From:	Kenneth Marshall
To:	info@frackinginquiry.wa.gov.au
Subject:	Fwd: Submission from KENNETH &GLENYSE MARSHALL: Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in WA 2017
Date:	Sunday, 18 March 2018 10:46:13 PM
Attachments:	180315 Information paper Fracking.docx

From: Kenneth Marshall [redacted]
Date: Saturday, 17 March 2018 at 8:57 PM
To: <info@frackinginquiry.wa.gov.au>
Subject: Submission from KENNETH &GLENYSE MARSHALL: Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in WA 2017

Kenneth and Glenyse Marshall
[redacted]

Dear Panel Members,

We are very concerned that the state government may allow hydraulic fracture stimulation (fracking) on much of the onshore environment of WA, outside of the Perth metropolitan, Peel and South-West Regions. Being Australian means we value family, communities, clean air and clean water, and we are not convinced this industry is supportive of those values.

We understand that about 52% of our state is covered by fracking exploration licences, over all the state's ground water reserves. We don't believe this industry can be safely regulated, and given there is predicted oversupply of conventional gas reserves domestically and internationally to fill the energy supply gap before renewable energy (including battery storage) can fulfil all our power needs (estimated to be in the order of 15 years), the risk is simply not worth it, except of course to those who stand to profit from it. WA has enough gas through our domestic gas reservation policy, so fracking in WA is not necessary to meet our gas needs. Australia needs a renewable energy future, which is likely to employ more people without the risks posed by fracking. The pace of innovation and cost reduction in renewable energy technologies (ie "disruptive technologies") may make fossil fuel extraction obsolete quicker than we think.

OUR CONCERNS:
Our concerns with the impacts of fracking are broadly:

1. The exploitation of unconventional gas reserves in WA, if permitted**,** would lead to a massive increase in Australia's greenhouse gas emissions. The carbon pollution released in WA alone would be three times more than what Australia's entire energy sector can emit, in order to comply with the Paris Climate Agreement (see http://climateanalytics.org/publications/2018/western-australias-gas-gamble.html). Furthermore, fracking is associated with substantial fugitive emissions from wells, to the extent that unconventional gas has the same (if not worse) climate change impact as burning coal.
2. In our dry continent, we believe the availability of agricultural land for food production, associated clean potable water, is our most strategic resource. But instead, the state

government classifies gas reserves as a strategic resource, which allows access to land, fracking regardless of the risks to water quality (from the leakage of contaminated water used in the fracking process), ground water depletion and agricultural viability. Between 40 and 100 million litres of water is used per well for the high volume wells now being being drilled in the USA and Canada. And if the current regulations continue to apply, the water will be mostly made available free-of-charge to the oil and gas companies operating in WA. Large toxic ponds of fracking fluids result at each well location – what studies have been done to access the impact on native bird life? What happens to them when the wells are decommissioned?

3. Disruption and stress in regional communities (both farmers and traditional owners) because landowners do not have the right to refuse access by oil and gas companies to their land. Research has shown elsewhere in Queensland and internationally there is a reduction in well-being and social cohesion, less local employment opportunities. We believe the economic benefits to local communities are purposely overstated. What research has been undertaken on potential impacts on each affected community in WA?
4. The serious impact on the health reported by those communities living or working near gas fields in Queensland and the USA following the commencement of fracking.
5. The industrial scale of fracking threatens the the environmental, landscape, heritage and tourism values of any region in which it takes place. The scale of the fracking operations is likely to be magnitudes greater than that which has occurred in WA in the past – high volume clustered multi-well pads with long laterals (with higher fluid pressures) as now being implemented in the USA and Canada - and eventually there could be over 100,000 wells in WA if the moratorium is lifted. The scale and sheer number of wells means that the likelihood of well failures and other factors that can irreversibly pollute the environment increases.
6. There are substantial truck movements associated with the industrial scale of fracking, estimated up to 4,000 truck movements per well over the lifecycle of each well. Regional communities are already struggling with the cost of road maintenance in regional areas, which largely falls on ratepayers. The number of truck movements also impact on communities in terms of noise, dust and pollution.

THE SCIENTIFIC AND HISTORIC EVIDENCE:

Scientific and historical evidence of the impacts of fracking in WA are not readily available, as the onshore gas industry is still in the exploration phase with only small scale exploration. We are not aware of any data made publicly available to date.

But from experience in other jurisdictions such as in Queensland and shale operations in the USA, backed by scientific studies, shows that fracking threatens the environment, agricultural land, communities and human health in the locations where it occurs. We believe there are more similarities than differences to fracking that is already occurring elsewhere in the world, and proponents that say otherwise have not justified their view. Please refer to the attached document "180315 information paper fracking" for a list of some of scientific and historical evidence that is available.

Some of the information paper has been sourced from **ROGER: Repository for Oil and Gas Energy Research**. See http://www.psehealthyenergy.org, and http://www.psehealthyenergy.org/site/view/1180 (enter the database of studies at the button 'Access Roger') to see a page showing all the sections – many, but not all of the papers are directly relevant.

More evidence is available in the **Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking**. This is compiled by the Concerned Health Professionals of New York, and is a fully-referenced compilation of the evidence for the

risks and harms of fracking that brings together findings from the scientific and medical literature, government and industry reports, and journalistic investigation. It contains over 1,200 papers, and it can be downloaded from http://concernedhealthny.org/compendium/ . A highly qualified group of health professionals and scientists have reviewed and summarised the publications so the information is readily available.

Based on this scientific evidence, the Concerned Health Professionals of NY and Physicians for Social Responsibility concluded: 'Findings to date from scientific, medical, and journalistic investigations combine to demonstrate that fracking poses significant threats to air, water, health, public safety, climate stability, seismic stability, community cohesion, and long-term economic vitality. Emerging data from a rapidly expanding body of evidence continue to reveal a plethora of recurring problems and harms that cannot be averted or cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly or without imperilling climate stability upon which public health depends'.

The studies showing evidence from the eastern states and the USA have not been acknowledged by the oil and gas industry in WA to date. These studies should be scientifically reputed through independent studies, not studies funded by industry bodies and companies that have a vested interest.

We are concerned that much of the scientific research with conclusions in favour of fracking have been funded by the oil and gas industry. For example, the Australia Institute considers the CSIRO to be a national, or even international treasure, with a hard-won reputation as a premier scientific institution. They say that's why it's so concerning to see budget cuts, combined with industry funding, is undermining the independence of its research. In the case of gas, their research revealed (gisera-and-threat-independent-science) that the CSIRO's gas research wing, GISERA, which gets $15 million from the gas industry, has executives from big gas companies on its research boards. Science should be independent - in particular from an industry whose profits rely so heavily on these studies finding in their favour.

THE REGULATORY MECHANISMS:

If fracking in WA is not banned (which is certainly our preference), we suggest regulatory mechanisms need to be substantially tightened, to protect the public interest, as follows:

1. Proponents must have investment grade Public Liability Insurance to obtain an Exploration Licence, including coverage of environmental consequences specific to the proposed exploration. No indemnification or limits of liability should apply.
2. A cost recovery mechanism must be established to ensure that state government can effectively monitor all wells.
3. Proponents must pay bonds sufficient for surety of remediation.
4. There must be substantial and enforceable penalties for breaches of the regulations.
5. A cost recovery mechanism should be established between the industry and each regional local government impacted by their operations to cope with cost of road maintenance caused by their operations.
6. The water used from public sources for exploratory and production fracking must be charged (with the quantities used publicly available). This will place a value on our ground water resources and motivate oil and gas companies to innovate to reduce the amount of water they use.

The Australian Petroleum Production and Exploration Association's chief operating officer in WA, Stedman Ellis, has stated an inquiry by the Legislative Council's environment and public affairs committee in 2015 had unanimously found that fracking posed negligible risks. And according to media statements made by the Department of Mines and Petroleum, more than 600 wells have been fracked in WA in the past 55 years with no evidence of environmental harm. In 2017, the Hon Michael Mischin MLC informed me that "Hydraulic fracturing has been practiced safely in Western Australia since 1958 with more than 780 wells developed in that time. Industry practices and technology have advanced significantly since the 1950s with improvements in the areas of well design and construction, fluids management, and reduction in surface footprints. Bad experiences in other jurisdictions ought not to be thought applicable to Western Australia" and "Fracking is one of the least intrusive means of resource extraction devised". If such statements by industry, government and agency proponents have validity, they should have no issue supporting a stronger regulatory regime that would be essential to protect the public interest, as according to them, those liabilities and penalties are very unlikely to ever eventuate!

THE SCIENTIFIC APPROACH TO REGULATE FRACKING:

We suggest the following approach in regulating fracking so that data is available across the whole industry:

1. The quality of surface water and aquifers at each pad location must be baselined before any drilling starts (and results made publicly available).
2. The atmospheric level of methane at each pad location must be baselined before drilling starts (and results made publicly available).
3. Water quality and and atmospheric methane must be regularly measured and reported during the life of the project, and at decommissioning, backed up by independently conducted spot inspections (and results made publicly available).

On the east coast, the oil and gas industry has warned of price increases and gas shortages if other states follow Victoria in banning fracking. The Queensland LNG fiasco is a perfect example of government policy failure and commercial ineptitude. That failure should not be pushed onto WA which took action in 2006 to develop a domestic gas reservation policy. But the east coast gas crisis has been criticised as a fabrication to drive up gas prices, which it has successfully done (see gas-crisis-a-crisis-of-guile-and-greed)

We believe the panel should acknowledge there is more than sufficient scientific evidence to recommend that fracking should be banned in WA. The state Labour government of Western Australia needs to be bold enough to stand up against the powerful vested interests, with their armies of lobbyists, just as they did in 2006 on the gas reservation policy. Fracking has been banned in many other jurisdictions, including Victoria, many states in the USA (see List of Bans Worldwide | Keep Tap Water Safe), some provinces in Canada, and many countries in Europe. We believe that any government that takes that crucial step will see in the years to come that it was absolutely the right thing to do.

Yours faithfully,

Kenneth & Glenyse Marshall

INFORMATION REVIEW ON UNCONVENTIONAL GAS DEVELOPMENT FOR WA SCIENTIFIC INQUIRY

Prepared by Dr Bryan Whan

1. SCIENTIFIC STUDIES SHOWING IMPACTS OF UNCONVENTIONAL GAS

This paper reviews information on the impacts of unconventional gas development, citing over 240 references from the scientific literature, submissions to other inquiries on unconventional gas, reports from industry and Government agencies, personal case studies, videos, TV documentaries, and other press. In many cases the references are extensive reviews and literature databases, so the information indirectly refers to over 1,000 papers and scientific studies. While the reference list is quite extensive, there are many more similar studies that could be cited. To illustrate the authoritative nature of this review, the sources of the information include:

***Organisations* such as:** *The Australian Council of Learned Academies, The Australia Institute, Melbourne Energy Institute, Doctors for the Environment Australia, Public Health Assoc of Aust, Aust Chief Scientist Office, Aust Council of Environmental Deans and Directors, Meat & Livestock Aust, Rural Industries Res & Development Corporation, Gas Industry Social & Environmental Research Alliance (GISERA), Office of Chief Economist, NSW Chief Scientist & Engineer, Qld Dept Natural Resources & Mines, National Toxics Network, Monash Univ, Univ of Qld, Qld Univ Technology, Southern Cross Univ, EPA NSW, Int Assoc of Hydrogeologists, National Academy of Sciences USA, Pennsylvania's Dept of Environmental Protection, NY State Dept of Environmental Conservation, NYS Department of Health Public Health, EPA United States, US Geological Survey, NY State Bar Association, USA Federal Court, Cornell State Univ, Univ of Colorado, Univ of Waterloo, Durham Univ, Stanford University, Duke Univ USA, Council of Canadian Academies, European Commission, Concerned Health Professionals of NY, Physicians for Social Responsibility USA, Johns Hopkins Bloomberg School of Public Health USA, U.S. Geological Survey, Climate Analytics.*

Papers published in (examples only): *Env Science & Technology, J of Env Science and Health, Env Science and Pollution Research, Env Health Perspectives, Env Science and Technology, Int J of Env Studies, J Env Psychology, Ecological Applications, Scientific American, Science, Oilfield review, Geofirma, The Tyee, J of Hydrology, Geophysical Research Letters, World Oil, Energies, Renewable Energy & Env Sustainability, Texas J of Oil, Gas & Energy Law, Seismological Research Letters, Scientific Literature, Env Geochemistry & Health, Epidemiology, J of Economic & Social Policy, Aust J Agric & Resource Economics, British Medical Journal, Psychiatry, Endocrinology, JAMA Internal Medicine, Medical J Aust, The Lancet, Compendium of Scientific Medical & Media Findings.*

There are extensive databases providing scientific evidence of the risks and harms.

