analysis" did they carry out before citizens were compelled to live in gasfields?

Risk Management - Profit Procurers Vs People Protectors

Involvement with the unconventional gas issue has taught me that Risk Management and Cost Benefit Analysis have two distinct meanings depending on whether you are a "Profit Procurer" or a "People Protector". Both manage risk. Profit Procurers manage the risk to gas company profits and power. People Protectors want to protect people and place.

Nowadays, most people understand basic Risk Management principles. Risk Management is the process of thinking systematically about all possible risks, problems, or disasters before they occur, and setting up procedures to avoid the risk, or mitigate and cope with any impact. Cost/benefit Analysis is the reasoned consideration of all the potential costs and benefits of a proposed development or action.

"Duty holders" are legally obliged - they have a "duty of care" - to exercise due diligence and to consider all risks, not just those for which regulations exist, but even hazards which they do not know about. This is the burden an average citizen takes on when they volunteer for a position such as Trustee of a Public Reserve. Such Trustees are obliged to actively seek out risks to public safety and to proactively deal with them. Ignorance is no excuse, and the public has no responsibility to educate Trustees about risk.

Prof Mary O'Kane, the NSW Chief Scientist and Engineer, captured the spirit of Risk Management when she said that risks associated with the CSG industry needed to be managed with "eyes wide open, a full appreciation of the risks, complete transparency, rigorous compliance, and a commitment to addressing any problems promptly".

I expected, as most people did, that managing the risks of operating gasfields in populated areas would be about protecting people and the environment from harm. I thought that cost/benefit analyses would go beyond "benefits" to actually consider "costs". I assumed that the "duty of care" belonged to the politicians, company executives, and landholders who were seeking to profit from forcing others to live, work, and raise families in gas fields.

But for gas company executives and their political supporters, Risk Management has nothing to do with the harm that gas mining might cause people or the environment. As they see it, risk management is about them and their interests. For them, Risk Management essentially translates to "damage control". Their "duty of care" is to themselves and their shareholders. Their goal is to make money. From their perspective, the only risk worth considering is the possibility that people might find out what they are up to and do something to impede their operations or inconvenience their network of sycophants and operatives.

The gas industry believes that there is no need to analyse costs because, as they see it, there is no down-side. For them the issue is straight forward. CSG mining is unambiguously good. Living amongst gas fields is great. Everyone and everything's a winner. Gas mining offers a once-in-a-lifetime "win, win, win" opportunity. All we need is a little trust, some vision, and a positive can-do attitude. There is nothing to worry about because the industry is proven safe. Anyway, should any problem arise our "world's best" regulations will take care of it. And if there is no risk, anyone who says otherwise is mistaken or crazy; either way, they deserve to be scorned.

There are potent commercial incentives for promulgating the fiction that gas mining is safe. If there is no real risk, then there is no need to go to the trouble and expense of genuine risk assessment and management. From there, it is a simple step to the fantasy that gas mining is the ultimate "free lunch", an inexhaustible feed with no bill, a kind of Magic Pudding that just keeps on giving.

But back in the real world, turning populated rural landscapes into gas fields is no "free lunch". The gas industry is no Magic Pudding.

Propaganda

For People Protectors, responsible risk management demands honesty, openness to new information, taking responsibility for the well-being of others, and a commitment to reasoned, logical, and respectful debate.

For the gas industry and their Profit Procurers, risk management is about propaganda, perverse reasoning, an indifference to the well-being of others, a willingness to denigrate those who do not agree, and a religious idolatry that worships money above all else.

Profit Procurers do not want people to look too closely at what they say, so they use various propaganda techniques to manage the risk that people might discover the truth.

Profit Procurers like to refer to long periods of time to engender a false sense of security - "CSG has operated in Australia for nearly 20 years, without any health concerns". What does time have to do with it? In 1898 the British Chief Inspector of Factories reported that asbestos had "easily demonstrated" health risks, but nearly 100 years passed before Australia banned asbestos use in 2002.

Profit Procurers use repeated claims of ignorance to give the impression that gas mining is safe - "I am not aware of any compelling evidence that CSG mining can harm health". An elegant, but pernicious feature of this tactic is that such statements remain true even when there is ample evidence available that CSG contaminants harm health, provided that the Profit Procurers keep themselves ignorant of the facts. When someone uses this deception, there is an incentive for them to avoid information that might compromise their cultivated state of ignorance. This is, of course, antithetical to what the average citizen and People Protectors would consider proper risk management.

Profit Procurers like to "play the man and not the ball". They denigrate critics to deflect attention from their weak arguments and to "justify" some very big claims. They feign that gas miners are more sinned against than sinning, and they want us to believe that there is no risk. But if there is any problem, the environmentalists and greenies are responsible for it. Examples of the tactic range from base ridicule to the ridiculous - "The truth is this: Digging coal is no threat to anyone, except the green ideologues who want to enfeeble our economy and enslave our bodies".

Profit Procurers assuage concerns about safety by citing lists of CSG regulations - "The upstream gas sector is well regulated and must comply with a number of acts", and such. But in the real world people do not always follow the rules, and regulations do not guarantee safety. If they did, there would be no crime and no acts of negligence.

Profit Procurers apply a double standard to scientific evidence. They set the bar very low for "proof" that CSG mining is safe, but demand an Olympic high jump for People Protectors who point out potential risks. NSW MLC Scot MacDonald expects the highest standard of scientific evidence - peer reviewed proof of causation - before he will entertain the possibility that there could be any health risk for people living in CSG gasfields. But when it comes to backing his claims, Mr MacDonald offers only an anecdote about what a Camden farmer told him as "evidence" that gas mining has no negative impact on livestock, property values, mental health, the environment, or amenity.

