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3 Attachments

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Inquiry Name: Inquiry into Unconventional Gas in Victoria.

Dr Wayne Somerville

SUBMISSION CONTENT:
To The Legislative Council’s Environment and Planning Committee’s Inquiry into Unconventional Gas in Victoria

I wish to submit three reports for consideration by the Legislative Council’s Environment and Planning Committee’s Inquiry into Unconventional Gas in Victoria.

I am a registered clinical psychologist in private practice. All three reports were prepared by me at my own expense. I am making these submissions as a concerned individual and health professional. I am not a member of any political party, nor am I a spokesperson for any environmental group.

All three reports were peer-reviewed by Dr Mariann Lloyd-Smith, Senior Advisor with the National Toxics Network; a Queensland medical practitioner, who has published papers on the health impacts of unconventional gas pollutants; and a Ph.D. chemist. The committee can obtain an independent confidential opinion on my reports from Dr Lloyd-Smith (info@ntn.org.au). If required, I can forward contact details for the other peer reviewers.

Submission 1 – My attached report entitled “Dr W Somerville (2015) How Could CSG Air Pollution in the Darling Downs Be an Acceptable Risk to Health?” analyses recently released National Pollutant Inventory (NPI) data for annual air pollution emissions reported by unconventional gas industry facilities in Queensland's Darling Downs. The south-east Queensland CSG industry is the only example to date of a fully operational unconventional gas field in Australia. Consequently, the Darling Downs industry serves as a guide to what can be expected if similar gas fields are established elsewhere. The industry supplied NPI data provides a minimal estimate of the air pollution necessarily created by the industrial processing of unconventional gas. Even though the nature and volume of this air pollution clearly represents a serious potential threat to human health from operating industrialised unconventional gas fields in populated areas, this issue has generally been overlooked, and is not considered in any detail by Prof Mary O’Kane, the NSW Chief Scientist and Engineer, in her reports on CSG operations for the NSW Government. My report argues that the processes recommended by Prof O’Kane, which form the basis for her general claim that CSG associated risk can be managed, are not capable of preventing or significantly ameliorating dangerous air pollution from CSG industrial processing.

Submission 2 - My attached report entitled “Dr W Somerville (2014) Is CSG Safe? A Failed Public Debate in the Interests of Community Health” provides perhaps the only detailed debate and analysis of arguments put forward by gas mining company Metgasco’s CEO Mr Peter Henderson and his industry advisers to support their claims that the CSG industry is proven to be safe. This report concludes that there is nothing in the cited studies, reports, and arguments offered by Mr Henderson and the gas industry that comes close to providing scientific evidence that operating industrialised gas fields in populated areas is safe.

Submission 3 - My attached report entitled “Dr W Somerville (2013) CSG and Your Health - Risk Management Tools” provides a review of the literature on health impacts of CSG and Shale Gas mining pollutants, and gives questionnaires to assist much-needed baseline assessments. I note that amongst other sources, the “Compendium” prepared by Concerned Health Professionals of New York provides an up-to-date compilation of the rapidly growing scientific and medical literature regarding the health impacts of unconventional gas mining (http://concernedhealthny.org/wp-content/uploads/2014/07/CHPNY-Fracking-Compendium.pdf).

Submission 1 is directly relevant to the Inquiry’s Terms of Reference (TOR) (2), regarding “public health risks, risk mitigations and residual risks of onshore unconventional gas activities, and TOR (5), regarding the “knowledge requirements and policy and regulatory safeguards that would be necessary to enable exploration and development of onshore unconventional gas resources, including (a) further scientific work to inform the effective regulation of an onshore unconventional gas
industry, including the role of industry and government, particularly in relation to rigorous monitoring and enforcement, and the effectiveness of impact mitigation responses; and (b) performance standards for managing environmental and health risks, including water quality, air quality, chemical use, waste disposal, land contamination and geotechnical stability”.