ROGER: Repository for Oil and Gas Energy Research (PSE) – 1400 papers *(1.24)*

The Physicians Scientists and Engineers for Healthy Energy maintains a citation database on shale and tight gas development involving about **1400** citations *(1.24)* - abstracts and links to scientific papers and peer-reviewed journal articles. http://www.psehealthyenergy.org/site/view/1180

Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking – 1200 papers *(1.26, 1.7* concernedhealthny.org/compendium/*)*

The New York based health organization, the Concerned Health Professionals of New York, has compiled the Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking - a fully-referenced compilation of the evidence for the risks and harms of fracking that brings together findings from the scientific and medical literature, government and industry reports, and journalistic investigation.

The latest edition of this compendium highlighted the following emerging trends:

- Growing evidence shows that regulations are simply not capable of preventing harm.
- Fracking threatens drinking water.
- Drilling and fracking emissions contribute to toxic air pollution and smog (ground-level ozone) at levels known to have health impacts.
- Public health problems associated with drilling and fracking, including reproductive impacts and occupational health and safety problems, are increasingly well documented.
- Natural gas is a threat to the climate.
- Earthquakes are a consequence of drilling and fracking-related activities in many locations.
- Fracking infrastructure poses serious potential exposure risks to those living near it.
- Drilling and fracking activities can bring naturally occurring radioactive materials to the surface.
- The economic instabilities of fracking further exacerbate public health risks.
- Fracking raises issues of environmental justice.
- Health care professionals are increasingly calling for bans or moratoria until the full range of potential health hazards from fracking are understood.

Many studies (numbers in brackets) are documented in the following categories:

- Air pollution (55)
- Water contamination (108)
- Inherent engineering problems that worsen with time (13)
- Radioactive releases (16)
- Occupational health and safety hazards (44)
- Public health effects, measured directly (23)
- Noise pollution, light pollution, and stress (12)
- Earthquakes and seismic activity (60)
- Abandoned and active oil and natural gas wells as pathways for gas and fluid migration (22)
- Flood risks (9)
- Threats to agriculture and soil quality (20)
- Threats to the climate system (56)
- Threats from fracking infrastructure (71)
- Inaccurate job claims, increased crime rates, threats to property value and mortgages, and local government burden (64)
- Inflated estimates of oil and gas reserves and profitability (23)
- Disclosure of serious risks to investors (Information from industry returns to Government)
- Medical and scientific calls for more study and more transparency (36)

The latest edition released in March 2018 *(1.26)* now shows evidence of actual human harm for what were considered potential risks previously. The report confirms that fracking is not safe for public health or the climate and cannot be made safe by any regulatory framework.

Based on this scientific evidence, the Concerned Health Professionals of NY and Physicians for Social Responsibility concluded:

'Findings to date from scientific, medical, and journalistic investigations combine to demonstrate that fracking poses significant threats to air, water, health, public safety, climate stability, seismic stability, community cohesion, and long-term economic vitality. Emerging data from a rapidly expanding body of evidence continue to reveal a plethora of recurring problems and harms that cannot be averted or cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly or without imperilling climate stability upon which public health depends. Industry swore that its cracking rock technology was safe and proven, but science now tells a different story. And in the words of a new commentary about fracking in the American Journal of Public Health: Mounting empirical evidence shows harm to the environment and to human health … and we have no idea what the long-term effects might be…. Ignoring the body of evidence, to us, is not a viable option anymore.'

The industry claims that 'concerns about unconventional gas are prompted by false and exaggerated claims peddled by opponents of development, who have often declared they intend to stop all new oil and gas activity' *(2.1)*. In reality, opposition to unconventional gas comes from thousands of highly qualified scientific and medical experts world wide, as well as concerned, well informed citizens who have taken the trouble to research the topic extensively or have had personal experiences. They do not want to see the disasters of Queensland and the USA repeated in Western Australia.

2. SOME BASIC FACTS *(1.1, 1.2, 1.3, 1.4) 26 references*

- Unconventional gas production is highly invasive. While conventional gas production generally requires single wells, shale and tight gasfields involve the industrialisation of entire landscapes as hundreds or even thousands of closely spaced gas wells are required to extract commercially viable quantities of gas. Gasfields also require vast networks of access roads, gas pipelines, processing plants, compressor stations, and wastewater holding dams and treatment plants.
- Valuable agricultural and horticultural land is lost. Native forests and wild life are impacted.
- Modern fracking techniques used for unconventional gas extraction are vastly different to older fracking methods used in WA's conventional oil and gas industries. These newer, more damaging fracking processes have only been in use since the 1990's and require vast quantities of water and chemicals, much higher

pressures, and riskier horizontal drilling techniques. Modern fracking technology has never been deployed on a commercial scale in Western Australia.

- Fracking is a water-intensive practice *(1.4)*. A single shale gas frack uses 11-34 million litres of water, and wells are often fracked on multiple occasions, sometimes up to ten times, multiplying overall water use.
- Some of this fluid returns to the surface as flowback, but up to 70% stays underground and is never recovered.
- Wastewater is brought to the surface during gas production. It may contain heavy metals, salts, radioactive materials and volatile organic compounds.
- WA could contain 280 trillion cubic feet of potential shale and tight gas resources *(1.12)*, with the Kimberley, Mid-West and South-West regions currently being targeted for exploration and pilot production.
- Fracking for unconventional gas is already underway in WA *(1.13)*, with around 12 exploration wells fracked in the past 11 years.
- Conservative estimates suggest that the Kimberley could see over 41,700 gas wells and the Perth Basin more than 14,500 *(1.14).*
- A large swathe of Australia is covered in coal and gas leases & applications. Families and communities are suffering as a result. In parts of Queensland, the unconventional gas industry has impacted on the health of families living close to mines and gasfields. These impacts are only just beginning to be recognised, although people have been providing anecdotal evidence of the impacts for many years *(1.15, 1.16)*.
- In Queensland, the rate of change has seen prime agricultural regions transformed into industrial areas through coal seam gas *(1.3)*. 18,000 wells have been approved, and tens of thousands more are planned.
- Australia gets little benefit from coal and gas production because 83% of the mining industry is foreign-owned. Mining is one of the smallest employers in Australia, employing only 2% of the population which is less than the arts and recreation services industry. Most gas is shipped overseas. *(1.17, 1.18, 1.19)*

Successful actions to stop development of unconventional gas *(1.20, 1.21, 1.23)*

- The Government of Victoria has introduced legislation to ban fracking and unconventional gas exploration.
- Tasmania has instigated a moratorium on fracking, with a possible ban ahead.
- The Northern Territory has a temporary fracking ban in place while it holds its own fracking inquiry.
- The Queensland Parliament passed a bill to restore the rights of landholders and communities to object to major mining projects.
- Parts of NSW are protected from unconventional gas development following legislation that prohibits all unconventional gas activities within 2km of residential areas and the Upper Hunter equine and viticulture critical industry clusters *(1.23)*.
- The South Australian Liberal Party has promised to ban fracking in the state's South East for 10 years if it wins the state election in March 2018.
- Many local councils across Australia have passed motions opposing unconventional gas development and calling for a moratorium.

The growing evidence of actual harm, and the potential environmental and health risks from shale gas development, has now resulted in decisive action from governments across the globe to halt the expansion of this industry. Internationally, jurisdictions with some form of ban or moratorium in place include Scotland, Wales, Germany, Bulgaria, Romania, the Netherlands, Northern Ireland, Wales, the Czech Republic, Luxembourg and France as well as the US States of New York, Maryland, Florida and Vermont and the Canadian Provinces of New Brunswick, Newfoundland, Nova Scotia and Quebec *(1.6, 1.7, 1.20)*

The community does not want unconventional gas *(1.22)*

More than 450 Australian communities have declared themselves coal or gasfield free. Close to 20 WA communities have said they want to remain Gasfield Free. These communities include Brunswick, Stratham, Dandaragan, Greenough, Cervantes, North Boyanup, Moora, The Vines, Forest Grove, Stirling Estate, Quedjinup, Caversham East, Leeman, Greenhead, Exmouth, Irwin, Jurien, Carnamah and Chittering.

Gasfield Free communities follow an extensive survey of residents who are asked house by house, street by street, whether they want to declare their communities Gasfield Free. When a community declares itself Gasfield Free it is making a powerful statement to the gas industry that the industry does not have a social licence to operate in the community.

Representing a large sector of the rural community, the Country Women's Association of WA passed a motion at its 2017 Annual Conference calling for an end to fracking and unconventional gasfields in WA. This follows a similar ban passed by the NSW branch of the CWA earlier in the year *(1.10).*

3. INDUSTRY CREDIBILITY – PERSONAL CASE STUDIES *30 references*

The gas companies, the Australian Petroleum Production and Exploration Association (APPEA), and the WA Department of Mines, Industry Regulation and Safety claim that: *(2.1, 2.2, 2.2a, 2.3, 2.4)*

- Mining for unconventional gas is safe, and the risks are known and can be managed.
- The gas industry has a good track record of safe operations in SA, Qld, WA, NSW, and Victoria.
- Gas mining will provide jobs and investment to boost the economy.
- The industry claims it is transparent, consultative, and honest, and is committed to ensuring the equitable treatment of all stakeholders, building relationships based on trust, openness and mutual respect.
- It claims the established industries have not been disadvantaged by natural gas development.

This review provides abundant scientific evidence that refutes these claims. The following examples of personal stories demonstrate the lack of credibility of the industry which claims a policy of consultation, honesty and public interest. These are examples only. There are many more similar stories available.

Landowners on the Darling Downs, Queensland *(1.3)*

- Families on the Darling Downs in Queensland have health problems through living close to the gas mining. They are no longer able to drink the water, with instances where gas was emitted from their water supplies. The presence of gas mining on their properties and the transformation of their prime agricultural land to an industrial zone which operates 24 hour a day has devastated their lives, and it has affected their mental as well as physical health. Their properties and livelihoods are ruined. The value of their properties has reduced drastically, preventing them from selling and moving on.
- Contrary to what the industry claims, 18 farmers and land owners in Queensland, NT and NSW featured in this video recounted experiences on how they were treated with contempt by the gas companies.

Megan Baker, Wilkie Creek Qld *(2.3)*

Megan's family suffered 5 years of negotiations and a legal battle with Arrow Energy, taking a huge toll on her family. The gas company dozed fences and introduced weeds, and vehicles would come and go all hours of the day and night. Stock were running everywhere because they could not be contained to one paddock due to the damage. They were forced out of production, so they eventually decided to sell the sheep flock.

Wayne Waker – Chinchilla, Queensland *(2.4)*

Wayne signed an access agreement for unconventional gas extraction by Origin Energy, but was given misleading information during negotiations. He was advised that coal seam gas would provide extra money and would have no impact. They cut boundary fences and went where they liked – all without consultation. He has pipelines running through his property, and 10 high vents pumping out methane gas. The company had no principles, morals or scruples, and treated the landowner with contempt. Wayne is worried about long term health, and his lifestyle and agricultural production have been ruined. His property is now not worth the original unimproved value.

Nood and Narelle Nothdurft – living in the heart of a gas field *(2.5)*

Their 860 acre farm was transformed into an industrialised gas field, with 4 processing plants and 7 gas wells. Within a 2.5km radius of their home there are 30 wells, 37 high point vents which vent methane 24/7/365, and hundreds of km of water and gas pipelines. There are 4 vents within 80m of their home with signs indicating the gas is flammable, explosive and dangerous. The gas company said it was only venting air, but FLIR camera images showed it was methane and VOCs. There is an unbearable noise generated from the gas infrastructure, with dust and methane emissions. Their children suffer from incredible health problems – severs headaches, vomiting, metal taste in their mouths, sore limbs, nasal problems.

Neil Stanley's story – Kogan Qld *(2.6)*

In late 2009, QGC drilled a gas well on an important cultural heritage site near Kogan in western Queensland. The site, a Bora Ring used in initiation ceremonies, was well documented and well known. QGC has never been made accountable for desecrating the site.

Greg and Joanne Vines' story – Wallumbilla, Qld *(2.7)*
For 2 years, the Vines battled gas giant Santos which wanted to lay a second pipeline through their property in south-west Queensland. The couple were worried about weeds being introduced as the machinery would have been in areas of parthenium infestation, a toxic plant that impacts heavily on pastoral production. Despite repeated requests, the company was unable to provide the Vines with adequate documentation to prove the machinery was weed free. The Vines locked their gates to keep the trencher off their land and protect their pasture business, but they were threatened with arrest on their own property and had their locked gates cut. Santos had a blatant disregard for people, and their fight has taken a heavy toll.