Of course, stories about a farmer's opinions prove nothing, at least not about the safety of the CSG industry. Most CSG pollution is invisible and undetectable by human senses. But just because you can not see them, it does not follow that gasfield pollutants are not there. Taking a Camden farmer's comments as evidence that gas mining is safe, would be like relying on a tradesman's opinion in the 1960s to determine whether or not asbestos was dangerous.

Baseline Data and Scientific Research

The gas industry and governments early on decided to avoid baseline testing of health and the environment. If there is no baseline data, no measure of how things were before drilling began, then regardless of how dirty and dangerous things become later on, the industry can always deny responsibility. They will say that no one can prove that people were not as sick, and the countryside not as polluted, before they turned up. Throw in a few slurs about farmers, and they had an airtight defense - or so they thought.

You might expect that regulatory authorities would have measured such things as atmospheric methane, human and animal health, and air and water quality, before drilling began. But there is no such baseline data.

Profit Procurers take advantage of the public's lack of scientific sophistication. No, I can't prove, and I have no "peer reviewed" research to show that venting every day 3.8 tonnes of VOCs and 6.4 tonnes of particulates into the air above the Darling Downs is a risk to children worth considering. But what do you think?

With no baseline data, health scientists are forced to rely on epidemiological studies which look for statistical correlations between past exposures to something and subsequent harm. This kind of research is difficult and time-consuming. The Vietnam War ended in the 1970s, but the health problems of Veterans and their families were not scientifically studied until the 1990s. It takes time for epidemiological research to catch up with reality.

Nonetheless, a rapidly growing body of scientific research points to potentially catastrophic impacts from operating gas fields in populated areas, and major epidemiological studies are underway. The number of published peer-reviewed studies of the environmental and health impacts of unconventional gas development increased from 6 in 2009 to 154 in 2014, and 96% of the 47 studies that directly assessed health impacts reported potential risks or actual adverse health outcomes. Findings include a correlation between birth defects and how close the mother lived to a gas field during pregnancy, and a relationship between the presence of gas mining and hormone-disrupting chemicals in the Colorado River and aquifer systems used for human consumption.

This is not the first time that Profit Procurers for dangerous industries have argued that a paucity of evidence proves there is no harm. In the 20th century, the leaded petrol, asbestos, and tobacco industries were well entrenched long before the community found out about the damage to health from using their products. Executives knew about the dangers, but actively suppressed knowledge of the truth as they promoted their products as safe, well regulated, and good for the economy. They attacked scientists, and repeatedly lied that there was no credible evidence that tobacco was harmful or addictive, or that breathing asbestos fibres causes cancer, or that ethyl lead accumulates in the bodies of children.

Profits reaped over decades were never discounted to reflect the true costs in suffering, illness, and death borne by the community. Today, like asbestos, tobacco, and leaded petrol in the past, the unconventional gas industry is promoted in the absence of any scientific evidence that it is safe and with no assessment of risks to people and the environment.

Reversing the "Burden of Proof"

Profit Procurers like to reverse what is known in legal and philosophical circles as the "burden of proof", that is, the obligation to provide sufficient evidence to back a claim.

In a criminal trial, the "burden" is on the prosecution to prove that the accused is guilty beyond a reasonable doubt. The defendant enjoys the presumption of innocence, and does not have to prove that they did not commit the crime. A lesser standard of "on the balance of probabilities" applies in legal contexts other than a criminal trial.

In regulatory contexts, the burden of proof rests with those seeking to profit from doing something that potentially exposes the public to risk. The "assumption of innocence" does not apply when a pharmaceutical company wants to sell a new, potentially hazardous medication to the public. Rather, they have to demonstrate the safety and efficacy of their product with scientific studies that compare health data taken before and after people use the medication. The public certainly does not have to prove that the new medication is harmful.

Acting as if they are in a criminal trial where their gas miner client is the defendant, Profit Procurers demand the presumption of innocence for the CSG industry. They insist that their developments and operations be assumed to be safe, unless and until the community can scientifically prove that gasfield pollutants are a risk to health.

Should gas companies have to scientifically demonstrate that their operations are safe before more people are compelled to live in gasfields? Or is it the community's responsibility to prove beyond a reasonable doubt that gasfield pollutants are a risk to health? It depends on whether you want to manage the risk to people or the risk to company profits.

For People Protectors, the onus is clearly on gas companies to prove their operations safe. This is not rocket science. Demonstrating the safety of gasfield industrialisation would have been simple and straightforward. All the companies and regulatory authorities had to do was to collect baseline health and environmental data in the Darling Downs, Camden, and the Liverpool Plains before gas wells were drilled, and then compare this to data obtained later, after the gas fields were operating.

If a regulatory authority, a court, or a government, ever gets around to evaluating the gas industry's claim that their operations are proven to be safe, the decision to avoid baseline testing might come back to haunt the industry. The negligent failure to obtain baseline data means that they can never prove that their operations are safe.

When prompted for evidence to back claims that CSG mining is safe, industry representatives sometimes misrepresent reports and research.

Misrepresenting Research

According to Metgasco CEO Peter Henderson, "There are numerous studies available to show that CSG operations represent a low health risk to the community".

Mr Henderson says that the Australian Institute of Petroleum's (AIP) Health Watch program proves that the CSG industry is safe.

> "The people most exposed to petroleum are healthy. The people probably most exposed to hydrocarbon gases and liquids, including substances such as BTEX which

> are naturally found in crude oil, are those who work in oil refineries and conventional natural gas processing plants. The AIP Health Watch program, which has been in operation since 1980 and is run by Monash University, shows that workers in the petroleum and natural gas production industry have better health than the general Australian community and are less likely to die of the diseases commonly causing death - including cancer, heart and respiratory conditions."

But that is not what the AIP study really found. There is no evidence here that going to work in the petroleum industry is a healthy lifestyle choice.

