



by Dr. Marion Carey

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Coal Seam Gas: future bonanza or toxic legacy?

“When one tugs at a single thing in nature, he finds it attached to the rest of the world”.

John Muir

John Muir was a writer and scientist who believed that protecting nature was vital to Man’s physical and spiritual health and well-being.¹ He seems to have understood that by tampering with natural systems without fully understanding them, we may cause unintended consequences in other natural systems.

The rapid expansion of coal seam gas (CSG) mining in Australia, has the potential for unintended consequences

which could put at risk other important natural resources such as safe long-term water supplies, clean fertile agricultural land and a countryside in which people are happy to live. Industry and state governments have been assuring us that this rapidly expanding technology is safe for people and the environment and can deliver huge economic returns. But what is their evidence? Disturbing information has been trickling through from the gas fields in the USA, where some observers have called the global gas drilling


boom “an uncontrolled health experiment on an enormous scale”.² In Australia, there has been an unprecedented groundswell of opposition to the expansion of the CSG industry, with opponents right across the political spectrum. A recent federal Senate Inquiry into this issue suggests there are many unanswered questions. It is appropriate to question whether the legal and administrative protections are adequate to ensure public health is not harmed and that environmental damage does not leave a legacy for generations.



Large scale coal seam gas development poses poorly assessed, yet potentially serious health risks to the community

There is the potential for public health to be affected directly and indirectly by CSG operations through contamination of water, air and soil, as well as long-term impacts on rural communities

Current assessment, regulation and monitoring of CSG impacts on the environment, public health and vulnerable communities is insufficient to provide confidence of adequate safeguards



“...gas may be an obstacle rather than a bridge to a cleaner energy future”

What is CSG and how is it extracted?

Coal Seam Gas (CSG) is primarily methane, trapped by water and ground pressure in the pores of underground coal seams. It is extracted from coal deposits that are too deep to mine economically in the traditional fashion. Steel-cased wells are drilled into the coal seams to release the gas.

Where coal seams are deep and of low permeability, the use of hydraulic fracturing or ‘fracking’ may be used. This involves pumping a mixture of water, sand and other additives at high pressure down the well and into the coal seam, fracturing the coal seam and providing a track for gas to flow back.

In releasing the gas, coal seams are depressurised and underground water in the coal seams is released to the surface as a by-product of the extraction process. This can

potentially affect interconnected aquifers above or below the coal seam. An aquifer is a seam of permeable rock such as sandstone that holds water.³

Much of CSG development activity is above the Great Artesian Basin (GAB), one of the largest underground water reservoirs in the world, covering about 22% of Australia’s land mass. This Basin is potentially a source of potable water for generations to come, but studies of its sustainability suggest that its renewal is limited, perhaps non-existent.^{3,4}

Much of our experience with gas extraction comes from North America, where sources are both shale gas and coalbed methane. CSG reservoirs tend to be shallower and have a higher concentration of gas than shale reservoirs. While shale reservoirs may all require fracking,

perhaps half of CSG reservoirs require fracking.⁵ While it is convenient for industry to deny the relevance of the US experience, there are similarities in techniques and chemicals used, and therefore risks and impacts of operation.

What do we know about CSG mining in Australia?

CSG is a multi-billion dollar industry, with mining exploration and production licences covering large sections of Australia.⁶ CSG has been produced in Queensland from the Bowen Basin since 1996, but volumes were initially small. There has been a recent rapid expansion in the industry, with it now encroaching on urban settlements and prime agricultural areas. In the five years to 2008 CSG production in Australia increased by 32 % per year⁷ and governments have struggled to keep up with the rapid development.

Most activity is in Queensland and NSW. Major CSG companies in Queensland include Arrow Energy NL, Bow Energy Ltd, Origin Energy, Queensland Gas Company (BG Group) and Santos. LNG plants are owned by Origin and Conoco Phillips, Santos and Petronas, Arrow Energy and Shell, Queensland Gas Company and BG Group.⁸

Huge investments are underway developing liquefied natural gas (LNG) plants and export facilities to exploit CSG reserves.⁵ Some of this development is impacting on World Heritage listed areas on the Great

Barrier Reef.⁹

The main CSG projects in NSW are the Camden and Gloucester Gas Projects, the Casino Gas Project in the Clarence-Moreton Basin and the Narrabri CSG Project in the Gunnedah Basin. In NSW, major players are AGL, Metgasco, Arrow, and Eastern Star Gas, whose operations at Narrabri have now been taken over by Santos.⁷

The Australian Petroleum Production & Exploration Association Ltd (APPEA) is the peak national body representing more than 80 companies in Australia's oil and gas exploration and production industry.