George Bender's story *(2.17, 2.18, 2.19)*
These videos outline George's experience in dealing with Origin Energy, Queensland Gas Company, Arrow Energy and Linc Energy in Queensland. The Bender family has farmed a piggery in the area since 1940. Health problems in the piggery coincided with the development of CSG in the area – pigs gasping for breath, skin rashes, eye irritations, neurological impacts, dizziness, unbalance, seizures, wasting away, low birth number and weight, and reproductive issues. There were thousands of deaths, but autopsies showed no known swine diseases. Although this was reported to the Queensland Government nothing was done.

Arrow and Origin gas companies put 18 gas wells on George's two properties, under duress, resulting in him losing six precious underground water bores. These bores are among 85 in the area that are likely to run dry within 2-3 year, and a further 528 will be impacted in the longer term. In negotiating its obligation to 'make good' this loss of water, Origin Energy tried intimidation, bribery, delaying tactics, and disingenuous offers, and even tried to take his 5 Megalitre water licence for free. He was threatened with legal action by Linc Energy, and Origin Energy issued a letter requiring him to sell his property in 30 days. It is now clear that these actions were without authority and quite illegal. Sadly, these actions pushed George to suicide in 2015.

Negotiations with Kimberley traditional owners *(1.5 and 1.9)*
A traditional landowner, Mitch Torres, recounted her experience at a negotiation meeting with a gas company, where the company representatives misled the indigenous people by saying the chemicals used in fracking were similar to those used in jelly beans. The indigenous participants had quite a different view about fracking when it was later explained correctly.

USA experience
There is extensive experience from USA of farmers living in areas subject to fracking. Farmers can't use the water, which catches on fire, and it is possible to have explosions in the house if it is not kept open. There are immense health issues, and children are most susceptible. Some farmers have been bought out by the gas companies, but they must sign confidentiality agreements. Agriculture and gas production cannot co-exist.

Misrepresenting tight gas as conventional

Gas companies have been known to misrepresent tight gas as 'conventional' in the past.

- Metgasco misrepresented the drilling planned at Bentley in NSW, obtaining an approval for conventional drilling, when it was in fact unconventional tight sands gas that is being sought.
- In South West WA, companies claim they are targeting conventional gas, when it is tight sandstone and limestone in the area. The company which originally applied for the gas licence over Capel, Boyanup and Dardanup was called 'Unconventional Resources Pty Ltd'. After community protest, they changed their name to Bunbury Energy.
- In the Mid-West, the Waitsia field is being heralded as the biggest conventional gas find in about 40 years. But the company has admitted they would start with 20 wells in 50 square kilometres. There is also tight Gas in exactly the same spot, so it is possible they will develop that eventually too. They will have the land access by then.

Industry credibility? Documentaries

A number of documentaries have been produced by reputable TV networks and production companies outlining the truth about unconventional gas production and its impacts.

- Lock The Gate: A fractured State *(1.5)*
- Australia's NOW Government – Fracking destroying our country *(2.8)*
- The Gas Rush: ABC's 4 Corners Feb 2010 *(2.9)*
- Undermined: Nine's 60 Minutes 14 May 2010 *(2.10)*
- Voices from Gasfields – it started with just one well *(2.11)*

- Food Security and Australia's Regional Way of Life: Coal Seam Gas: Alan Jones - National Press Club Address 19 October 2011 *(2.12)*
- Coal Seam Gas: Channel 10 'The Project' 21 Feb 2013 *(2.13)*
- Fracking an inconvenient truth 17 Aug 2013 *(2.14)*
- Exposing the real price of the US fracking industry *(2.15)*
- Water on fire – Marcellus shale reality *(2.16)*

4. CHEMICALS USED IN HYDRAULIC FRACKING *23 references*

Hydraulic fracture stimulation fluid is generally composed of around 90 per cent water, with 9.5% sand or ceramic beads, and 0.5% chemicals (1.25). Chemicals are added to improve the transportation of the proppant, prevent the growth of bacteria, reduce mineral clogging and prevent well corrosion over time. In Western Australia, all chemicals to be used need government approval.

The industry and supporters of fracking argue that only a small amount of chemicals is used in fracking (1.25, 4.17, 4.18, 4.19), and the chemicals used can be found in household products (4.21, 4.19, 4.18).

What the literature shows

4.1 Risks of chemicals *(4.3, 4.2, 4.1, 1.6)*

- While chemical additives make up less than 2% of the fracking fluid, this still translates to large quantities. A typical 15 million litre fracturing operation would use from 80 to 330 tons of chemicals *(4.20)*. A well may be 'fracked' a number of times. An estimated 18,500 kilograms were used in a coal seam gas fracking in Australia with up to 40% not recovered *(4.4)*.
- While some chemicals can be found in home products, they may not be safe for humans and the environment if they make their way into water supplies (3.8). While some chemicals may be harmless when used appropriately in the home at low concentrations, it does not follow that they are safe in the amount and processes used in fracking, and in various untested combinations with numerous other chemicals. Even common salt can be harmful used in the wrong way.

Fracturing fluids can move through the environment and come into contact with humans in a number of ways, including surface leaks, spills, releases from holding tanks, poor well construction, leaks and accidents during transportation of fluids, flowback and produced water to and from the well pad, and run-off during blowouts, storms, and flooding events.

Hardly any of the chemicals used in fracking operations have been assessed by chemical safety regulator the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). And little is known about the 'synergistic' effects of these chemicals – how they behave when mixed with other natural and introduced chemicals in a high pressure, high temperature environment *(4.5)*.

Benzene, Toluene, Ethylbenzene, Xylene or BTEX are volatile organic compounds (VOCs) found naturally in crude oil, coal and gas deposits and associated groundwater *(4.9)*. While they are prohibited from use in WA, they can be released from the coal seam via drill holes or fractures *(4.10)*. The short term health effects of BTEX include skin, eye / nose irritation, dizziness, headache, loss of coordination and impacts to respiratory system. Chronic exposure can result in damage to kidneys, liver and blood system. Benzene is strongly linked with leukemia *(4.11)* and diseases such non-Hodgkin's lymphoma (NHL).

Other VOCs can also be toxic. Some are known to cause cancer in animals (e.g. methylene chloride) or humans (e.g. formaldehyde), or are suspected human carcinogens (e.g. chloroform, bromodichloromethane). VOCs are also key ingredients in forming ozone (smog), which is linked to asthma attacks, and other serious health effects. VOC exposure may result in eye, nose, and throat irritation, headaches, visual disorders, memory impairment, loss of coordination, nausea, damage to liver, kidney, and central nervous system *(4.12)*. In one study, samples taken from the top of the well-head, a day after the well had been 'fracked', detected VOCs (bromodichloromethane, bromoform, chloroform and dibromochloromethane), as well as benzene and chromium, copper, nickel, zinc *(4.6)*.

Naturally occurring radioactive materials (NORMs) are found in coal seams and shale, e.g. uranium, thorium, radium-228 and radium-226 *(4.13)*. The radioactive material can be released through the drilling process in drill cuttings/muds and flowback water. Radium is a known carcinogen and exposure can result in increased incidence of bone, liver and breast cancer. Radon, a decay product of radium can cause lung cancer. The level of reported radioactivity varies significantly, depending on the radioactivity of the reservoir rock and the salinity of the water co-produced from the well. The higher the salinity, the more NORM is likely to be mobilized. Since salinity often increase with the age of a well, old wells tend to exhibit higher NORM levels than younger ones *(4.14)*.

In Australia, BTEX chemicals have been found in 5 out of 14 monitoring wells at Arrow Energy's gas fields, near Dalby, Queensland. Benzene was detected at levels 6 and 15 times the Australian drinking water standard (0.001 milligram per litre /1ppb) *(4.15)*. Toluene and methane have been detected in a private drinking water bore in Queensland *(4.16)*.

For a typical shale gas well, daily produced water volumes range from 300 – 4,500 litres *(4.7)*. The amount of produced water from a coal seam gas well varies between 0.1 - 0.8 megalitres (ML) per day *(4.8)*.

4.2 National Toxics Network findings *(4.22)*

The National Toxics Network has found many volatile organic compounds that affect breathing or are carcinogenic or neurotoxic around homes in the vicinity of gas fields *(4.22).* It also tested drinking water tanks, and found heavy metals, chemicals like methylene chloride, caesium 137, and radioactivity. Emissions must be reported by industry, and one gas field, selected as an example, was reported to have produced 1,900 tons of oxides of nitrogen and 1,500 tons of carbon monoxide. Of great concern is the amount of particle matter that is produced. The Australian Chemical Regulatory system is quite inadequate at protecting the rights of the community.

5. WELL INTEGRITY AND FAILURE *17 references*

The industry claims there is no real risk of wells leaking, as well casings are thick and made of concrete and steel

What the literature shows *(1.3, 3.4, 3.5, 3.6, 3.7, 5.1, 5.2, 5.3, 5.4)*

5.1 Do modern gas wells leak?

- There is growing evidence to show that even strict regulations are simply not capable of preventing harm, and that 'world's best practice' well construction just isn't enough to stop wells leaking.
- Studies consistently show that oil and gas wells routinely leak, allowing for the migration of natural gas and potentially other substances into groundwater and/or the atmosphere. Recent research suggests that the act of fracking itself may induce pathways for leaks.
- Some incidents, breaches of approval processes and conditions have come to light only because of whistle-blowers within government departments and gas companies.
- If Regulations only apply to the title holder during production, the rest of the community, who do not get any financial benefit, will have to bear the costs of maintaining the wells forever.

The International Association of Hydrogeologists in 2015 noted in its submission to the Hawke Inquiry *(5.6)*:

- Deterioration and failure of improperly decommissioned wells will, over time, result in long term release of oil and/or gas into the environment. Pathways in the annulus may develop that would allow oil, gas, and brine to move vertically across geologic formations and contaminate groundwater. Substances dissolved in the brine may include those that occur naturally in the shale formations and others injected during the hydraulic fracturing process.
- Upwardly migrating gas, known as stray gas, represents an explosion hazard if not properly vented away from buildings and drinking water wells.
- The risk that annular pathways will develop increases over time as chemical, mechanical, and thermal stresses causes deterioration of well structures and components.
- Failure modes of improperly abandoned wells include the formation of cracks in the cement casing or packers, corrosion of steel production casing, faulty valves, and leaking temporary plugs or surface caps.

5.2 Industry reports of risks

An industry paper in Oilfield Review 2003 *(5.5)*, published by Schlumberger, one of the world's largest companies specializing in fracking, admitted about 5 per cent of wells leak immediately, 50 per cent leak after 15 years, and 60 percent leak after 30 years.

The US Securities and Exchange Commission's website reviews annual forms filed by unconventional gas companies that identify the risks associated with their operations *(1.7)*. It is a requirement for companies to disclose 'the most significant factors that make the offering speculative or risky'.

- Oil and natural gas companies have routinely warned of drilling's serious risks. Such hazards and risks include leaks, spills, release of pollutants, flooding which could affect operations in low-lying areas, explosions, blowouts, environmental damage, property damage, injury, and death.
- Chesapeake Energy Corporation has stated that 'horizontal and deep drilling activities involve greater risk of mechanical problems than vertical and shallow drilling operations.'
- The companies also routinely warn of inadequate insurance to cover drilling harms.

The risks identified by these oil and gas companies are consistent with those identified in the exhaustive scientific studies undertaken.