The authors of the AIP Health Watch study say that "selection bias" explains the relatively better health statistics for petroleum industry workers compared to age-adjusted figures for the Australian population. That is to say, subjects in the study were selected from the beginning to be healthier than the average. Pre-employment health checks are mandatory in the petroleum industry, and participants in the AIP study use less tobacco than the general population, so you would expect them to enjoy some better health statistics.

Despite the selection bias, the 14th AIP Health Watch report found that for male employees "two cancers, mesothelioma and melanoma, have been and are still occurring at statistically significantly higher rates than in the general population", and prostate cancer was "also in statistically significant excess". For women employees, the incidence of melanoma "is slightly higher than in the general female population", as is the rate of lung cancer among women. And the findings of a case controlled study provided "strong evidence for an association between previous benzene exposure in the Australian petroleum industry and an increased risk of leukaemia."

Mr Henderson directed me to AGL's Camden Environmental Health Impact Statement (EHIS) which, according to him, "covers the full spread of potential health risks" and "concludes that its proposed Camden Northern Expansion would have posed low and acceptable risks to community health and to air, groundwater and surface water".

I read AGL's Camden EHIA and could find no evidence there that CSG mining in Camden was safe. There was no data comparing health prior to, and following the setting up of, gas fields. In fact, there was no reference to any health data collected during 13 years of operations in Camden.

As the authors explained, like all such Health Impact Assessments, the AGL EHIA is a "desk-top assessment", not a real-world study with data obtained from real people. The report emphasised that for many CSG pollutants only "very limited data" and "no suitable human health guidelines" are available. This "virtual" study also assumed that there are no cumulative, interactive, or magnifying effects when people are exposed to a complex mix of dangerous substances, some of which can damage health in minute doses.

Mr Henderson also cited the Queensland Government's CSG Health Report, but again I could find no reason why he thought that this proved that CSG mining is safe. The report concluded that its very limited data did not establish a definite link between CSG pollutants and illness; an outcome that was inevitable given the nature of the exercise. Nonetheless, the report noted that the information it relied on "did provide some evidence that might associate some of the residents' symptoms to exposures to airborne contaminants arising from CSG activities."

The NSW Chief Scientist's Report

When Prof Mary O'Kane, the NSW Chief Scientist and Engineer, released her final reports in October 2014, the gas industry claimed that Prof O'Kane had given them a "green light" because she concluded:

> "The Review studied the risks associated with the CSG industry in depth and concludes that - provided drilling is allowed only in areas where the geology and hydrogeology can be characterised adequately, and provided that appropriate engineering and scientific solutions are in place to manage the storage, transport, reuse or disposal of produced water and salts - the risks associated with CSG exploration and production can be managed."

Concerned citizens pondered the provisos; what "areas" and what "scientific solutions" was Prof O'Kane referring to?

The crux of the matter seemed to be the Professor's opinion that managing CSG risks required the "careful designation of areas appropriate in geological and land-use terms for CSG extraction". This sounded like a call for long overdue, genuine cost/benefit and risk analyses. It is hard to imagine more inappropriate areas for gasfields than the Darling Downs and the Liverpool Plains.

For Prof O'Kane, hitherto non-existent, baseline health data was essential - "Health risk assessments need to be conducted before a project commences to identify any possible risk to human health and methods to minimise those potential impacts". But there is no such data, so what is to be done to protect communities like the Darling Downs which are already exposed to CSG pollutants?

Prof O'Kane's report is fundamentally flawed. Prof O'Kane inexplicably overlooked air pollution created by the industrial processing of CSG. She inadequately identified drilling, seam depressurisation, spills and leaks, and flaring, as the only sources of gasfield air pollution, and concluded, "Of the risks identified, spills and leaks appear to be the only ones that have occurred to date". It was as if Prof O'Kane did not know about the massive amounts of air pollution reported by the gas industry to the National Pollutant Inventory (NPI) even though there were multiple submissions to her investigation that referred to this data.

Not one of Prof O'Kane's ideas about how CSG health risks might be managed is relevant to the threat posed by air pollution from the industrial processing of CSG in the Darling Downs.

No, "dilution" can't be "the solution". It might be for an occasional, limited release of a pollutant, but not for massive amounts of dangerous substances released constantly into the air above a populated area. You cannot assume that thousands of tonnes of pollution are going to dissipate to nothing, as if the atmosphere is an infinite sponge. And you cannot rely on the wind to blow all that pollution away on to someone else.

CSG air pollution tends to concentrate in particular areas depending on factors such as wind direction, time of day, season, type of pollutant, factory location, surrounding topography, and many other factors. Beware of the morning dew. At night, pollution tends to settle into lower areas, concentrating near the ground, rather than dissipating into the air above.

As Prof O'Kane explained, the scientific study of how pollutants dilute in the atmosphere is complex, and should be performed before licences are granted in the first place; and the professor here was referring only to minor emissions from spills and leaks and such. Prof O'Kane did not even consider air pollution from CSG processing, so don't hold your breath waiting for any scientific study of this great big "elephant in the room". No one knows what happens to the air pollution above Darling Downs gasfields, or how much of it is being breathed in, absorbed, or consumed by the people forced to live there.

Prof O'Kane suggested that "the maturity of the industry" would guarantee effective risk management; as if with the mere passage of time Profit Procurers in the tobacco and asbestos industries had morphed into People Protectors concerned about the public's health.

It is not clear how Prof O'Kane's recommendations for "improved" standards, scientific research, technological development, and regulation would reduce the gigantic volumes of air pollution created when CSG is mined and processed in the Darling Downs.

Nonetheless, if all of Prof O'Kane's recommendations for baseline data and ongoing monitoring of pollutants were adopted, it would probably be the end of the unconventional gas industry. The industry can only flourish if people are kept in the dark. If the science envisaged by Prof O'Kane is ever performed, the truth will be well and truly out, and that would be the end of the ill-conceived agenda to turn fertile Australian farming country into gas fields.