Submissions 2 and 3 are directly relevant to the Inquiry’s Term of Reference (2), regarding “public health risks, risk mitigations and residual risks of onshore unconventional gas activities”.

Please contact me if you require further information, or if I can be of any further assistance to the Inquiry.

Wishing you all the best with your important deliberations for the people of Victoria.

Yours faithfully,

Wayne Somerville

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CSG and Your Health:
Understand the Risks, Protect Your Family

Self-help Risk Management Tools:
A Report on the Health Impacts of CSG and Shale Gas Mining
&
CSG Health Checklists


For further information, please contact:
Dr Wayne Somerville email: waynes@bordernet.com.au
Download copies from the CSG Page at www.creeksbend.com
<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Protecting public health – The role of baseline data</td>
<td>3</td>
</tr>
<tr>
<td>Will governments and industry protect community health?</td>
<td>4</td>
</tr>
<tr>
<td>What can we do to protect the health of our communities?</td>
<td>6</td>
</tr>
<tr>
<td>Mental Health Impacts of the “CSG Experience”</td>
<td>7</td>
</tr>
<tr>
<td>Physical Health Impacts of Unconventional Gas Mining</td>
<td>9</td>
</tr>
<tr>
<td>Dangerous Substances</td>
<td>9</td>
</tr>
<tr>
<td>Industrial Chemicals</td>
<td>9</td>
</tr>
<tr>
<td>Dust, Particulates and Diesel Emissions</td>
<td>11</td>
</tr>
<tr>
<td>Risks to Health</td>
<td>11</td>
</tr>
<tr>
<td>Pathways to Human Contamination</td>
<td>16</td>
</tr>
<tr>
<td>Air Pollution</td>
<td>17</td>
</tr>
<tr>
<td>Water Pollution</td>
<td>20</td>
</tr>
<tr>
<td>Soil Pollution</td>
<td>24</td>
</tr>
<tr>
<td>Cases of Human Disease Associated with Gas Mining</td>
<td>24</td>
</tr>
<tr>
<td>Protecting your family’s health</td>
<td>28</td>
</tr>
<tr>
<td>Symptom Checklist</td>
<td>31</td>
</tr>
<tr>
<td>Exposure to Gas Mining Questionnaire</td>
<td>33</td>
</tr>
<tr>
<td>CSG Concerns Questionnaire</td>
<td>36</td>
</tr>
<tr>
<td>The Depression Anxiety Stress Scale – 21</td>
<td>39</td>
</tr>
<tr>
<td>Selected Downloadable References</td>
<td>41</td>
</tr>
<tr>
<td>References</td>
<td>45</td>
</tr>
</tbody>
</table>

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CSG and Your Health:
Understand the Risks, Protect Your Family

A Report on the Health Impacts of CSG and Shale Seam Gas Mining


“Despite the rapid expansion of CSG developments, the health impacts have not been adequately researched, and effective regulations that protect public health are not in place. There is a lack of information on the chemicals used and wastes produced, insufficient data on cumulative health impacts, and a lack of comprehensive environmental monitoring and health impact assessments. In circumstances where there is insufficient evidence to ensure safety, the AMA recommends that the precautionary principle should apply. This is essential given the threat of serious and irreversible harms to human health.”

Dr Steve Hambleton, President of the Australian Medical Association, May 2013

Introduction

Gas mining has traditionally used a limited number of wells in unpopulated areas to extract gas from naturally formed underground reservoirs. In contrast, “unconventional” mining for gas from coal seams, shale, and tight sands can involve thousands of wells spread across populated areas, and the horizontal drilling, fracturing, and depressurising of gas-bearing strata. All forms of unconventional gas mining share a common technology and involve the use and liberation of similar dangerous substances.

Mining for Coal Seam Gas (CSG) and other forms of unconventional gas is an unprecedented threat to our community. Australians have never before faced the prospect of living and raising children amidst heavily industrialised gas fields - in landscapes dominated by gas wells, pipes, flares, busy roads, wastewater ponds, and pumping and compression stations. Entire communities are being exposed to a myriad of psychological and social stresses, and a witch’s brew of air, water, and soil contaminants.