5.3 Frequency of well failure

- Estimates of well failure rates vary although the more conservative well failure rates found in the literature are between 4.6% and 8.9%.
- Davies *et al.* (2014) *(5.7)* reviewed reliable databases of well integrity from around the world and found that failure rates were highly variable from 1.9 to 75 per cent, with the Marcellus Shale well failure rate at 6.3 per cent, for example. They found a greater proportion of failure in injection wells (such as those required for hydraulic stimulation) when compared to production only wells (such as in traditional oil/gas fields). They concluded it is not possible to have zero per cent well integrity failure. They also noted that the amount of information retained by oil and gas companies and regulators was not sufficient for an exhaustive study, and were not released even if available.
- A 2009 study from Alberta, Canada of more than 315,000 oil, gas and injection wells of various ages, showed that 'injection wells' into which liquids or gases are pumped are 2-3 times more likely to leak than conventional 'production wells'. The same study found that horizontal or inclined wells are observed to have significantly higher failure rates than vertical wells. It is universally acknowledged that problems with casing centralisation and cement slumping in horizontal or inclined wells may contribute to the increased incidence of leakage.
- Data from Pennsylvania's Department of Environmental Protection (DEP) for 2000-12 show over nine percent of shale gas wells drilled in the state's north eastern counties leak within the first five years.
- According to state inspections of all 6,000 wells drilled in Pennsylvania's Marcellus Shale before 2013, 6 to 10 per cent of them leaked natural gas, with the rate of leakage increasing over time. The rate was 6 per cent in 2010 (97 well failures out of 1,609 wells drilled); 7.1 per cent in 2011 (140 well failures out of 1,972 wells drilled); and 8.9 percent in 2012 (120 well failures out of 1,346 wells drilled) *(5.13)*. Wells with horizontal underground arms were four times more likely to fail than vertical wells in the same area.
- A 2011 report from Pennsylvania, USA, showed about 75% of groundwater wells sampled within 1 kilometre of gas drilling in the Marcellus shale were contaminated with methane from the deep shale formations. Isotopic fingerprinting of the methane indicated that the deep shale was the source of contaminations, rather than biologically derived methane.
- In 2016, an interdisciplinary team led by University of Colorado researchers found methane in 42 water wells in the intensely drilled Denver-Julesburg Basin where high volume, horizontal fracking operations began in 2010. Of the 42 affected wells, 11 had already been identified by state regulators as suffering from 'barrier failures' *(5.8)*.
- In 2014, University of Waterloo researchers warned that natural gas seeping from 500,000 wellbores in Canada represented 'a threat to environment and public safety' due to groundwater contamination, greenhouse gas emissions, and explosion risks. Ten percent of all active and suspended gas wells in British Columbia now leak methane, and some hydraulically fractured shale gas wells in that province have become 'super methane emitters', spewing as much as 2,000 kilograms of methane a year *(5.9, 5.10)*.
- In 2014, the Council of Canadian Academies identified inherent problems with well integrity as one of its top concerns about unconventional drilling and fracking. According to one expert panel, 'the greatest threat to

groundwater is gas leakage from wells from which even existing best practices cannot assure long-term prevention.' Cement may crack, shrink, or become deformed over time, thereby reducing the tightness of the seal around the well and allowing the fluids and gases to escape into the annulus between casing and rock and thus to the surface *(5.11)*.

- In 2015, the New York State Department of Environmental Conservation stated 'there is a risk that well integrity can fail, especially over time, and questions have arisen about whether high-volume hydraulic fracturing can cause seismic changes which could potentially result in fracturing fluid migration through abandoned wells or existing fissures and faults. Thus, high-volume hydraulic fracturing could result in significant adverse impacts to water resources from well construction and fracturing fluid migration' (5.12).
- Professor Anthony Ingraffea (Cornell State University, and previously a consultant and researcher in the oil and gas industry) showed leaking gas wells in a video *(5.4)*.
  An analysis of industry literature showed:
    - In 340,000 oil and gas well in Canada, 15-16% of conventional wells leak and 65% of modern deviated wells leak.
    - 35% of 1.8 million global wells leak – 5% in young wells and 35% in old wells.

  An analysis of public 75,000 inspection reports in Pennsylvania between 2000-2013 showed:
    - Leakage in old wells pre 2009 of 13% for unconventional wells and 20% for conventional wells.
    - Leakage in modern wells post 2009 were better, but still 12% in unconventional wells.

5.4 Incidents in Australia

- Peter Lindsay, a former CSG industry regulator in the Queensland Government (DERM) claimed that some of the infrastructure in Queensland is already failing *(1.3)*.
- An example of the effect of corrosive water on cementing and casing is provided by deep oil exploration wells drilled in the Perdika/Great Artesian Basin in NT in the 1960s. Now, some fifty years later, the steel casing has almost entirely corroded away, resulting in inter-aquifer contamination. This well required expensive rehabilitation works to stem artesian flow. This single bore cost the Northern Territory and Commonwealth Governments $500,000 to plug as the company responsible for the well was insolvent. This example highlights the issue of operator insolvency due to the boom and bust cycles of oil and gas development which complicate efforts to hold liable parties responsible and provide for timely environmental reclamation.
- A scalded area in NSW's Pilliga Forest has not recovered almost 10 years after a wastewater spill by Eastern Star Gas. Wastewater leaking from a pond in the Pilliga (on tenements that Santos bought from Eastern Star Gas) resulted in the contamination of groundwater with uranium and arsenic.
- There have been numerous reports of water contamination and health impacts by people living close to Australian CSG fields in Camden, NSW and on the Western Darling Downs in Queensland.
- In Western Australia a well in the Whicher Range, east of Margaret River was fracked in 2004 using diesel as the fracking fluid because other fluids caused the clay soils to swell. The experimental technique failed and 53% of the 1.1m litres of diesel remains trapped down the well. *(5.15, 5.16, 5.17)*
- Hovea 8, a well in the northern Perth Basin, was shut in 2011 due to casing corrosion during production, only eight years into its operational life *(5.2, 5.14).*
- In the Robe River oilfield of the Carnarvon Basin during the 1980's, some old wells were bleeding gas and saline water (*5.2*).

6. IMPACTS ON WATER - Ground water and Surface water *31 references*

The industry claims that the risk of groundwater and surface water contamination is very low. *(2.1, 2.2, 2.3, 2.4)*

What the literature shows

6.1 Contamination of aquifers and surface water

There are numerous examples of peer-reviewed literature showing serious unconventional gas impacts on groundwater in the USA, regardless of the industry's insistence that there are no impacts. This should provide a warning to Western Australia that impacts do occur and are usually found by third parties *(5.2)*.

The gas industry claims that because shale and tight gas extraction involves deeper rock layers, they are safer than gas extraction from shallow coal seams. But according to a European Commission Report *(6.1)* there is an overall high risk of ground and surface water contamination resulting from fracking.

Aquifers can be contaminated by fracking:
- through water seeping from leaking wells
- from faults induced by fracking
- from surface spills of produced water involved in the fracking process
- contaminated water from the gas source per se. *(1.6, 6.2, 6.3, 6.4).*

After fracking at each well, the large volumes of hazardous flow back fluid must be stored and disposed of. Surface water pollution can occur:
- when there are accidental spills of fluids or solids at the surface
- when well blow outs occur
- through discharge of waste water onto land surfaces or into waterways *(1.6, 6.2, 6.3, 6.4).*

Flowback fluids contain hazardous fracking chemicals as well as naturally occurring toxic substances released from target geological zones such as:
- methane
- BTEX (benzene, toluene, ethylbenzene, xylene)
- polycyclic aromatic hydrocarbons (PAHs)
- naturally occurring radioactive materials (NORMs)
- heavy metals and other volatile organic compounds (VOCs) *(6.5, 6.6, 6.7, 6.8).*

6.2 Contamination of ground water and drinking water in USA – Results of studies

- In the US state of Pennsylvania alone, more than 240 private drinking water wells have been contaminated or have dried up as the result of drilling and fracking operations over a seven-year period. There has been widespread drinking water contamination in 550 water samples throughout the heavily drilled Barnett Shale region in northern Texas *(6.9)*.
- In March 2016 a USA federal jury awarded two Pennsylvania couples $4.24 million after finding an oil and gas company responsible for contaminating their well water during drilling and fracking activities *(6.31)*.
- Fracking-related solvents were found in private drinking water wells near drilling and fracking operations in Pennsylvania *(6.10)*.
- Elevated levels of methane have been found in groundwater discharging into a stream near fracking operations in Pennsylvania along with high levels of methane in nearby private water wells due to a defective casing *(6.11)*.
- Comparison of pre-drill and post-drill data on water quality found changes in water chemistry that coincided with the advent of drilling and fracking activities. Methane was also detected in most houses tested in this study *(6.12)*.
- 56 of the 143 well owners surveyed in south-western Pennsylvania in 2015 indicated changes in water quality or quantity. Chloride, sulphate, nitrate, sodium, calcium, magnesium, iron, manganese and strontium were commonly found, with 25 households exceeding the secondary maximum contaminate level for manganese. Methane was detected in 14 of the 18 houses tested. Since 2009, 65 horizontal wells were drilled within a 4 km radius of the community and each well was stimulated on average with 3.5 million gallons of fluids *(6.13)*.

- A 2016 study by Stanford University scientists determined that fracking and related oil and gas operations have contaminated drinking water in the town of Pavillion, Wyoming, where residents have long complained about foul-tasting water *(6.14, 6.15)*.
- Analysis, in the journal *Environmental Science & Technology, 2017*, revealed 6,648 spills from the fracking industry from just four states - Colorado, New Mexico, North Dakota and Pennsylvania, in 10 years *(6.16)*. The researchers determined that up to 16 percent of fracked oil and gas wells spill hydrocarbons, chemically laden water, fracking fluids and other substances.
- Analysis of published data (Vengosh *et al.* 2014, *6.4*) showed evidence of stray gas contamination, surface water impacts in areas of intensive shale gas development, and the accumulation of radium isotopes and other contaminants in some disposal and spill sites.
- Recent research from the USA found higher levels of arsenic and other heavy metals, plus higher salinity, in water bores which were less than 3km from shale gas wells *(6.17)*. Other research has found increased methane concentrations in water bores closer to shale gas wells, creating an explosion hazard *(6.18)*.
- Studies from Duke University in the US have found high levels of radioactivity in a creek used for disposal of wastewater *(6.19)*.
- Using geochemical and isotopic tracers to identify the unique chemical fingerprint of Bakken region brines, a 2016 Duke University study found that accidental spills of fracking wastewater have contaminated surface water and soils throughout North Dakota where more than 9,700 wells have been drilled in the past decade. Contaminants included salts as well as lead, selenium, and vanadium. In the polluted streams, levels of contaminants often exceeded federal drinking water guidelines. Soils at spill sites showed elevated levels of radium *(6.20)*. Contaminants were observed in spill sites up to 4 years following the spill events, and it was concluded there is clear evidence of direct water contamination from fracking *(6.21)*.
- High levels of iodide, bromide, and ammonium were found in samples of wastewater from fracking operations in two US shale formations. The same chemicals were found when fracking wastewater was discharged into rivers and streams at three treatment sites in Pennsylvania and during an accidental spill in West Virginia *(6.22)*.

6.3 Experiences in Australia

- A review by Klohn Crippen Berger Free *(6.23)* for the Queensland Department of Natural Resources and Mines concluded that gas from CSG development can even occur in water bores that do not experience a water level decline from CSG development. These impacts have also been reported by numerous landholders who suffered bore impairment from excess gas.
- There have been numerous reports of water contamination and health impacts by people living close to Australian CSG fields in Camden, NSW and on the Western Darling Downs in Queensland. They are similar in nature to reports in the United States *(6.24)*.
- In Australia, Gavin Mudd from Monash University showed gas bubbling from the Condamine river. The industry claims this was not due to Coal Seam Gas! (1.3). The bubbling can be explained by the fact that the Condamine River is a Groundwater Dependent Ecosystem i.e. it is dependent on surface expressions of ground water *(2.19).*
- Spills have also occurred in Australian CSG operations. A scalded area in NSW's Pilliga Forest has not recovered almost 10 years after a wastewater spill by Eastern Star Gas. Wastewater leaking from a pond in the Pilliga (on tenements that Santos bought from Eastern Star Gas) resulted in the contamination of groundwater with uranium and arsenic *(6.24)*.
- In May 2013 some 240,000 litres of oil were spilled at a conventional well in Santos's Zeus field west of Thargomindah. Despite clear evidence, the Queensland environment department chose not to prosecute Santos for this breach of conditions *(6.24)*.
- In the Northern Territory, Origin Energy used unlined pits for the storage of waste water, and then failed to responsibly remove all contaminants, leaving polluted water in areas that then flooded. Photos are available showing the state of a shale gas pad after gas fracking activities stopped in 2015 *(1.6).*
- There have been a number of recorded contamination events in NSW during the exploration phase of coal seam gas development. Santos' CSG operations in the Forest region of NW NSW recorded at least 20 coal seam gas waste water spills and continuing leaks from evaporation ponds. Santos' records show spills and leaks from all parts of the operations, from evaporation ponds, pipelines, the wastewater treatment facilities and at well sites *(6.25)*.

- Eastern Star Gas was responsible for pollution offences in NSW. The EPA issued two penalty notices with fines of $1,500 each to Eastern Star Gas for discharging polluted water containing high levels of salt into Bohena Creek in March and November 2010 *(6.26).*
- In 2014, Santos was found guilty of polluting an aquifer in the Pilliga Forest *(6.27)* with radioactive uranium 20 times safe levels, as well as toxic heavy metals *(6.28)*.
- A spill in June 2011 in the Pilliga resulted in 10,000 litres of untreated toxic coal seam gas wastewater containing a mix of heavy metals (including arsenic, lead and chromium), salts and petrochemicals that killed vegetation and wildlife. Santos was found guilty in the NSW Land and Environment Court and fined $52,000 *(6.29)*.

7. IMPACTS ON AIR *26 references*

The industry states that the most common well integrity risk is slow leakage of methane around the external casing, but the consequences of such leaks, although negative from a climate change perspective, do not threaten health because natural gas is not toxic, the frequency of substantial leaks is low, and the leakage rates are low as well. (2.1)

What the literature shows

Unconventional gas mining and fracking will lead to large deliberate and fugitive emissions of methane, adding to climate change *(1.6)*.