The CSG industry extracts very large volumes of water and produces huge amounts of waste salt. Some estimates are that there will be 40,000 coal seam gas wells in Australia, with withdrawal of 300 gigalitres of water from the ground each year, producing 31 million tonnes of waste salt over the next 30 years. The industry has not yet come up with a solution for this major waste disposal problem.¹⁰

(A gigalitre is 1,000,000,000 litres).

CSG has been widely promoted as a cleaner alternative to coal, with less greenhouse gas emissions and risk of climate change. However recent research has cast doubt on this: gas may be an obstacle rather than a bridge to a cleaner energy future.^{11, 12}

Are CSG mining methods safe?

It would be at present difficult to undertake adequate health risk assessments of CSG operations as insufficient information has been gathered on the nature and doses of chemicals entering water and air and the exposures of people to these chemicals. However concerns about long-term effects of some chemicals used in or generated by CSG mining include hormonal system disruption, fertility and reproductive effects and development of cancer.

APPEA has listed about 45 compounds used during fracking in Australia¹³ but as there is no

national requirement for public disclosure of all chemicals used, we cannot be sure others are not used. CSG companies frequently infer safety of these products due to the fact some are components of household products. However just because we may have hair bleach or antifreeze in the cupboard does not mean it is safe to drink it.

A range of hazardous chemicals are reported to be used in Australian fracking operations, including ethylene glycol, glutaraldehyde, fumaric acid and 2-butoxyethanol. Ethylene glycol, for example, is used to make anti-freeze. When it breaks down in the body, it forms chemicals that crystallize and collect in the kidneys and can affect kidney function. It can also form acidic chemicals in the body, affecting the nervous system, lungs and heart.¹⁴

“Communities living near hydrocarbon gas drilling operations have become de facto laboratories for the study of environmental toxicology”

The BTEX group of chemicals (Benzene, Toluene, Ethyl benzene and Xylene) are volatile organic compounds and found in petroleum compounds. Long-term exposure to benzene can affect the bone marrow, causing anaemia, and increasing the risk of leukaemia.¹⁵ BTEX chemicals have been used as fracking fluids, even though this practice is now banned in Queensland and NSW. However, the fracking process itself may release BTEX from sediments into surrounding air or water.¹⁶

APPEA assures us “*Some of the chemicals used in fracking may have some toxic characteristics...; however, when diluted such as in fracking gels, they present minimal to no human or ecological*

risks”¹³. It would be interesting to know how this statement can be made in light of the dearth of any properly designed studies of human populations exposed to fracking activities. When we look for published scientific studies demonstrating such safety or in fact health impact assessments by government or other bodies we find virtually nothing. Some US authors have said “Communities living near hydrocarbon gas drilling operations have become de facto laboratories for the study of environmental toxicology”.²

There has been no comprehensive hazard assessment of the chemical mixtures used and their impacts on the environment or human health. Only two of the twenty-three most commonly used fracking chemicals have been assessed by the national regulator (NICNAS), and neither of these has been specifically assessed for use in fracking.¹⁶

A report on one of the two fracking chemicals that have been assessed for use in other situations - the persulfate salts used in hair bleaching preparations - state they are “*hazardous chemicals and ...harmful if swallowed, irritant to the skin and eyes and able to cause allergic responses*”.¹⁷

The companies argue that only a very small percentage of fracking fluids consist of these chemicals, but because of the huge volumes of fluids used, cumulatively these chemicals may still constitute literally truckloads in volume.¹⁸

Additionally, some compounds such as benzene can present a risk to health even in minute quantities (as indicated by the Australian drinking water guidelines for benzene of 1ppb, the equivalent of a drop of water in a swimming pool).¹⁹

What is the impact of CSG on water supplies?

Chief amongst the potential threats to health is contamination of surface and ground waters, particularly drinking water sources. The chemical additives used in fracking, their

degradation products, and compounds mobilised from sediments during the process can pose a risk to animal and human health by contaminating water used for drinking, washing, stock watering and food production. These can include toxic, allergenic, mutagenic and carcinogenic substances as well as methane. Waste water coming to the surface may contain volatile organic compounds, high concentrations of ions, heavy metals and radioactive substances.

The CSG industry uses enormous quantities of water, with predicted extractions of around 7,500 gigalitres from groundwater systems over the next 25 years. The National Water Commission is concerned that "CSG development represents a substantial risk to sustainable water management."²⁰

The Australian Senate interim report noted concern about the potential impact of the extraction of large volumes of water on the pressure within adjacent aquifers, and the possibility of contamination of water.²¹ A recent report by JP Morgan indicated a range of risks to water supplies from CSG operations.³

The industry continues to assure us that there can be no contamination of aquifers, despite growing evidence

to the contrary. "CSG wells are constructed in a way that ensures there can be no migration of gas to neighbouring bores and aquifers."¹³

Research in the US has found systematic evidence for methane contamination of drinking water associated with shale-gas extraction.²² Methane in drinking water is a concern for human health and is an indicator of the potential for contamination with other compounds.