The fundamental problem with unconventional gas mining is the unmanageable creation of dangerous pollution during production. Liquefied Natural Gas (LNG) burns cleaner than coal, but this benefit is only achieved by polluting air, water and soil and by compromising the health of communities where the gas is mined and processed.

Professor Mary O’Kane, the NSW Chief Scientist and Engineer, concluded that “considerable work and research still needs to be conducted by researchers, government and industry to determine the potential risks to health from activities related to CSG extraction”.

Nonetheless, we already know much about the potential for unconventional gas mining to harm human health, and specific threats are identified and understood.

Protecting Public Health - The Role of Baseline Data

Any industry that exposes people to potentially harmful products or processes has an obligation to assess and manage risks to health. Legal responsibilities for duty of care and due diligence require “duty holders” to actively seek out evidence of possible threats, and to think beyond known dangers to consider all risks, “not only those for which regulations and codes of practice exist”.

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When assessing health risks, a proposed development is not entitled to the presumption of innocence accorded a defendant in a criminal prosecution. The development can not be assumed to be safe (i.e., “innocent”) until it is proved to be harmful (i.e., “guilty”) “beyond a reasonable doubt”.

For instance, new medications are not approved for public use until they have been rigourously tested in controlled studies that look for harmful effects by comparing data taken before and after use of the medication. The “burden of proof” is on the pharmaceutical company, which has to demonstrate that the medication is safe before it can be sold to the public.

Corporations that seek to profit from operating heavily industrialised gas fields in populated areas should be responsible for establishing the safety of their operations. Citizens should not need to prove that gas mining is dangerous.

Baseline health assessments are essential to establish the safety of gas mining operations. Scientific methodology for determining the safety of a product or process requires well designed research that compares data on human health and the presence of potentially harmful substances in water, air, and soil, obtained both before (i.e., the “baseline”) and after development takes place.

**Will governments and industry protect community health?**

“There is no credible evidence that CSG operations have a negative impact on humans and livestock. CSG operations have operated safely in Australia for over 16 years and following extensive reviews have the support of Australian, Queensland and NSW governments.”

Metgasco CSG Mining Company, 2012

“That information (from anti-CSG activists) has gone into the mainstream to such an extent that there is a perception and a view that this is a risky, dangerous, unhealthy industry, which is in fact the furthest from the truth.”

AGL has been operating a project in Camden for over 13 years, “where there has been no health impacts, no water contamination taking place, no fugitive emissions of any magnitude have been detected, so therefore the perception they’ve built up is far from reality, but the perception has driven public sentiment and in turn public policy”.

Michael Moraza, AGL Upstream Gas Group General Manager, 2013.

The proper assessment and management of risks to human health requires more than CSG companies deciding what constitutes “credible” evidence and simply declaring that their mining operations are in all ways safe.

If CSG companies confidently “know” that their operations are safe, there is a greatly reduced likelihood that they will discharge their duty to the community to properly monitor, investigate, and prevent or mediate health risks associated with operating gas fields in populated areas.

AGL’s failure to monitor air emissions at their Camden CSG operation illustrates how vital health risk assessment processes can fail.
In March 2013 the Environment Protection Authority (EPA) fined AGL for not maintaining its emissions monitoring equipment. In the August 2013 “Undertaking to the Environment Protection Authority” signed by AGL Director Michael Moraza, the EPA expressed “concern” that in 2007 AGL’s emissions monitoring equipment began to break down, and by 2009 all their monitoring equipment had stopped operating. Monitoring for the single pollutant nitrous oxide only recommenced in July 2012.