Risk to Aquifers

In 2011 Federal Liberal Senator Bill Heffernan warned, "We don't want to look back in 50 years time and regret what we are doing". Senator Heffernan elaborated on his concerns in a 2012 letter to the author:

> "I am most alarmed about the contamination of aquifers from coal seam gas fracking and we need to adopt a full and comprehensive, social and environmental assessment of current and future coal seam gas projects." "More concerning is the environmental impact and damage to our prime agricultural land caused by fracking to our water supply and impact on Australia's food security, this is most disturbing".

In 2015 NSW MLC Rev Fred Nile noted, "Recently we have seen contaminated leaks from coal seam gas projects in the Pilliga State Forest and in Gloucester".

In 2005 the former NSW Energy Minister Mr Chris Hartcher said:

> "However, the people of the Central Coast cannot be sacrificed on the altar of economic expediency. Their entitlement to clean, safe water must be paramount." "Experiences in the United States of America, and in the State of Wyoming especially, clearly demonstrate disastrous problems associated with this industry through groundwater loss, contamination and waste water… the ground water issue is not an irrelevancy or one to be dismissed in a single rhetorical phrase. It is at the very heart of this debate."

It is worth noting that the US industry argues that extracting shale gas is inherently safer than mining CSG because it takes place at a much greater depth, further away from aquifers used by humans.

In 2005, NSW Liberal MLC Dr Peter Phelps said:

> "This is the big lie which every one of them believes and which is propounded by the green movement time and again; that is, that there is aquifer cross-contamination. We have evidence to prove that that is a lie. We have had coal seam gas mining operations in Australia for 20 years and there is not one instance of proven aquifer cross-contamination. After 20 years of mining there is not one piece of evidence to demonstrate aquifer cross-contamination. That is hardly surprising when one looks at the structures used on boring operations. There is a steel pipe covered by concrete and then another steel pipe, which is a sure-fire way of avoiding cross-contamination."

Many sections of pipe are joined together to make a gas well. Joins leak, steel rusts, and concrete crumbles. Some wells leak from the start, all wells fail eventually, and on the ground things do not always go to plan. Gas mining company Metgasco's drilling notes give us a glimpse of what drilling a gas well is really like.

> "Issue #14 - Riflebird E4 (Lost Circulation; Loss of integrity). Pumped 2200 litres of grout into annulus but did not get a return to surface; took another 3000 lt without any return to surface; another 400 l with swelling pellets; 'It is obvious we have very little if any grout seal around the casing'; grouted; added Tuff swell, bran etc; still no returns to surface; used 'lost circulation material'; pumped bentonite and shredded paper to penetrate cracks; gas metre went into alarm mode 'off scale'; hole spurting air and water; volumes of gas."
>
> "Issue #15 - Riflebird E5 (Lost Circulation; Intercepted large water flows; Borehole collapse). Early problems with sand & gravel; lost circulation completely @ 98-100m; losing drilling mud to the formation; broke suction due to mud pits collapsing and losing mud; 'The site is a mess. The mud pits are a mess. See what tomorrow brings' caving clay & sand well collapsed ~96m; Large water flow 25 lt/sec @ 92m; unable to air drill; hole blockage @ 716 m."

The case of aquifer contamination from a leaking Santos waste water pond in the Pilliga is particularly sobering. CSG waste water leaked through a torn plastic pond liner to contaminate an aquifer with uranium levels 20 times higher than safe drinking limits, as well as high levels of lead, aluminium, arsenic, barium, boron and nickel. As Associate Professor Melissa Haswell-Elkins commented:

> "This incident demonstrates that aquifer contamination does occur, despite the assurances we so often receive to the contrary." "While we have some comfort that this particular aquifer is not a source of water for humans, livestock or crops, we remain concerned about potential problems where mining is close to water sources that do have these uses, and the health implications that flow from this and many other aspects of the industry."

There is precious little monitoring going on, but taken together, the Pilliga aquifer contamination and a January 2015 report that monoethanolamine borate, a fracking chemical, was found in water samples near AGL's pilot CSG gasfield at Gloucester raise the disturbing possibility that such contamination could be more the rule than the exception.

CSG Waste Water - Turning a Problem into a Product

Eliminate concern about health risks, and CSG wastewater becomes a profitable product. It is an impressively creative business plan; build gas fields, sell the gas, and then sell the untreated waste water back to farmers who lost their bore water because you built the gasfield.

Metgasco CEO Mr Peter Henderson laid it out in his 2013 letter to the author:

> "We have a range of studies to demonstrate that our water, after some salt removal, is suitable for irrigation. It is suitable for stock watering, even without salt removal."

Mr Henderson would not show me his "thorough analysis" or the "range of studies" that supposedly indicated his CSG waste water was worth bottling. But AGL's CSG waste water from its operations in Camden contains arsenic, strontium, barium, nickel, lead, bromine, iodine, fluoride, methane, naphthalene, benzo(b)fluoranthene, benzo(a)pyrene, benzene, and Total Petroleum Hydrocarbons (TPHs) at levels which exceed Australian drinking water guidelines. In Camden, the maximum readings for arsenic, barium, benzene and the TPHs exceed drinking water standards ten or more times. I understand that, after treatment at an industrial waste plant, the Camden CSG waste water is used to make bricks.

The unconventional gas industry has no evidence that living in gas fields had been proven safe. Nonetheless, there are incontestable facts regarding the nature and impact of operating industrialised gas fields where people live and raise children. The question is, what do we make of these facts? Do they indicate the likely presence of risk? Or do they support the a priori assumption that unconventional gas mining is in all ways safe for people, animals, and the environment?

The Physical Reality of Unconventional Gas Mining

Gas mining traditionally uses a limited number of wells in unpopulated, remote areas to extract gas from naturally formed underground reservoirs. "Unconventional" mining for gas in seams of coal, shale, and "tight sands" typically involves thousands of interconnected wells spread across populated, rural landscapes - 40,000 CSG wells are planned for Queensland's Darling Downs. Underground, these vertical wells connect to kilometres of horizontally drilled, fractured, de-watered, and depressurised gas-bearing strata.