7.1 Gas emissions associated with fracking

- Damien Maher, a Senior Research Scientist with Southern Cross University, showed that methane levels surrounding gas mines were consistently higher – up to 3 times background values *(1.2)*. It was previously shown that in the Condamine River area, considerable atmospheric methane levels and bubbling in the river, were associated with the CSG development in the Surat Basin area where fracking had occurred *(7.1)*.
- It is increasingly being recognised that volatile chemicals used in the fracking process, and the gases released, pose health risks to workers and people living nearby. Volatile organic compounds and hydrocarbons (including the carcinogen benzene) are released during unconventional gas operations, from venting, holding tanks, ponds, compressors and other infrastructure. Some of these mix with nitrous oxides from diesel-fuelled machinery, creating ground level ozone – a significant respiratory irritant *(7.2)*.
- Emissions measured near gas wells include the BTEX compounds - benzene, toluene, ethylbenzene, and xylene – of which benzene is a contributor to lifetime excess cancer risk *(7.3)*. Emissions of formaldehyde, hydrogen sulphide, acrylonitrile, methylene chloride, sulphuric oxide, and volatile organic compounds (VOCs) are recorded near gas drilling, and all have potential adverse health effects. Trimethyl-benzenes, aliphatic hydrocarbons, and xylenes may cause neurological effects, and can irritate the respiratory system and mucous membranes *(7.4).*
- A 2012 study detected 44 hazardous air pollutants at unconventional gas well sites *(7.5)*, whilst other recent USA studies *(7.6)* show that drilling and fracking emissions often contain strikingly high levels of benzene. The NYS Department of Health Public Health Review noted that 'studies provide evidence of uncontrolled methane leakage, emissions of other volatile organic chemicals, and particulate matter from well pads and natural-gas infrastructure as well as intermittently high dust and benzene concentrations'.
- Exposure to a range of harmful substances associated with unconventional gas operations constitutes a serious health hazard to those working or living near unconventional gas development *(7.7)*. Emissions can contribute to community odour problems and respiratory health impacts such as asthma.
- The Bakken shale emits 250,000 tons of ethane per year *(7.8)*. Emissions in this single region are 10 to 100 times larger than reported in inventories. Ethane is a gas that affects climate and decreases air quality.

7.2 Recorded Methane Venting in Australia (7.9, 7.10)

- An independent energy advisor, Tim Forcey, used an FLIR GF-320 infrared camera in the Queensland coal seam gasfields in 2017 to demonstrate substantial gas emissions from vents. Videos show:
    - Continuous releases of methane from "high-point vents" on water-gathering pipelines.
    - Intermittent releases of methane from other gas field equipment.
    - Methane bubbling from the Condamine River and Wambo Creek.

- Given the very large number of high point vents and other gas field equipment vents which are located throughout the Queensland CSG fields, if the scale of venting detected by the FLIR camera was replicated, it would represent a potentially vast, unmeasured contribution to global warming.

7.3 Concerns admitted by industry

Industry reports illustrate the level of industry concern:

- The industry publication GasTips, World Oil Oilfield Review, stated that between 7% and 19% of more than 1000 wells drilled from 2005 to 2007 in western Canada had gas migration along the casing annulus, and 9% to 28% of them had gas leakage through surface casing vents *(7.11)*.
- Unintended natural gas migration along production wellbores, even for conventional gas, has been a chronic problem for the oil and gas industry as a result of poor primary cement jobs, particularly in gas wells *(7.12)*.
- Brufatto et al (2003) cite USA Mineral Management Service data from the Gulf of Mexico indicating, 'By the time a well is 15 years old, there is a 50% probability that it will have measurable gas build up in one or more of its casing annuli *(7.13)*.
- Schlumberger, one of the world's largest companies specialising in fracking, published in its magazine as long ago as 1994: 'Older fields will continue to benefit from the expertise of the corrosion engineer and the constant monitoring required to prevent disaster *(7.14)*.

7.4 Climate change:

The industry claims that more natural gas would enhance Australia's ability to meet increasing energy needs while at the same time reduce greenhouse gas emissions (2.1).

What the literature shows

Methane is a more powerful greenhouse gas than carbon dioxide – 86 times more powerful when considered over a 20-year timeframe and 34 times more over a 100-year timeframe. Large amounts of methane leak into the atmosphere throughout the lifecycle of gas development and production, so unconventional gas is likely to be as bad or worse for climate change than coal or oil *(7.24, 3.4).*

As climate change is widely considered the major global health threat of this century, fugitive emissions produced from the gas industry are an unacceptable health risk *(7.15).*

A recent review by the Melbourne Energy Institute on methane fugitive emissions from unconventional gasfields in the USA *(7.16)* concluded:

- Actual measurements above USA gasfields have recorded fugitive emissions of up to 17% of production. For comparison, the unconventional gas industry in Australia claims that its fugitive emissions amount to only 0.1% of production *(7.17)*.
- 'Top down' methods of measuring fugitive emissions, such as satellite imagery and aerial borne surveys, have revealed methane emissions that are many orders of magnitude greater than emissions recorded from 'bottom up' surveys using ground measurements'.
- It is widely recognized that at more than about 3% leakage, gas is actually more polluting than coal when used to generate electricity *(7.18)*.

The Australia Institute showed that emissions from unconventional gas have been severely underestimated in Australia *(7.19)*. The current methodology for measuring greenhouse gas emissions from unconventional gas extraction is based on assumed and outdated methane emissions factors, rather than direct measurement of wells, pipelines and other gasfield infrastructure. The estimate used by the Australian Government is 0.058 tonnes of methane leaked per kilotonne of methane produced, or 0.0058%. This estimate is based on a historic USA emissions factor designed for measuring conventional gas emissions and is no longer used in the USA. Actual measurements by 16 peer reviewed research projects, using improved technology to take direct measurements from gas fields in the US, have ranged from 2-17% of production *(7.20)*.

The impact of these unaccounted-for methane emissions is seen in recent research showing that USA methane emissions have risen 30% in the last decade. The study used evidence from atmospheric observations to trace the largest rise of these emissions to the central part of the USA, where oil and gas extraction has expanded dramatically over the same time period (7.21).

The Melbourne Energy Institute reported that methane gas migrating to the surface due to coal seam dewatering and depressurisation for coal seam gas production was a potentially significant source of greenhouse gas *(7.22, 7.25)*. It found that migration of methane along existing natural faults and fractures is possible and may increase with continued depressurization by unconventional gas mining. It noted that presence of free methane in water bores can be the direct consequence of depressurisation of the coal seams. The Melbourne Energy Institute also concluded that Australia may be dramatically under-estimating the fugitive methane emissions from unconventional gas.

Bista (2017) from Murdoch University *(7.23)* concluded that greenhouse gas emissions resulting from the development of Western Australia's five onshore gas basins would be equivalent to all other Australian emissions sources combined at 2014 levels each year for 20 years which is the general lifetime of a well. This paper concludes that onshore gas fracking without any control mechanism could not be considered as a transition fuel for climate change mitigation in Australia. Fracking emissions could be a highly significant source of greenhouse gas emissions nationally as well as globally.

New analysis by a leading European climate research institute, Climate Analytics *(7.26)*, has found the domestic carbon pollution from WA's proposed unconventional gas development is three times more than what Australia's entire energy sector can emit to comply with the Paris Agreement. Gas from the Canning basin alone would emit carbon pollution two times more than Australia's Paris Agreement energy sector budget. If emissions from conventional gas are included, the total emissions are 4.4 times higher than what Australia's entire energy system can emit to comply with the Paris Agreement.

8. IMPACTS ON LAND *17 references*

8.1 Transformation of productive land into industrial landscape

The biggest impact on land is the transformation of entire regions of beautiful productive land into an industrial landscape. **It could be argued that this alone is reason to not allow unconventional gas mining.** While the industry claims that the footprint is relatively small, a quick investigation shows this is not correct. The industry will claim that new technologies involving multiple lateral drillings will reduce this footprint, but this is yet to be determined.

The background paper for the WA Inquiry claims that the footprint for unconventional gas will have a smaller footprint than coal seam gas *(8.1)*. It is not appropriate to assume that yet. Australia's former and present Chief Scientists, Prof Chubb and Dr Finkel, have both admitted that Australia's unconventional shale gas industry will have a larger footprint, and require considerably more water, than CSG *(8.2, 8.3).*

8.2 Well Density

Prime agricultural regions in Queensland have been transformed into industrial areas through coal seam gas *(1.3)*. 18,000 wells have been approved, and tens of thousands more are planned. The impact of the infrastructure on the landscape and water table is apparent when flying in this area *(8.16).* The impact of the industrialisation is neatly demonstrated in a series of 'Before and After' photos of various forest and agricultural areas in Queensland. *A warning from Queensland:* http://www.csgfreenorthwest.org.au/qlds_story *(1.8)*

Although conventional oil and gas production can have many of the same types of water resource and environmental impacts (spills, well integrity failure etc.), the well density in an unconventional gas field, is hundreds to thousands of times higher than a conventional field *(5.2)*.

Early in the development of the tight gas industry, hydraulic stimulation was done on vertical wells so a higher well density was required. However, since the development and reduced cost of horizontal drilling techniques, lower well densities are more typical with multiple wells starting from the same drilling site or pad. Although this reduces pad and well density in the landscape, it potentially puts greater pressure on the sites in terms of likelihood of impact due to the increased failure potential in the vertical portion of the well hole. Regardless, there are large increases in well density when compared to conventional oil and gas *(5.2)*.

8.3 Rehabilitation

It may not be possible to fully restore sites in sensitive areas following well completion or abandonment, particularly in areas of high agricultural, natural or cultural value (European Commission report, *8.4, 1.6*). Over a wider area, with multiple installations, this could result in a significant loss or fragmentation of amenities or recreational facilities, valuable farmland or natural habitats.

Soils across the Darling Downs, some of the most productive agricultural land in Australia, can never be returned to prime agricultural land after development for unconventional gas *(8.17).*

A recent USA study documents the failure of plant and soil systems disturbed by drilling and fracking activities to return to pre-drilling conditions following rehabilitation - even after 20 to 50 years *(8.5)*.

An interdisciplinary study published in *Science* 2015 demonstrated that the accumulating land degradation has resulted in continent-wide impacts of the unconventional gas industry in the United States, as measured by the reduced amount of carbon absorbed by plants and accumulated as biomass. This is a robust metric of essential ecosystem services, such as food production, biodiversity, and wildlife habitat, and its loss 'is likely long-lasting and potentially permanent'. The land area occupied by well pads, roads, and storage facilities built during this period is approximately three million hectares, roughly the land area of three Yellowstone National Parks *(8.6)*.

8.4 Fragmentation and Biosecurity

Experts in Australia have identified that the considerable surface footprint of CSG infrastructure represents a serious threat to biodiversity fragmentation through direct clearing of bushland, loss of native vegetation, fragmentation of important remnant vegetation, spread of invasive species and increased fire risk *(8.7)*.

The sheer scale of gas wells and associated infrastructure, presents genuine risks for unique natural landscapes. In Queensland, farmers have reported serious invasions of weeds following CSG development. One cattle farmer has initiated legal action against a CSG company after he had to destock his property at Dalby after a sudden infestation of the noxious African lovegrass weed following CSG activities *(8.8)*.

Lawyers in Queensland representing farmers dealing with the CSG industry consider that weeds may ultimately be one of the biggest legacies of the CSG industry *(8.9)*, and have highlighted the weaknesses of biosecurity measures.

8.5 Seismic Activity

Evidence arising in the past 18 months has demonstrated links between fracking and waste fluid reinjection with increased seismicity and earthquakes.

- International researchers in 2016 concluded that the underground injection of waste water from oil drilling had contributed to earthquakes in California in 2005 by changing pressures along an active fault *(8.10)*.
- An article in the Texas Journal of Oil, Gas, and Energy Law in 2016 exhaustively reviewed the literature on earthquake activity in areas of six states (Arkansas, Colorado, Kansas, Ohio, Oklahoma, and Texas) and concluded that courts should impose strict liability for earthquake damage caused either by fracking itself or by the underground injection of fracking fluids *(8.11)*.
- Emerging data summarised in Scientific American in 2016 suggested that pressure changes caused by fracking wastewater injection can migrate for years before encountering a geological fault and altering stresses in ways that allow for slippage *(8.12).*
- A Canadian team of researchers determined in 2016 that hydraulic fracturing itself is linked to earthquake swarms in western Canada, in contrast to the central United States where disposal of fracking waste is the cause of most induced seismicity. Furthermore, lowering the volume of injected fluid may not be sufficient to prevent quakes *(8.13)*.