For nearly a decade, the residents of Pavillion, in Wyoming USA, complained about drinking water from their wells and a range of health complaints. This area has been drilled extensively for natural gas but the company denied any responsibility, so the US EPA investigated. The draft report released last month indicates that ground water in the aquifer contains compounds likely to be associated with gas production practices, including hydraulic fracturing.

"Chemicals detected... include methane, other petroleum hydrocarbons and other chemical compounds. The presence of these compounds is consistent with migration from areas of gas production." "Residents of the town

have been advised to use alternate sources of water for drinking and cooking, and have adequate ventilation when showering."^{23, 24}

Accumulation of contaminants in aquifers can have long-term impacts. Studies on the transport and fate of volatile organic compounds have found they can persist in aquifers for more than 50 years and can travel long distances, exceeding 10 km.²⁵ Will CSG operators be monitoring aquifers and accountable in 50 years?

The Senate interim report noted "there is a risk that residues of chemicals used in fracking may contaminate groundwater and aquifers used for human or stock consumption or irrigation... It is acknowledged that in one case in Australia, fracking resulted in damage to the Walloon Coal Measures, causing leakage between that and the Springbok aquifer."²¹ The Walloon Coal Measures are part of the GAB, and government and even industry assessments acknowledge the reality of impacts on groundwater here by CSG operations, with reductions in water in landholder bores and inter-aquifer transfer of poorer quality water.^{26,27,28,29,30,31}

Department of Environment. The opinions in the article are not necessarily the opinions of the Department.



Aerial view of Coal Seam Gas wells dotting the landscape on the Darling Downs, Queensland.





A homeowner holds up a glass of water from a now unusable well. The well's contents turned into a methane slurry after coal bed methane development began nearby.

CSG waste water may be stored in tanks or pits at the well site, where spillage can occur, injected into underground storage wells, discharged into nearby surface water, or transported to wastewater treatment facilities.³² Increasingly, large volumes will need to be treated to remove salt and other contaminants, with associated energy costs, and removal methods are not 100% effective.³³

There are already examples of produced CSG water legally discharged into waterways with contaminants of concern to the environment.¹⁰

Is CSG mining a threat to food production?

The Senate interim report noted "Exploration for, or production of, gas has the potential to severely disrupt virtually every aspect of agricultural production on cropping lands and, in extreme circumstances, remove the land from production."²¹

Sustainable food production in Australia and food security may be threatened by CSG activities in number of ways, including:

- impacts on rivers, groundwater

- systems and aquifers, with impacts on the ecosystems that support food production
 - reductions in water quantity and quality with increases in a range of contaminants and salinity
 - loss of land area to CSG infrastructure and related activities such as waste disposal
 - contamination of land and damage to soils through increasing salinity, chemical contamination, changing pH, altered soil structure
 - potential for contamination of food products through chemical traces in crop irrigation or livestock water
 - lowered farming efficiency and quality of life in rural areas
- CSG development involves progressive industrialisation of rural areas. As gas in coal seam wells dries up relatively quickly, new ones continually need to be developed. The huge problem of disposal of salt and brine has not been solved and presents risks to water and land. The Senate Inquiry estimated that the industry will be handling some 750,000 tonnes of salt per annum.²¹
- Food that is chemically

contaminated is not secure food. Australia needs to keep its reputation as a clean green food producer. Only one instance of failure in water treatment which is used to produce food could be disastrous for the food production industry. There are a number of reports of increased death rates and health problems in animals exposed to gas drilling operations in the US, with some needing to be quarantined from the food chain.^{2,34}

In the words of an Australian farmer:

"It is critical that any chemicals used in drilling and CSG well stimulation activities do not migrate to the bores of groundwater users. It is critical also that natural occurring chemicals and compounds in coal seams and strata formations are not mobilised to water aquifers tapped by water bores. Many homes use bore water, the livestock we eventually eat as steak, chicken, lamb and pork from supermarkets more often than not drink it, and the plants we grow for grain and vegetables soak up bore water through their roots and foliage systems under irrigation."³⁵

The Senate report states "The coal seam gas industry is a relatively short lived industry. It may have a life of only 25 to 30 years in most regions. However, if it is not properly regulated, that period of time is sufficient to do serious damage to agricultural productivity on some of the best farmland in Australia... In some areas intensive CSG production may be incompatible with agriculture".²¹

How else might CSG mining affect our health?