All forms of Unconventional Gas mining - shale, coal, and tight sands - share a common technology and involve the use and liberation of similar substances.

A fundamental problem with Unconventional Gas mining is the unmanageable creation of dangerous pollution. Liquefied Natural Gas (LNG) burns somewhat cleaner than coal, but this benefit to consumers is only achieved by polluting the air, water and soil, and harming people's health, where the gas is mined and processed.

A typical CSG well is drilled to a depth of about 1,000 m, which is equivalent to the height of 8 Sydney Harbour Bridges stacked one on top of the other. In gas wells, the diameters of the hole drilled through rock, and the sections of steel pipe inserted into it, narrow with increasing depth. At 1,000 m the hole in the rock is about 22 cm wide with an 18 cm diameter steel pipe. The bore hole and pipe narrow further at greater depths. The steel pipe ends where horizontal drilling begins.

To prevent methane and other gases from escaping into the atmosphere via the borehole, and to block the movement of gases and liquids between rock layers, aquifers, and the depressurised gas seams, for the entire vertical length of the well the space between pipe and rock has to be effectively sealed for all eternity. This is purportedly achieved by pumping cement into a gap between pipe and rock - a space which is 1.9 cm (¾") wide for the deepest 800 m of the borehole.

The creation of a continuous cement barrier in a 1.9 cm (¾") gap a kilometre underground is the engineering marvel that supposedly guarantees the safety of unconventional gas drilling. The manufacturer's warranty for steel pipes in CSG wells is 2 years. There is no guarantee on the cement.

CSG, Tight Sands, and Shale Seam gases are predominantly methane, but can also contain carbon dioxide, carbon monoxide, and nitrogen; hydrocarbons, including ethane, propane, butane, benzene, toluene, and xylenes; other volatile organic compounds (VOCs), such as carbon disulfide, hexane, cyclohexane, ethylbenzene; toxic non methane hydrocarbons; and various particulates.

Gas bearing seams also naturally contain: various salts; heavy metals, such as lead, arsenic, mercury; radioactive materials, including radium 226, radium 228, thorium, strontium, uranium and radon; and barium, boron, and sulphate.

During drilling, fracturing, and dewatering of gas-bearing seams, Unconventional Gas mining uses, produces, and liberates chemicals, as well as dust, particulates, and diesel emissions.

In Australia, there is no requirement for disclosure of all chemicals used in Unconventional Gas mining operations. There is no publicly available comprehensive list of chemicals used in fracking. Most chemicals used in Unconventional Gas mining have not been assessed for their toxicity, persistence, or long-term health impacts. There has been no assessment of new compounds that form when mining chemicals interact with other substances or with natural catalysts such as sunlight, water, air, and radioactive elements.

In Australia, about 18,500 kg of chemical additive is used per CSG well, and up to 40% (7,500 kg) of this is not recovered. That is to say, with each well, about 7.5 tonnes of chemicals stay underground.

In Australian Unconventional Gas operations, drilling fluid can include dangerous substances used as viscosifiers, weighting agents, bactericides/biocides, corrosion inhibitors, defoamers, emulsifiers and deemulsifiers, lubricants, scale inhibitors, polymer stabilisers, breakers, and salts.

Hydraulic fracturing fluids, used to facilitate gas flow, include gelling agents, gel stabilisers and breakers, friction reducers, surfactants, biocides, clay stabilisers, buffer fluids, iron control agents, pH adjusting agents, and diluted acid to dissolve minerals.

Substances used or liberated by Unconventional Gas mining can escape into air, soil, and water systems during most stages of the gas production process - from exploration drilling, production testing, well completion, processing, venting, flaring, and waste water storage, through to transportation and supply of the processed gas.

Gas is liberated when injected and naturally occurring water and chemicals are pumped from the gas-bearing seam to the surface via the steel bore pipe. So-called "produced water" is stored in huge dams lined with strips of builder's plastic taped together to prevent leakage and contamination of surrounding soils.

The gas industry claims that reverse osmosis filtration renders CSG waste water safe for human use and for discharge into the environment. Chemicals that are not successfully treated by this form of filtration include bromoform, chloroform, naphthalene, nonylphenol, octylphenol, dichloroacetic acid, and trichloroethylene.

CSG wastewater has been released into Queensland waterways, but there are options for disposing of CSG wastewater other dumping it into rivers. Spraying untreated wastewater onto roads to suppress dust is popular. Some gas company executives tout filtered, and in the Northern Rivers even unfiltered, CSG wastewater as suitable for irrigating crops. The NSW Environmental Protection Agency (EPA) pulled the pin on such a trial in Gloucester when diluted CSG water from AGL's operations created a build up of heavy metal residues in the soil.

Hailed by some politicians as a great step forward, rather than a leap of faith, the Queensland Gas Company (QGC) paid for a 20-kilometre pipe to each day transport up to 100 megalitres of treated CSG water to Chinchilla's weir, the source of the town's drinking water and a favourite swimming spot for children.

Water pumped from gas bearing coal seams is salty. Rural Australians have long known that salt is better left underground, and should not be brought to the surface where it ruins fertile country. CSG produced water stored in ponds is sometimes treated with chemicals and processed by desalination plants to remove the salt, which is stored in brine ponds for later disposal.

Using the National Water Commission's estimate of an annual extraction of 300 gigalitres of water by the CSG industry, it is projected that 31,000,000 tonnes of salt will be brought to the surface over the next 30 years. This is enough salt to fill the Melbourne Cricket Ground (MCG) 15 times over. The industry has no idea how it might safely dispose of this much salt, but when waste water ponds are built near rivers, floods sometimes relieve the miner's problem for a time.