The evidence is strong enough that the Oklahoma Supreme Court ruled unanimously that homeowners can sue the oil and gas industry for injuries or property damage resulting from earthquakes. The number of earthquakes of magnitude 3.0 or higher has skyrocketed in Oklahoma since the advent of the fracking boom, with fewer than two per year before 2009 and more than 1,100 predicted to occur in 2015 *(8.14)*.

The Dutch government plans to compensate people whose homes and buildings were damaged in a 3.4 magnitude quake, blamed on extraction at Europe's biggest gas field. More than 900 homes and buildings were damaged, according to an association which collates reports from residents. Groningen, which houses the

European Union's largest gas field, has been plagued by tremors which increased as gas production rose in the region through the 1990s. *(8.15)*

9. IMPACTS ON HUMAN AND ANIMAL HEALTH *55 references*

The industry claims that unconventional gas activities are safe. To justify this, it quotes a report from Queensland Health which concluded no clear link could be drawn between the health complaints of some residents and the local CSG industry (2.1). 'This report found that the nature of complaints meant there were multiple possible causes and explanations including faecal contamination in the water supply, the use of wood-fired heaters or open fires, and rainwater contaminated with bacteria, viruses or other organisms. These causes are not related to gas operations. The report noted the most prevalent reported symptoms are headache, transient (reversible) eye irritation, nosebleeds and skin rashes. These are common medical complaints.'

What the literature shows

There is a rapidly growing body of research that demonstrates that unconventional gas operations can have serious consequences for human and animal health.

Adgate, Goldstein and McKenzie (2014) *(9.1)* present a clear argument that unconventional gas mining poses risks to health, both directly and indirectly, and at the local, regional and global level. Thus, decisions on unconventional gas mining made by all Australian states and territories, and by other nations, affect us all.

There are numerous independent reviews involving many hundreds of peer-reviewed papers demonstrating the impacts of unconventional gas on human health.

9.1 Impacts shown from 700 peer-reviewed papers *(9.4, 9.4a, 9.2, 7.2, 9.3, 9.6)*

Scientific literature involving more than 700 studies on the impacts of unconventional gas development show:

- 84% of public health studies indicate risks to public health
- 69% of water studies show actual or potential water contamination
- 87% of air quality studies indicate elevated air pollution.

9.2 Saunders – 156 papers

A review of 156 publications (Saunders et al., 2016) (9.8) found multiple potential hazards to human health from exposures to harmful air and water pollutants associated with unconventional gas mining (9.7).

The major concerns identified were (9.9):

- There are direct local health concerns associated with living and working in close proximity to all steps of the unconventional gas mining process, not just the hydraulic fracturing ('fracking') component. These include potential exposures to air pollutants released during the whole process, including volatile organic compounds, fine silica, oxides of nitrogen, hydrogen sulphide, formaldehyde, ground level ozone and diesel fumes.
- Local communities may also face stress from an array of changes, including exposure to noise, lights, odours, and dust, as well as worries and fears about health, accidents, declining property values, increased traffic, industrialised landscapes, loss of community cohesion, post-construction job losses, local business loss, and changes to community character.
- Findings from various research studies have suggested associations between living close to unconventional gas operations and higher frequencies of negative health indicators, such as lower birth weights, more birth complications, more self-reported symptoms such as migraines, nasal and sinus problems and fatigue, and more hospitalisations due to heart, nerve and asthma conditions.
- At a local and regional level, unconventional gas activities near drinking water sources carry the potential for impacts on water quality.
- Dealing with wastewater from hydraulic fracturing safely remains a major challenge – each method and proposed new solution carries with it potential problems and complications.
- At a global level, there are grave concerns about the unconventional gas industry's contribution to climate change.

9.3 Review by Concerned Health Professionals of New York & Physicians for Social Responsibility.

Sources:

- *Concerned Health Professionals of New York & Physicians for Social Responsibility Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction). (2018, 2016, 2015) (1.26, 1.7, 9.14).*
- *Chesapeake PSR (2016) The health effects of fracking. Fracking harms human health. Chesapeake PSR Physicians for social responsibility. Health and Energy Brief. (9.6) Author – Gina Angiola, MD*
- *Doctors for the Environment Australia: Submission to Inquiry into Hydraulic Fracturing in NT April 2017 (7.2)*

Some of the public health effects of unconventional gas development outlined in the Compendium of Fracking Risks compiled by the Concerned Health Professionals of New York *(1.26, 1.7)*, include:

- increased rates of hospitalization for cardiological complaints, cancer, skin conditions, and urological problems;
- increase in frequency of health symptoms reported by residents as distance between households and gas wells decreased; with rashes and upper respiratory problems more prevalent among persons living less than one kilometre from drilling and fracking operations;
- increases in commercial vehicle accidents;
- a sharp rise in ambulance calls and emergency room visits for drug related cases and oilfield related injuries and accidents;
- increase in infant deaths to six times the normal rate over three years;
- congenital heart defects, and possibly neural tube defects in newborns, associated with the density and proximity of natural gas wells within a 10-mile radius of mothers' residences;
- elevated rates of low birthweight among infants born to mothers living near drilling and fracking operations during their pregnancies;
- reductions in average birthweight and length of pregnancy as well as increased risk for low birthweight and premature birth associated with proximity to fracking operations *(9.16)*.

Health impacts have been identified from exposure due to proximity to active wells.

- In 2015, researchers at the Johns Hopkins Bloomberg School of Public Health analysed data from roughly 10,000 birth records in Pennsylvania and found a statistically significant association between proximity of the mother to active fracking operations and premature births and high-risk pregnancies *(9.10, 9.11)*.
- In 2016, researchers at the Johns Hopkins Bloomberg School of Public Health analysed medical records of more than 35,000 asthma patients, ages 5 to 90 years old, and found a statistically significant association between proximity to active fracking operations and mild to severe asthma exacerbations *(9.12)*.
- In 2016, researchers at the Johns Hopkins Bloomberg School of Public Health analysed responses to questionnaires received from more than 7,000 adult primary care patients in central and northern Pennsylvania, and found statistically significant associations between proximity to active fracking operations and various combinations of migraine headaches, chronic rhinosinusitis and fatigue symptoms *(9.39)*.
- In a further study from Pennsylvania, published in 2015, researchers examined health care use with fracking activity from over 95,000 inpatient hospital records. They found that hydraulic fracturing, as determined by well number or density, had a significant association with cardiology hospital inpatient rates, and well density had a significant association with neurology hospital inpatient rates *(9.13)*.

Exposures that may take years to become clinically apparent were identified.

- In 2015, researchers at the University of Pennsylvania and Columbia University reported an increase in cardiac and neurologic hospitalizations in two Pennsylvania counties with active fracking operations, compared with a neighbouring county where such operations had been banned *(9.34)*.
- In 2016, researchers working collaboratively with local residents near oil and gas operations in Wyoming reported combined results from environmental sampling and biomonitoring in one of the first studies of its kind. Toxicants and their metabolites, including BTEX chemicals known to damage multiple organ systems, were detected in air samples and in the urine of residents *(9.35)*.
- In 2016, researchers documented endocrine-disrupting chemicals in surface waters near fracking wastewater disposal sites in West Virginia. Such chemicals can have potent effects on human development at exceedingly low concentrations during critical developmental windows *(9.36)*. Researchers have also documented adverse effects on development and reproductive capacities of both male and female mice at concentrations that are relevant to real-life human environmental exposures *(9.37, 9.38)*.

Drilling and fracking emissions contribute to toxic air pollution and smog (ground-level ozone) at levels known to have health impacts *(9.14)*.

- The New York State Department of Environmental Conservation determined that fracking could increase ozone levels in downwind areas of the state, potentially impacting the ability to maintain air quality that meets ozone standards.
- Air near gas wells in rural Ohio had levels of polycyclic aromatic hydrocarbons that surpassed those in downtown Chicago. They were also ten times higher than the levels found in rural areas without fracking operations, raising the lifetime risk of cancer for residents living near the well pads by 45 percent.
- Increased air pollution and smog formation poses a serious risk to all those already suffering from respiratory issues, such as children with asthma.

Public health problems associated with drilling and fracking, including occupational health and safety problems, are increasingly well documented *(9.14)*.

- Health impacts among residents living near drilling and fracking operations include increased rates of hospitalization, self-reported respiratory problems and rashes, motor vehicle fatalities, trauma, drug abuse, and low birth weight among infants.
- Benzene has been detected in the urine of well pad workers in Colorado and Wyoming.
- The National Institute for Occupational Safety and Health identified oil and gas extraction industry workers among those at risk for silicosis, an incurable lung disease caused by exposure to silica dust from the silica sand that is used extensively in fracking operations.
- Fatality rates among workers in the oil and gas extraction sector in North Dakota were seven times the national fatality rates in this industry, which itself has more deaths from fires and explosions than any other private industry. An increase in workplace deaths has accompanied the fracking boom in West Virginia.

Drilling and fracking activities can bring naturally occurring radioactive materials to the surface *(9.14)*.

- Exposure to increased radiation levels from these materials is a risk both for workers and for residents.
- In Pennsylvania, radon levels in homes have been rising since the advent of the fracking boom, and buildings in heavily drilled areas have significantly higher radon readings than areas without well pads—a difference that did not exist before 2004.
- University of Iowa researchers documented a variety of radioactive substances including radium, thorium, and uranium in fracking wastewater, and showed their radioactivity increased over time; they warned that radioactive decay products can potentially contaminate recreational, agricultural, and residential areas.
- The New York State DEC's Findings Statement noted that naturally occurring radioactive materials (NORM) are brought to the surface in the cuttings, flowback water and production brine. The build-up of NORM in pipes and equipment has the potential to cause a significant adverse impact because it could expose workers handling pipes, for cleaning or maintenance, to increased radiation levels.

Unconventional gas development affects human health and well-being not only through direct exposures to toxic chemicals in air, water and soil, but also through many stressors introduced into communities. These include excessive noise and light pollution, increases in traffic accidents and fatalities, increases in domestic violence, alcohol and drug use, crime and disruptions of family and community relationships.

The Physicians for Social Responsibility concluded that the science is increasingly clear. The health risks posed by fracking are real, significant and unacceptable. No regulatory framework has been shown to adequately protect public health or the environment *(9.6)*.

9.4 Medical health survey in the Tara region, Queensland *(9.15)*

This report documents an investigation during February and March 2013 by a concerned General Practitioner, in relation to health complaints by people living close to coal seam gas development in SW Queensland.

- Information was collected on 113 people from the 38 households in the Tara residential estates and the Kogan/Montrose region. Of these, 17 were children 5 years of age or less, 31 were children aged between 6 and 18, and 65 were adults aged between 19 and 82.
- 58% of residents surveyed reported that their health was definitely adversely affected by Coal Seam Gas, whilst a further 19% were uncertain. The pattern reported was outside the scope of what would be expected for a small rural community.
- In all age groups there were reported increases in coughs, chest tightness, rashes, difficulty sleeping, joint pains, muscle pains and spasms, nausea and vomiting. Approximately one third of the people over 6 years

of age were reported to have spontaneous nose bleeds, and almost three quarters were reported to have skin irritation. Over half of the children were reported to have eye irritation.
- A range of symptoms were reported which can sometimes be related to neurotoxicity (damage to the nervous system), including severe fatigue, weakness, headaches, numbness and paraesthesia (abnormal sensations such as pins and needles, burning or tingling). Approximately one third of the all the 48 children to age 18 (15/48) were reported to experience paraesthesia. Almost all the 31 children aged 6-18 were reported to suffer from headaches, over half of which were severe. Severe fatigue and difficulty concentrating were reported for over half of the people 6 years and over. Parents of a number of young children reported twitching or unusual movements, and clumsiness or unsteadiness.

No baseline air or water monitoring or baseline health studies were done prior to the Queensland Government permitting the widespread development of the CSG industry in close proximity to family homes. No ongoing health study or surveillance and no ongoing testing to monitor chronic exposure levels is in place. This is clearly unacceptable.

Since 2008, the people near Tara have informed successive Queensland Governments of their health problems, but their reports of ill health have been trivialised and ignored. A recent report released by the Queensland Government (the one quoted by the industry *(2.1)*) was inadequate and flawed. Only 15 people were examined clinically, with no medical staff actually visiting the site. The study undertook minimal non-systematic environmental sampling and relied mainly on inadequate industry commissioned data. Positive findings of volatile chemicals were dismissed, despite the fact they are potentially capable of causing health impacts, especially over long periods of time.

A 2018 paper by Dr McCarron *(9.32)* suggested a link between the escalating rise in hospital admissions for circulatory and respiratory conditions and a massive increase in air pollutants from the unconventional gas industry in south east Queensland. While recognising limitations on the data, partly due to anomalies in the data reported by industry and inadequate Government monitoring, it was concluded there was sufficient evidence to warrant full investigation.