AGL provided false information to the EPA in Annual Returns from 2006 to 2011, and its publicly available 2007 to 2011 Annual Environmental Performance Reports included the “false and misleading” statement that, “Full results of the continuous emissions monitoring for the reporting period are kept on file”. “AGL advised that the non-reporting was due to oversight combined with a lack of understanding by AGL staff regarding the significance of the equipment breakdown”. 9

What evidence could underpin AGL Manager Mr Moraza’s claim that there has been “no health impacts, no water contamination taking place, no fugitive emissions of any magnitude” at their Camden gas field? In this case, the absence of evidence of harm does not mean that there is no harm, only that there is no data. Further, AGL’s permitted annual air emissions of 103,000 kg of nitrogen oxides10 do appear to have some “magnitude”, especially given that their CSG emissions include significant amounts of other unmonitored substances.

It is not clear why gas mining companies and regulatory authorities have not obtained the pre-drilling baseline health and environmental data essential for proving the safety of this industry. Only a few politicians have called for proper assessment of health risks prior to approval of unconventional gas mining. Even if the possibility of great harm was small, those promoting gas mining would have a responsibility to properly assess and manage risks to public health. But in this case, evidence to support the claim that gas mining is safe is entirely lacking, while abundant scientific research indicates a high level risk of potentially catastrophic health impacts from operating gas fields in populated areas.

Reports of people being harmed have been dismissed on the perverse grounds that a lack of baseline data makes it impossible to “prove” that their health deteriorated after CSG drilling began. Such arguments demonstrate a disregard for principles of risk assessment and duty of care, and reverse the “burden of proof” that should apply when assessing risks to human health. If we do not heed the warning that “those who cannot remember the past are condemned to repeat it”, unconventional gas mining could become the 21st Century’s version of last century’s asbestos and tobacco health tragedies, only much worse.

By the 1930s, scientists had linked asbestos to cancer, but in Australia asbestos was not banned until 2003. In the late 1970s, court documents proved that industry executives had known all along that asbestos was dangerous, but had concealed this information as they promoted their business. The 1964 US Surgeon General’s Report found that cigarette smoking was the cause of lung and laryngeal cancer, but until court cases in the late 1990s, the tobacco industry lied about the known health impacts of smoking, and claimed that nicotine was not addictive and that there was no “proven” link between cancer and smoking.

The asbestos and tobacco industries thrived while executives denied the known health risks of their products and public regulators did little. Profits harvested over decades were never discounted to reflect the true costs in suffering, illness and death borne by the community.

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Nowadays, like asbestos and tobacco in the past, unconventional gas mining is promoted in the absence of proper risk assessment. As before, regulatory authorities appear unwilling or unable to effectively protect public health.

**What can we do to protect the health of our communities?**

Many people have called for assessment of the health risks from operating gas fields in populated areas, but this is not a straightforward process. Epidemiological studies can take years to complete, and the current threat to health is serious and urgent. Baseline data has to be collected prior to drilling and for many areas that time has passed. Communities are already exposed to dangerous pollutants. In the Northern Rivers, the safety of the existing 60 or so CSG wells cannot be assumed, and no one knows whether people have been exposed to levels of pollution sufficient to cause illness.

In the current circumstances, responsibility for protecting community health falls on individuals. A self-help process of risk assessment and management could make a difference.

A good understanding of how gas mining pollutants can affect health is essential. A potential danger that is not recognised cannot be avoided or mitigated. If you do not know that the fibro you are breaking up contains asbestos, you will have no idea that you are being injured. If you develop lung cancer years later you will have no idea why this has happened to you. People need to understand the risks and how they could be harmed.

Medical professionals need information about CSG health impacts so they can properly diagnose and treat affected patients. Gas field pollutants can cause severe permanent injuries, and for all affected people, but especially for children, it is essential that exposure to harm ends as soon as possible. Unlike asbestos and tobacco-related illnesses, some symptoms of gas poisoning develop quickly, and effective treatment is possible if symptoms are promptly and accurately diagnosed.

This report and the questionnaires are self-help risk management tools which could help people better protect their families from the health impacts of unconventional gas mining.