When drilling for gas, the evaporation of "flowback" (i.e., the injected fluid that returns to the surface with substances from the gas seams) can cause severe air pollution. Flaring, the burning off of gases, releases hydrogen sulfide, methane and BTEX chemicals (benzene, toluene, ethylbenzene and xylene) into the air, as well as metals such as mercury, arsenic and chromium.

During construction of a gas field, much dust and particulates are created by vehicles, drilling, and spraying waste water on dirt roads. Gas mining is good business for truckies, and every stage of operation creates heavy truck traffic. Diesel exhaust from vehicles and other equipment contains a mix of fine particles, and gases like carbon monoxide, oxides of sulphur and nitrogen, and volatile organic compounds including BTEX.

The Australian Unconventional Gas industry is most developed in Queensland's Darling Downs. This rich agricultural area in the drainage basins of the Condamine and Maranoa Rivers, west of Brisbane, is home to 5.5% of Queensland's population. About 20 percent of the residents are children 14 years or younger.

Physics dictates that it takes a lot of energy to process CSG. Pumping huge volumes of water and chemicals into and out of kilometres of wells and fractured seams is no easy task. We are fortunate that the Australian Government's National Pollution Inventory (NPI) provides at least a partial accounting, based on gas industry data, of the air pollution created during CSG processing. The NPI collates data for fugitive emissions, and pollution from fuel combustion, drilling, vehicle movements, and the venting and flaring of gas.

NPI data from 20 CSG facilities in the Darling Downs indicated that over a one-year period (2013-2014) pollutants emitted into the atmosphere included about 1,383 tonnes of Volatile Organic Compounds (VOCs), 13 tonnes of Acetaldehyde, 2.2 tonnes of BTEX, 241 tonnes of Formaldehyde, 8,788 tonnes of Carbon Monoxide, 12,189 tonnes of Oxides of Nitrogen, and 2,325 tonnes of particulates. Much of this pollution was concentrated in an intensely industrialised corridor in the Darling Downs.

NPI data indicated that on an average day during 2013/14, CSG processing released 3.8 tonnes of VOCs, more than 57.4 tonnes of Carbon Monoxide and Oxides of Nitrogen, and more than 6.4 tonnes of particulates into the air above the Darling Downs.

To visualise the scale of CSG air pollution in the Darling Downs, I recalculated NPI data to give the number of 20 litre plastic drums (height 39 cm, width 28 cm, depth 21 cm) that would be needed to contain the quantity of liquid Volatile Organic Compounds released into the air during the reporting year 2013/14. If stacked in a column, one on top of the other, these drums would stand about 28 kilometres high, or about 3 times the height of Mt Everest.

It is early days for the gas industry in Queensland. The gasfield industrialisation of the Darling Downs, the Surat, and other rural areas is very much a work in progress. The industry is set to expand a number of times over, with a proportionate increase in pollution.

Soil can be contaminated by gas mining pollutants accidentally, via spillage or leakage of chemicals and wastewater, and deliberately, by putting wastewater onto roads, disposing of drilling mud in landfills, and by spraying wastewater and drilling mud onto agricultural lands. Wind can blow dust onto soil from dried waste water ponds and roads that have been sprayed with waste water.

Farmers appreciate the importance of the morning dew - it is sometimes all that gets a pasture through drought. Dew on grass is an unassessed pathway for gas mining air contaminants that settle overnight to pollute soils and to enter the human food chain. Nothing is known about the nature, quantity, or range of distribution of gasfield pollutants dissolved in and transported by dew.

Nature abhors a vacuum. As intended, taking water from deep underground frees up previously bound gases which then either move up the well, or work their way through fissures in the rock. An unknowable network of conduits for the liberated gas is created by drilling and hydraulic fracturing, and by the de-watering of previously existing cracks and faults.

The removal of vast amounts of underground water and gas creates a three-dimensional zone of negative pressure. Water and rock from zones of higher pressure, above, below, and beside the depressurised seam, is forced towards cavities. As the Earth seeks to equalise pressures, the most obvious consequence of this induced geologic turmoil is the lowering of water tables and the depletion of farm bores.

As CSG mining company Santos explained,

> "There can be significant losses in pressure both within the (coal seam) 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."

If depressurising a deep coal seam causes a drop in water levels closer to the surface, it means that CSG mining has fractured sandstone layers and/or opened up pre-existing fissures. These pathways allow gases, chemicals, and water from different geologic strata to mix, thereby altering groundwater chemistry. They also allow greenhouse gases that have been safely sequestered since deep time to vent into the atmosphere.

Vast gas fields drill for methane here and across the United States. Given its potency as a greenhouse gas, most people would expect that gas companies, regulatory authorities, and scientists have measured methane concentrations in the air above gas fields, but they have not.

Apart from a few tests by a scientist in Colorado, our only insight into the potentially planet changing consequences of Unconventional Gas mining comes from the pioneering 2012 work of scientists from Southern Cross University's Centre for Coastal Biogeochemistry in Lismore. We are indebted to them.

As Dr Isaac Santos and Dr Damian Maher drove the 500 km from Lismore to the Tara gas fields in Queensland's Darling Downs, their instruments recorded atmospheric methane concentrations about the current global average of 1.8 parts per million (ppm) - atmospheric methane concentration has risen nearly 160% since pre-industrial times.

When the SCU scientists reached the gas fields near Tara, methane and radon readings increased threefold. Australia set a new "world record", when methane levels of 6.89 ppm exceeded the previous highest reading from a Siberian gas field. The chemical "fingerprint" (i.e., methane-CO2 isotope ratio) indicated that these emissions were coal seam gases. When the scientists tested the bubbling Condamine River, they found methane concentrations of 53 ppm, and again the chemical signature of coal seam gas.