9.5 Health Impacts Associated with Air and Water Pollution *(9.7)*

An array of chemicals capable of causing significant health impacts may be released during unconventional gas operations *(9.7, 9.17)* including:
- Volatile organic compounds, including BTEX (Benzene, Toluene, Ethylene and Xylene), that occur naturally in the shale, and evaporate from the flowback wastewater after fracking and from flaring excess gas
- Polyaromatic hydrocarbons (PAHs), heavy metals, naturally-occurring radioactive materials (NORMs)
- Endocrine-disrupting chemicals
- Nitrogen oxides
- Hydrogen sulphide from gas processing
- Formaldehyde (from the breakdown of escaping methane)
- Diesel fumes from extensive truck movements
- Ground level ozone, that forms from mixtures of pollutants and which is known to travel large distances.

Workers, and possibly people living very close to hydraulic fracturing operations, may also be exposed to unsafe levels of fine silica due to the large volumes of sand used, increasing the risk of silicosis *(9.7)*.

The following are some health studies that have emphasized the health risks posed by potential exposure to chemicals that may be released during unconventional gas operations via water and air.
- USA experience has indicated that health risks associated with air pollution are at least as serious to the health of people living nearby as the risks mediated through water contamination *(9.7, 9.42, 9.43)*.
- While significant concern has been raised about the large number and potential toxicity of the chemicals used in hydraulic fracturing and drilling muds, many researchers emphasise that the highly saline flowback waters containing naturally occurring chemicals are of substantially greater concern from an environmental and public health aspect *(9.44, 9.45, 9.46)*. The combination of chemicals and their resulting by-products can accumulate and persistent indefinitely in the environment, or be taken up by plants and animals and may enter the food chain *(9.7)*.
- A study by Elliott *et al. (9.45)* examined the carcinogenicity data on 1177 chemicals in fracking fluids and wastewater and 143 chemicals identified in scientific papers reporting air pollutants published before 2016. Over 80% of these chemicals were not evaluated for carcinogenicity. Among 119 chemicals that were

evaluated, 49 water and 20 air pollutants were possible or known carcinogens, and 20 were associated with leukemia/lymphoma, including benzene, butadiene, cadmium, diesel exhaust and PAHs *(9.7)*.

- A second study by Elliott et al. *(9.47)* examined the reproductive and developmental toxicity of 1021 chemicals identified in fracturing fluid and waste-water, and found that toxicity information was lacking for 781 (76%). Among the 240 that had been evaluated, 103 were known to have the potential for reproductive toxicity and 95 for developmental toxicity *(9.7)*.
- Toxins of greatest concern linked to gas extraction include volatile organic compounds (like benzene), poly-aromatic hydrocarbons, heavy metals and radioactive materials. These can affect the respiratory, endocrine, nervous and cardiovascular systems, and some, notably benzene, can cause cancer *(9.7, 9.44, 9.48)*.
- Diesel engines emit particulate matter, nitrogen oxides and volatile organic compounds, and was recently classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC 2014) *(9.7)*.
- Silica, handled in very large quantities in the drilling and hydraulic fracturing processes, has the potential to pose serious risks to the respiratory health of exposed workers, causing silicosis decades later. There is also evidence of potent endocrine disrupting chemicals associated with the industry *(4.23)*. Ground level ozone, that forms from mixtures of pollutants emitted during unconventional gas mining is also of significant concern, and can travel large distances, acting at a regional level *(9.7)*.
- Anecdotal reports and findings of a community study found significantly higher reports of respiratory (39% vs 18%) and skin (19% vs 3%) conditions among people living within 1 km compared to those living more than 2 km from shale gas wells in Pennsylvania *(9.7, 9.49)*.
- People living near unconventional gas wells throughout the world, including near coal seam gas wells in Tara, Queensland, have anecdotally reported similar distressing symptoms, as well as headaches, nosebleeds, numbness and tingling sensations *(9.7, 9.15, 9.50)*.
- A study conducted by Macey et al (2014) identified levels of air-borne toxins above Federal guidelines in four USA States where substantial oil and gas production activities had occurred.
- Negative health outcomes have been found to occur more often in groups of residents with greater exposure to shale gas mining, compared with groups with lower exposure *(9.7)*:
    - Developmental problems during pregnancy and infancy – lower birth weight, small for gestational age, higher frequency of serious birth complications, specific birth defects *(9.51, 9.52, 9.52)* .
    - Hospitalisations – for cardiovascular and neurological disorders and for those with existing asthma conditions *(9.54, 9.55)*.
    - Symptoms – migraine headaches, chronic nasal and sinus irritation, fatigue, nausea, skin rashes, eye irritation, nosebleeds, and asthma worsening requiring medication changes *(9.15, 9.49, 9.54)*.
- Petroleum-based hydrocarbons can break down underground in ways that promote the leaching of naturally occurring arsenic, a known human carcinogen, into groundwater *(9.19)*.
- Elevated levels of toxic BTEX (Benzene, Toluene, Ethylene, Glycene) chemicals in flowback water from fracked wells were detected at AGL's Waukivory CSG Project at Gloucester, NSW *(9.20)*. It is likely the chemicals were mobilized due to the fracking process. This well is now abandoned.
- In a 2013 study, surface and groundwater near unconventional gas activity in Colorado contained endocrine-disrupting chemicals in concentrations high enough to interfere with the response of human cells to male sex hormones and estrogen. Exposure to endocrine-disrupting chemicals can increase the risk of reproductive, metabolic, neurological, and other diseases *(9.33).*

9.6 Impacts on mental health, psychosocial wellbeing and community cohesion

There are many avenues through which the unconventional gas industry can harm mental health and individual and community wellbeing *(9.9)*.

- The initial phase impacts include distress and anxiety due to disagreements that split the community into those who support the industry and those who oppose it.
- In the 'boom' phase, tight-knit communities can feel inundated with strangers coming in, swamping unprepared health and mental health services. Crime may also increase. Such impacts are detrimental to the social cohesion, and for some, the moral character of the community.
- In the post-construction phase, jobs decline dramatically and housing demand drops. Production ramps up with drilling and fracking, with its 24-hour lights, noise, odours, tree clearing and truck movements - causing some people to feel a loss of control, loss of peace and a feeling of being trapped and unable to escape.
- These phases present risks of depression, anxiety and increased use of alcohol and other drugs for coping.

Doctors for the Environment Australia note that 'water and air pollution, water shortages, permanent degradation of productive agricultural land and loss of livelihood and landscape all have mental health consequences for communities living in a gas field' *(9.21)*.

A 2013 study involving 12 workshops established that CSG operations in south west Queensland placed rural communities 'under sustained stress' *(9.22)*. Study participants reported that mining and CSG operations 'significantly impacted or exacerbated issues such as the health, social fabric and economy of the community', and the authors noted that local health services faced 'unsustainable pressure'.

A 2014 article in the Medical Journal of Australia noted that 'gas developments can have numerous and considerable social and psychological effects, which may exacerbate more direct health risks' *(9.23)*.

A 2014 CSIRO study *(9.24)* noted that local farmers perceived the nature of CSG development in South West Queensland as an 'invasion' or 'occupation', whilst a previous study in Chinchilla found residents describing a 'tsunami of change' *(9.25)*.

Interacting and engaging with CSG companies also have a significant negative impact on farmer's wellbeing *(9.26)*, resulting in issues of stress, conflict and disconnection.

A survey of 378 Australian farmers, predominantly from Queensland and NSW, published in the Journal of Environmental Psychology in 2016 *(9.27)*, found that farmers concerned about the impacts of coal seam gas on their health, community and the environment, were more likely to report symptoms of depression and decreased levels of wellbeing.

Schlumberger Oilfield Australia Pty Ltd was fined $162,500 after a worker at a Queensland drilling site was burned when exposed to unsafe levels of radiation *(9.41)*.

9.7 Livestock health risks (9.28, 9.6)

Twenty-four case studies in USA have been compiled of apparent harm to animals, mainly resulting from contamination of water wells, springs, ponds or creeks, some due to accidents or negligence, and others a consequence of normal operations. On seven cattle farms studied in the most detail, half the herd, on average, was affected by death or failure to breed.

In one case, of 60 cattle with access to a creek contaminated with fracking wastewater, 21 died and 16 failed to reproduce, while 36 cattle without access to the tainted water remained healthy *(9.40)*.

In another case, of 140 cattle exposed to fracking waste, about half died and many others bore stunted or stillborn calves, while 60 others in another pasture had no problems.

The Concerned Health Professionals of NY compiled several other cases of affected livestock. In Pennsylvania, one farmer whose cows were exposed to drilling wastewater in 2010 lost 8 out of 11 newborn calves.

In 2020 – 2016 serious health issues appeared in pigs on a property in Queensland after coal seam gas was developed – problems that had never appeared before in its 70 year history, and could not be attributable to any known swine diseases *(2.19).* Symptoms in the pigs included breath difficulties, skin rashes, eye irritations, dizziness, unbalance, seizures, wasting away, and many deaths. Sows had reproductive problems, abortions, and low birth number, and piglets had low birth weight. In one instance, 5 sows had 38 out of 61 piglets still born two months after a particularly bad gas emissions event.

9.8 Involvement of health experts (9.7)

Far too frequently, public health, psychological/mental health and medical expertise are 'missing from the table' in assessing the impacts of unconventional gas on health (Goldstein et al., 2012). Experts in engineering, safety science, environmental management and toxicology, while extremely important, should not be assumed to also have a comprehensive, in depth understanding of the impacts of unconventional gas on the health and wellbeing on people's lives. Direct public and psychological health expertise is required.

9.9 Precautionary principle

Many people assume that the precautionary principle is being applied by government *(9.7)*, i.e.

- preventive action would be taken in the face of uncertainty
- the proponents of a proposed activity would be required to demonstrate its safety, not the community
- governments would explore a wide range of alternatives to possibly harmful actions

- government would encourage public participation in decision making.

In submissions to the NSW Chief Scientist and Engineer's examination of the public health and safety of coal seam gas mining in 2013, many public health organisations and the Australian Medical Association, called for application of the Precautionary Principle. The Australian Medical Association stated simply, 'If in doubt, turn CSG off' *(9.30)*.

The British Medical Journal recently published a joint letter with similar sentiments signed by 18 leading medical scientists, stating: 'The arguments against fracking on public health and ecological grounds are overwhelming. There are clear grounds for adopting the precautionary principle and prohibiting fracking' *(9.31)*.

Many public health and medical organisations in Australia are calling on governments to apply the Precautionary Principle in this situation, and refrain from allowing unconventional gas mining to occur in Australia until there is sufficient evidence demonstrating that it is safe for people and the environment. Among these organisations are:

- Doctors for the Environment Australia
- Public Health Association of Australia
- Australian Medical Association
- National Toxics Network
- Climate and Health Alliance, which includes 28 professional health bodies, e.g. Australian Psychological Association, Australian Council for Social Services, Australian College of Nursing, Australian Research Alliance of Children and Youth.

10. IMPACTS ON COMMUNITY (Social surrounds) *23 references*

The industry and Governments justify the development of unconventional gas because it will create local jobs, revive ailing rural communities, and provide tremendous economic benefits.

What the literature and experience show

10.1 Impacts on the community

In the course of its work supporting landholders and communities facing the impacts of unconventional gas developments, Lock the Gate Alliance hears firsthand about the impact unconventional gas development is having on the livelihoods, health and well-being of Australian farming families living adjacent to and surrounded by gas activities. These harmful impacts include: intimidation, coercion and bullying by UG companies; intolerable noise and light pollution from flaring, traffic and UG infrastructure; contamination and depletion of water in farm bores; rivers bubbling with methane; bores running dry; stock losses associated with pipeline construction and water contamination; costly and time consuming interruptions to farming operations; huge trucks and heavy machinery on small local roads affecting lifestyle, safety and road infrastructure; dust impacts on pasture; increases in weed infestation; industry workers leaving mess from pipeline construction in farm paddocks; workers destroying fences and leaving gates open; properties not able to be sold; credit being denied; mental health impacts resulting from dealing with companies and the impacts of industry development; and physical health symptoms including respiratory ailments, headaches, rashes, nausea and vomiting, and nose, throat and eye irritations.

For many affected landholders, these impacts affect all facets of life and are making their living situation untenable. Personal testimonies of a number of affected landholders can be viewed in a series of short films compiled by the Lock the Gate Alliance talking about the impacts on them *(10.1)*.

While the gas companies move on once the commercially viable gas has been extracted, the communities suffer long term *(1.3)*. The unconventional gas mining leaves massive damage, and the community must foot the bill. Yet the community did not want it.