CSG operations can also cause health impacts through air contamination. Volatile organic compounds (VOCs) can be released during drilling, methane separation, and by compressors and other equipment. Fracking chemicals and waste water held in evaporation ponds can evaporate into the local atmosphere and be inhaled. In addition to direct effects, VOCs

can contribute to the production of ground-level ozone, a known respiratory irritant that causes lung inflammation and impaired lung function.³⁶

The cumulative impacts of water and air pollution, degradation of agricultural land and loss of amenity and landscape, all have mental health consequences for communities living in a gas field. The CSG process can divide previously close-knit rural communities, and it seems the traditional Australian “fair go” doesn’t apply. Farmers do not have the right to veto a CSG operation on their land which may have been nurtured by their family for generations. This can lead to anger, anxiety and powerlessness. Miners can legally force their way onto farmers’ land with a court order if they don’t comply. One CSG company recently served a court order on a blind Hunter Valley farmer who refused access because he was concerned about damage to his water supply, and needed to preserve the physical integrity of his land to be able to farm without normal vision.^{37,38}

A Hunter Valley psychiatrist has documented the mental health impacts of CSG extraction he has witnessed.³⁹ “Exploration is when the psychological stresses are first noticed in the community. ... uncertainty starts to generate community anxiety.... The community starts to divide between the few who see it as an opportunity for an additional income and the larger number who hear the risks and see little in the way of benefits. ... Seismic surveys come and go with some damage to paddocks, heavy vehicle traffic ruining country roads, and noise. Drilling occurs with the same complications. The town takes on a different look...Lifetime plans are put on hold or cancelled. Property development in the area declines as a result of the general uncertainty. Rental property is more expensive... The gas company employs very few locals.

Exploration wells are fracked to optimize the flow and the wells are flared for months. There is

no explanation of the risks and precautions taken in these fracking and flaring operations. There is no publicity given to any air or water testing. There have been at least two separate unpredicted explosions locally due to gas migration known to the community from just a dozen exploration wells...This results in understandable anxiety about safety risks. In Gloucester this first phase has taken 5 years so far and production has yet to commence”.

Are there adequate safeguards for our health?

Overseas there have been bans or moratoriums on shale gas mining in France and parts of the USA and South Africa, with the European Parliament calling for comprehensive regulation.⁴⁰

The US EPA has begun a study to investigate the potential adverse impacts that hydraulic fracturing may have on water quality and public health.³²

Our own governments’ reassurances appear less convincing once publicly available data start to emerge. The Queensland government reported that in only the first six months of 2011 there were forty-five CSG compliance related incidents, including twenty-three spills of CSG water during operations, four uncontrolled discharges of CSG water, three exceedances of discharge limits, three overflows of storage ponds, and other incidents relating to vegetation clearing and BTEX contamination.⁴¹

Recently 10,000 litres of saline water leaked at the Narrabri CSG Project, now operated by Santos. The incident was not reported at the time despite an obligation to do so under the conditions of the petroleum exploration licence.⁴²

And yet people concerned about their water supplies and asking for testing of water before CSG operations begin may be forced to protest publicly and risk being arrested.⁴³

The NSW Ombudsman has raised serious issues about conflicts of interest in the assessment of CSG

developments and under resourcing of compliance and enforcement activities. The same government department is responsible for both promoting investment in the CSG industry and regulating it.⁴⁴

A number of Australian health experts, including one of our Nobel Laureates, are sounding alarm bells.⁴⁵ Some US public health experts say that claims of safety lack credibility in the face of a growing litany of accidents and contamination problems.⁴⁶They are advocating the need for the precautionary principle to be observed in the absence of health data.⁴⁷While the industry calls for definite proof of health effects, as with tobacco and asbestos, by the time evidence is iron-clad, damage may be well underway. We need to act to prevent serious impacts.

Conclusion

In the words of one analyst:⁴⁸ “ in the rush to supply CSG to China, Australia could forfeit its water security, and consequently its food security...It seems clear that every Australian has good reason to be concerned about whether Australian CSG mining will impair the Australian way of life.”

Human health relies on the maintenance of a healthy environment, clean drinking water, secure food production, and supporting community and family life. Any major new development should ensure human health is protected. Adequate information is needed to support risk assessment and health protection. Greater transparency, improved monitoring and enforcement, and high quality research would start to fill this gap. There is a strong case for a uniform national regulatory framework incorporating the need for health impact assessment. Meanwhile the precautionary principle should be exercised with any CSG development. The new CSG gold rush should not be allowed to endanger the health of generations of Australians.

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