As Dr Maher explained, the SCU scientists discovered a blanket of methane, of unknown thickness, extending tens of kilometres around Tara:

> "We are talking about enrichment (levels of methane) over scales of 10, 15, 30 kilometres. So this suggests that we don't have just one leaking well, it suggests that we have got wide scale enrichment of atmospheric methane."

Why is there a landscape-scale venting of coal seam gases into the atmosphere around Tara? According to the SCU researchers:

> "In natural conditions, methane is contained within the coal seam by water pressure…what happens (in CSG mining) …we get lowering of the water table, horizontal drilling, fracturing, infrastructure leakage, but our evidence suggests that we also have leaks through the soil as well, and these leaks through the soil are not counted in any fugitive estimates."

Many Queensland CSG wells leak methane, but the real threat - the "Pandora's Box" scenario - is the uncontrollable escape of coal seam gases across landscapes.

Methane is colourless and odourless. You can see escaping gas in the Condamine River because it bubbles through water, but it makes no sense to assume that the ancient greenhouse gases are venting only through rivers. We just can not see it coming out of the ground, but that does not mean it's not there.

And no, the Condamine River has not always bubbled like a spa. If it had, we surely would have heard about the wondrous, bubbling river years ago. Greenhouse gases have not been spewing from the Condamine for millions of years. You might thank the gas miners for this new "natural wonder", but they are shy about taking credit.

The Human Dimension

The transformation of rural landscapes into industrialised gas fields profoundly changes the lives of the people who live there. But the gas experience is not necessarily stressful, and is not seen as undesirable by everyone. It depends on your perspective, and whether you are a gas field winner or loser.

People who profit from gas mining tend to consider it a good thing. If they profit enormously, they think it is a very good thing. Company executives, shareholders, and employees see gas mining as their livelihood. The economic benefits ripple out to contractors, hoteliers, accommodation providers, sex industry workers, drug dealers, some property owners, and others who benefit financially.

The people threatened by, or who suffer losses or injuries from, gas field development are most at risk of developing symptoms of emotional distress and physical ill-health.

Country people tend to earn less, and have less access to services and facilities, than do town and city folk. But farming families usually feel none the poorer for that. Their compensation is being able to work independently in natural surrounds on their own land.

The values of rural properties fall in areas which are subject to gas drilling or slated for gas field development. As Andrew Stoner, then Leader of the NSW Nationals said in February 2013:

> "I wouldn't want a CSG well five metres from my property. It's going to affect my property value a hell of a lot. Nobody is going to want to buy that value, ah that piece of land rather, um, and there's always the potential for something to go wrong, so I understand why people are concerned."

In effect, the gas induced loss of land value is a compulsory, cruel transfer of intergenerational wealth from farming families to mining companies. For many farming families, their land is their life's work. Their homes and farms are their major assets, and often the only legacy they leave their children. For affected rural people, the loss of property value and damage to their land is resented deeply and feels like a personal injury.

The CSG industry cannot be integrated into a functioning regional economy because it can only give by taking; it always "robs Peter to pay Paul". The industry generates short-term activity, but devastates the long-term wealth creating capacity of established local industries.

Respect for government diminishes when principles of "a fair go" and an economic "level playing field" are usurped by a form of "command and control" Socialism that favours powerful mining companies over small businesses and individual citizens.

Economic activity is not, of itself, necessarily a good thing. Burning a town to the ground would fire great economic activity, and usher in a boom time for builders, Bunnings, and brickies; but that does not mean it is a good idea. Putting gas fields across prime farming country might give GNP a kick, but that does not mean it is in Australia's best interests.

Every rural landowner subject to a Petroleum Exploration License (PEL) faces the prospect of gas companies being legally empowered to forcibly enter their properties, build roads, set up camps, drill wells, dig dams to hold contaminated water, and establish noisy, brightly lit up well sites that run 24 hours a day for years.

The sense of threat that comes with such changes can trigger the "fight or flight" response that is built into us and all animals. Anxiety is a protective emotion that signals the presence of danger. Adrenaline and anger prepare us to fight or run. If the ancient biological response works to remove the danger, all will be well. But this response cannot work with a threat as complex and dangerous as gasfield industrialisation, and Nature's protective response can break down leaving chronic stress, anger, and depression in its wake.

For affected rural people, the loss of control over their land, the disregard of their right to the quiet enjoyment of home and assets, and the diminished quality of their lifestyles creates emotional shock. Anxiety and grief, complicated by disturbed sleep due to noise and light pollution, can result in debilitating symptoms of psychopathology.

Country people often feel a bond, a spiritual connection, to the land they work and care for. My wife and I farm, and just about every landholder we know shares our desire to pass on our properties better for our having lived on them. The distress felt when the land someone loves is damaged has been described as "Solastalgia", a loss of solace. For people who care, their powerlessness to protect Mother Earth and their grief over the loss of "Nature's gifts of beauty rich and rare" cuts deep.

After I gave evidence to the NSW Parliamentary Inquiry into CSG, a woman from Tara told me how she visited a farmer friend to find him curled up on the floor, crying. He was being driven mad. He could not escape the noise of a nearby gas compression station. He could not sell his land. He could not afford to move away.

Rural communities are grieving for the loss from suicide of George Bender, a well-known Darling Downs farmer. George fought the gas miners for years to keep them off his land, before he succumbed to the relentless pressure. A woman who attended George's funeral cried as she told me about the dreadful impact this event was having on the local community. She told me about intimidation, bullying, and harassment suffered by people who resisted the gas companies.

And, of course, there are few things more distressing in life than serious illness suffered by family members.

Risks to Physical Health

Dangerous substances used or liberated by gas mining expose communities to a complex mix of persistent, bio-accumulative, toxic, carcinogenic, mutagenic, teratogenic (i.e., agents that interfere with embryonic development), and hormone disrupting pollutants. These can seriously injure health even in minute quantities, measured in parts per billion.