Queensland's experience shows that reality does not match the unconventional gas industry's claims. Few benefits are realised outside the gas industry, and there are serious social and economic effects on local communities and existing businesses *(10.2)*.

10.2 Unconventional gas led to a degradation of public resources in QLD

A study in the Darling Downs of Queensland between 2008 and 2013 by the industry-funded Sustainable Minerals Institute at the University of Queensland surveyed stakeholders from different sectors in the local community including the local business community, agriculture, local government, advocacy groups and environmental consultants, as well as the mining and unconventional gas industries *(10.3)*. Far from mining and unconventional gas providing economic benefits, local businesses felt that it had reduced financial capital, human capital, infrastructure, social capital and natural capital. Local businesses had to compete with inflated gas industry wages to recruit and retain staff, and they experienced increased rent and competition for services. There were disruptions to farmers from the rollout of access roads, pipelines, water treatment plants and other infrastructure.

10.3 Community cohesion and wellbeing:

The Queensland and NSW experience has shown that when an unconventional gas industry is forced upon communities against their wishes, there is potential for significant conflict and social upheaval and disruption as a result *(1.6).* Lock the Gate members and local community groups report a range of impacts on their mental and emotional wellbeing, including:

- A sense of injustice that they do not have the right to refuse access to companies for UG activities and that this industry is being forced on an unwilling population.
- Fear and anxiety about the impacts of the unconventional gas industry on their family's health and the quality of the air and water they rely upon.
- Concern about the impact of unconventional gas development on the economic viability of their farms and property values.
- A sense of anger and betrayal that governments are supporting industry rather than communities in the development of the unconventional industry.
- A sense of anger that the industry is being pushed ahead rapidly without proper consideration of the impacts and before proper scientific studies have been done and baseline data collected.

Doctors for the Environment Australia note that the lack of a veto right for landholders in relation to unconventional gas development, the stress involved in dealing with companies (often against their will), the lack of full information and disclosure on the realities of unconventional gas development, and the often underhanded tactics employed by companies contributes to a sense of powerlessness, betrayal and frustration amongst landholders and affected communities. The injustice and powerlessness contribute to distress and poorer mental health outcomes. Unconventional gas development can 'divide previously close-knit rural communities, increasing tension and disharmony'.

According to DEA, in eastern Australia, the stress and disruption caused to farmers has already been shown to force some of them to leave a CSG drilling area, allowing once productive lands to lapse into disuse. In the USA long-time residents are moving, unable to bear the changes the gas industry has wrought on their landscape and community.

A study on landholders in Queensland found that unconventional gas operations placed rural communities under sustained stress, with study participants describing significant impacts on the health, social fabric and economy of local communities (10.4).

10.4 Boom Bust impact

The scale of the 'bust' after the short unconventional gas construction period ends is severe, and long-term job opportunities are extremely limited. Queensland Treasury figures reveal that more than 10,000 fly-in-fly-out jobs have been lost in the Surat Basin since the CSG construction boom peaked in 2014. In June 2014 there were 14,490 non-resident jobs in the region, and by June 2016 that had reduced to just 3,820 jobs (10.5), similar to pre-CSG levels.

The gas industry frequently makes claims about delivering substantial flow-on jobs in regional communities, particularly in the services industry, and job multipliers are frequently used to derive large job estimates. However, research undertaken by CSIRO's Gas Industry Social and Environmental Research Alliance found that job spill-overs into non-mining employment in the Surat Basin were negligible (10.6).

10.5 Employment impacts (*The Australia Institute, 2017 7.19*)

- While gas companies continually spruik the promise of more jobs for local communities as a justification for unconventional gas development, the simple fact is that it is a relatively small employer in the long term.
- The majority of gas industry jobs are required for the short construction phase only, they are not ongoing, as modern gas fields are highly mechanized and need very few people to operate them. Local employment opportunities are minimal with the majority of skilled workers being brought in from elsewhere with fly-in-fly-out workforces.
- The industry has made some incredible claims about its capacity to employ. In 2012 it claimed it created 100,000 jobs whereas the Australian Bureau of Statistics showed there were only 9,372 additional jobs. A 2011 report prepared for Santos by Allen Consulting Group found that a potential coal seam gas development in Northwest NSW would increase employment opportunities in NSW by 'around 2,900 ongoing full time positions', even though the project would only create about 30 gas industry jobs. Over 500 jobs would apparently be created in the public sector, at taxpayer expense *(10.7)*.
- Far from creating many additional jobs, the coal seam gas industry has been found to reduce employment in certain sectors. The Office of the Chief Economist's 2015 Review into the Socioeconomic Impacts of Coal Seam Gas in Queensland reported that 1.8 agricultural jobs are lost for every CSG job created *(10.8)*. Similarly, a study of Queensland's unconventional gas expansion by CSIRO's Gas Industry Social and Environmental Research Alliance found that for every 10 additional people employed in coal seam gas, 18 agricultural jobs were lost *(10.9, 10.10)*.
- The Chair of the NT Fracking Inquiry claimed there could be 32,000 jobs created by fracking in the NT, yet the Australia Institute states from the Inquiry's own research, there is a very high probability that no long term jobs will be created in the Northern Territory. Even the best case would be for only 500, but this was a very low probability. The Research Director of the Australia Institute criticised the inquiry chair, saying its own commissioned research had been ignored. The Chair later admitted she had quoted the wrong figure. *(10.19,10.20).* Interestingly, the APPEA claimed that up to 6,300 new long-term jobs could be created *(2.1)*.

10.6 Property values and credit Availability

Rabobank, the world's leading specialist in food and agribusiness banking, stated risks from unconventional gas mining included reductions in farm productivity, efficiency, land values and credit availability. It also indicated that concurrent CSG mining and agricultural activities could result in problem loans or defaults (10.11).

In 2016 it was revealed that a Queensland family was unable to obtain a bridging loan using their property for equity, because the property had four coal seam gas wells on it. The Commonwealth bank stated that coal seam gas wells on the land make the security unacceptable for residential lending purposes *(10.12, 10.13)*.

10.7 Insurance

Insurance companies have refused to insure against risks associated with unconventional gas extraction, both in Australia and in the USA. In the USA, homeowners can be confronted with uninsurable property damage for activities that they cannot control *(10.14)*.

In the north west of NSW, farmers have been refused insurance cover for risks and contamination associated with unconventional gas extraction *(10.15)*.

Landholders are concerned they may be liable for any negative impacts caused by hydraulic fracturing. In 2014, the NSW Chief Scientist released a report, which concluded that the CSG industry was markedly under-insured and that landholders were likely to bear a substantial risk as a result *(10.16)*.

Meat and Livestock Australia has advised there is a genuine risk that landholders may ultimately be responsible for liabilities arising from unconventional gas activities if they lead to personal injury, property damage, or contamination *(10.17)*.

The Rural Industries Research and Development Corporation cited a case study in Queensland where a landowner was advised by their supply chain partners that they would be liable for any contamination caused by coal seam gas activities. Neither the CSG company nor the insurer would agree to indemnify the landholder against that risk *(10.18)*. Legal advice indicated:

- Gas companies are refusing to include provisions in access agreements to accept liability for any contamination that may occur.
- Gas companies in Australia are under-insured and do not have adequate insurance to cover the types of risks that CSG activities bring.

- Some graziers have reported that insurers have examined the risk to them of unconventional gas contamination and found it too high to offer insurance.

One must ask the obvious question: **Why don't the companies cover the liabilities if the process is so safe and free of risks?**

10.8 USA experience

The impacts on the community in Australia are a repeat of the experience in USA. Sixty-four studies showed industry claims of job creation and economic benefits were exaggerated, and economic analyses found that property values, tax revenues and tourism diminished *(1.7).*

10.9 Experiences in dealing with social impacts in Queensland *(10.21,10.22, 10.23)*

Dr Wayne Somerville, a clinical psychologist in northern NSW, has dealt with mental health impacts arising from unconventional gas industrialisation in NSW and Queensland *(10.21).* Turning rural areas into gas fields creates social, psychological and environment stresses that undermine mental health. The impacts from unconventional gas industrialisation arise not only from its adverse impacts on the environment and human health, but also from the negligent approach to risk management from gas companies, regulators and political supporters. Governments promote interests of mining companies over individuals, small businesses and farming communities. The inability to control access to property, loss of property values, and damage to land, destroys farmers livelihood and the legacy for their children.

The gas industry and its political supporters appear to believe the industry is entitled to an assumption of innocence i.e. that unconventional gas is safe unless the community can prove otherwise *(10.21).* This is the reverse to other industries, such as the pharmaceutical industry, where the industry must prove a new product is safe before it is approved. There is community concern that it appears the regulatory authorities do not have the interests of the community at heart.

Rev Graham Slaughter *(10.22) w*itnessed how the rapid expansion of the unconventional gas industry marched over people's lives and communities with very little long-term benefit, compared to the pain, suffering and disruption that has occurred. It is clear co-existence is not possible. There was a strong distrust of the Government, as queries were ignored and there was a reluctance to properly investigate health problems. The lure for wealth took precedence over community well-being, as mining companies had greater access to water and farmers' land could be taken over.

Dr Geralyn McCarron, a Brisbane GP, outlined studies to indicate the Queensland Government has failed in its duty of care to people in the gas fields *(10.23).* Despite warnings from the AMA, appropriate research and regulations were not initiated. Data collected by the gas industry showed that emissions of air toxins known to cause human health escalated. Particulate matter known to cause cardiovascular and respiratory diseases were up 6,000% to 1,926t. Oxides of nitrogen, which affect the eyes, throat and lungs, were up 500% to 10,000t. Formaldehyde, an irritant to eyes, nose and throat, and can cause cancer, increased from 12kg to 160t. Problems raised with the Government have been ignored and treated with contempt. High levels of volatile organic compounds around homes, radioactivity, toxic fumes from flares, acid rain, and cancer concerns were reported without any action. The gas industry claimed that steel particles coated by sulphur and chlorine were sugar deposits left by insects!

11. IMPACTS ON AGRICULTURE *8 references*

11.1 Threat to agriculture in WA

Across Western Australia large areas of highly productive farmland are under threat from Unconventional Gas mining. Unconventional gas production is highly invasive, with the industrialisation of entire landscapes from the closely spaced wells, networks of roads and gas pipelines, and the infrastructure to extract, process and store the gas and waste. Fracking is an extremely water-intensive practice, taking valuable water from agricultural use. These activities have the potential to severely disrupt virtually every aspect of agricultural production and potentially even remove the land from production.

The presence of mining in the area reduces surrounding land values. Valuable agricultural and horticultural land is lost. Native forests and wild life are impacted. Experience elsewhere in Australia has shown that land owners have been refused bank finance due to uncertainty of the asset caused by the presence of wells on the property *(10.11, 10.12, 10.13*).

11.2 Landholders will lose millions every year by hosting unconventional onshore gasfields

A 2016 CSIRO report found the alienation of productive farmland for CSG infrastructure in Queensland resulted in losses in gross economic returns of up to 10.9% *(11.1)*. The total losses to gross revenues varied between $1.32m and $3.29m per property and averaged $2.17 million.

The Lock the Gate Alliance notes that the methodology used in this study estimated economic losses based solely on reduction in land area and did not attempt to quantify losses resulting from disruption to operations, dust generation, spills and leaks of wastewater or the spread of weeds. Therefore, total losses to landholders will undoubtedly be far higher.

11.3 Threats to agriculture and soil quality *(1.7)*

The compendium of scientific, medical, and media findings *(1.7)* cited 20 studies and concluded:

- Drilling and fracking take agricultural land out of production and pose risks to the agricultural sector.
- In California, fracking wastewater illegally injected into aquifers has threatened crucial irrigation supplies to farmers in a time of severe drought.
- The reuse of fracking wastewater for irrigation in California's San Joaquin Valley raises questions about contamination of food crops via bio-absorption through roots.
- Studies and case reports from across the country have highlighted instances of deaths, neurological disorders, aborted pregnancies, and stillbirths in farm animals that have come into contact with wastewater.
- Potential water and air contamination put soil quality as well as livestock health at risk.
- Farmers have expressed concern that nearby fracking operations can hurt the perception of agricultural quality and nullify value-added organic certification.
- Fracking chemicals in agricultural soils can interact with each other in ways that slow down their biodegradation.

11.4 Land owners have no rights to prevent access by the mining company *(11.2, 11.3, 11.4)*

Landowners have no rights to veto gas development on their land. Petroleum leases are issued by the Department of Mines and Petroleum with no consultation or rights to object. The affected landowners, businesses or the community do not have to be notified, as has been the case with the current leases. If a landowner initially refuses access, the matter will be referred to a Magistrates court after three months to decide on appropriate compensation.

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Prepared by Dr Bryan Whan for Lock The Gate Alliance

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