Of special concern are the massive amounts of endocrine (hormone) disrupting chemicals released into the environment. In our bodies, tiny amounts of hormones control basic functions such as digestion, growth, emotions, sexual development, reproduction, sleep, and the immune response. About 100 of the chemicals used in gas mining are known or suspected to be hormone-disrupting. Exposure to tiny amounts of these substances can profoundly damage health and increase the risk of birth defects, cancer, and neurological and other diseases, especially in children. Health effects can be unpredictable and delayed, and can remain hidden for decades and span generations.

Children have been likened to sentinels because they are more vulnerable to gasfield pollutants than are adults. Children are likely to be the first to fall ill. Relative to adults, kids are closer to the ground and tend to be more active outside. They drink more water, breathe more air, and eat more food per kilo of body weight then do adults. Children have a longer "shelf-life", and their living longer than adults puts them at greater risk from illnesses such as cancer that take years to develop.

As was the case with thalidomide, children are particularly sensitive to gasfield pollutants during critical stages of development. A child's health can be affected by its mother's exposure to gasfield pollutants during pregnancy, and even by the exposure of its mother and father prior to the child's conception. Elevated levels of symptoms suggestive of nervous system damage have been found in children in the Tara area.

Only two of the 23 most commonly used fracking chemicals said to be used in Australia have been assessed by the National Industrial Chemical Notification and Assessment Scheme (NICNAS), and neither of these has been specifically assessed for use in fracking.

It will never be possible to know how much pollution the Unconventional Gas industry creates, but thanks to the aforementioned Australian Government's National Pollutant Inventory (NPI), I can at least give you a sense of the nature and scale of gasfield air pollution. I will discuss a few of the many dangerous substances released by the CSG industry into the air above the Darling Downs during the 2013/14 NPI reporting year.

On an average day, CSG processing emitted 3.8 tonnes of Volatile Organic Compounds (VOCs) into Darling Downs air.

VOCs, including the BTEX chemicals (benzene, toluene, ethylbenzene, xylene) can cause eye, nose, and throat irritation; headaches; dizziness; respiratory distress; visual disorders; memory impairment; loss of coordination; nausea; and damage to liver, kidney, and the central nervous system. Some VOCs are very toxic and cause cancer and other irreversible health effects including neurological problems and birth defects.

On an average day, the CSG industry released over 662 kilograms of formaldehyde into air above the Darling Downs.

Exposure to low levels of formaldehyde irritates the eyes, nose and throat, and can cause skin and lung allergies. Higher levels of exposure cause a build up of fluid in the lungs, and death. Formaldehyde is classified as a known human carcinogen by the International Agency for Research on Cancer (IARC) and as a probable human carcinogen by the U.S. EPA.

Every day, CSG processing emitted 24 tonnes of carbon monoxide into the Darling Downs air.

Inhalation of low levels of carbon monoxide can cause headache, dizziness, light-headedness and fatigue. Exposure to higher concentrations can cause sleepiness, hallucinations, convulsions, loss of consciousness, and death. Exposure can cause personality and memory changes, mental confusion, and loss of vision. Long term chronic health effects including heart disease and nervous system damage can occur from low level exposures. Children born to pregnant women exposed to carbon monoxide can exhibit low birth weights and other defects.

On an average day, CSG processing added 33.4 tonnes of oxides of nitrogen to Darling Downs' air.

Exposure to low levels of oxides of nitrogen can irritate eyes, nose, throat and lungs, and produce coughing, shortness of breath, tiredness and nausea. Breathing high levels of oxides of nitrogen can cause rapid burning, spasms, and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of tissues, a build up of fluid in lungs, and possibly death.

On an average day in the Darling Downs, CSG processing emitted more than 5.5 tonnes of particulate matter PM10, 892 kilograms of PM2.5, and an unmeasured quantity of ultra-fine particulates, into the air.

Particulates, and especially the finer PM2.5 particles which are 40 times smaller than the width of a human hair, can be drawn deep into the lungs where they cause inflammation and spread damage throughout the body. Ultra-fine particles (PM0.1) can penetrate cells and change genetic material.

In gas fields, dust and particulates are especially dangerous because they hydrate and absorb toxic chemicals from the surrounding air. If inhaled, these particulates take chemicals deep into the body. Particles that fall to the ground can be tracked into the house, where they can be inhaled after vacuuming. Recent research suggests that there is no safe level of exposure to particulates and, as usual, risks are greatest for sensitive groups such as the elderly and children.

There is no doubt about it. Unconventional Gas mining and processing involves the release of dangerous substances into the environment.

Conclusion

In evidence to a September 2011 hearing of the NSW Upper House Inquiry into CSG, I tried to communicate my fears for the future:

> "I am deeply concerned that if this industry is allowed to permanently change the land and country life, then the result will be widespread emotional distress, social disruption and political turmoil. There is great anxiety and fear in the community… If governments perpetuate the deliberate destruction of property, lifestyle and prospects for country Australians, many will become depressed, some will suicide, but some will respond with anger, revenge and violence."

As I write this in February 2016, in NSW there are no Petroleum Exploration Licences in the Northern Rivers or Gloucester. The future of Santos's operations on the Liverpool Plains is uncertain due to economic factors and their lack of a social licence. There are moratoriums on the unconventional gas industry in Victoria and Tasmania. But in Queensland, the industry continues unabated.

I remain deeply concerned about the widespread emotional distress, social disruption, and illness that this industry is inflicting on citizens in the Darling Downs. Unconventional gas mining has permanently changed the land and life in the Downs for the worse, forever. Affected citizens in the Darling Downs community are suffering great anxiety, fear, and depression as a consequence of their being forced to live in gasfields.

I respectfully request that the Committee do all that it can to alleviate the suffering of citizens affected by Unconventional Gas mining and protect communities and country from further harm.

Yours faithfully,

Dr Wayne Somerville