- The Report on the Health Impacts of CSG and Shale Gas Mining reviews what is known about the dangerous substances and processes, potential pathways to contamination, and health impacts associated with unconventional gas mining.

- The Symptoms List presents symptoms that researchers have associated with exposure to gas field pollutants. If repeated over time, the list can provide either ongoing reassurance of a clean bill of health, or alternatively assist early recognition of a change in health status.

- The Exposure to Gas Mining Questionnaire records information about possible sources of contamination.

- The CSG Concerns Questionnaire records ratings of emotional distress from various dimensions of the CSG experience.

- The Depression Anxiety Stress Scale (DASS-21) - If repeated over time, responses to this questionnaire could help a person to better recognise changes in symptoms of anxiety or depression.
The Report and the associated questionnaires are educational materials only, and are not any form of medical assessment or treatment or legal advice. In all cases, you should discuss any concerns that you have about your mental or physical health with your family doctor. No guarantee is given or implied that the report or the questionnaires carry any legal weight, and you should seek professional legal advice for any questions you have regarding gas mining, personal injury, the law, or other legal issue.

The Report on the Health Impacts of CSG and Shale Gas Mining and associated questionnaires are provided free of charge in the interests of community health. You can copy and distribute these documents provided that they are reproduced in full, without alteration and with all citations and references, and no fee is charged. Copies of these materials and many of the referenced publications are available for free download by clicking the links in the attached “Selected References on Gas Mining Health Impacts” on page 41 of this document.

Risks to worker and public health from unconventional gas mining can arise from political and industrial processes that cause emotional distress and/or create air, water, soil, light, and noise pollution.

Mental Health Impacts of the “CSG Experience”

The rapid transformation of rural communities into industrialised gas fields introduces complex social, psychological and environmental stresses that can undermine health.

The CSG experience is not necessarily stressful in itself - people who profit from gas mining often consider it a good thing. People who feel threatened by, or who suffer losses or injuries as a result of gas mining are most at risk of developing symptoms of emotional distress.

A sense of threat can trigger the “fight or flight” response - a natural coping mechanism which helps us survive dangerous situations. Anxiety signals the presence of danger, and adrenaline and anger prepare us to fight off, or escape from, the threat. If these responses lead to action that successfully removes the danger, then stress will ease. But if the threat cannot be removed, stress reactions can become chronic and result in symptoms such as sleep disturbance, anxiety and depression.

Potentially Distressing Features of the CSG Experience include:

- Loss of control over access to one’s property
- Loss of the right to quiet enjoyment of home and property
- Diminished quality of lifestyle

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

- Noise\textsuperscript{11} and light pollution
- Disturbed sleep cycles

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Grief, emotional shock, and a sense of loss, complicated by disturbed sleep due to noise and light pollution from lighting, traffic, compressors, and reverse osmosis plants, can lead to debilitating symptoms of psychopathology.\(^\text{12}\)

During sleep, the brain and body repeatedly cycle through stages of dreaming to deep sleep. Deep sleep repairs the body, and dreaming works to resolve emotional issues and consolidate memories. Noise and light pollution disrupt dreaming and deep sleep, impede natural healing and restorative processes, and can trigger anxiety and depressive illnesses.

- Loss of land value
- Lack of adequate compensation
- Compromised livelihood from loss of productive agricultural land

For many farming families, their land is their life’s work. For most people, their home is their major asset and legacy for their children. For affected people, the loss of property value and damage to their land feels like a personal injury. The decline in land values can be resented as an unfair transfer of wealth from families to mining companies.

- Denial of an economic “level playing field”
- Politicians’ lack of respect, and even contempt for citizens’ concerns
- Damage to privately owned assets and small businesses

Respect for Government and the rule of law can be undermined when principles of “a fair go” for all and an economic “level playing field” are seen to be abandoned in favour of powerful mining companies. The perceived violation of individual rights and lack of regard for small businesses can foster unhealthy beliefs that political and legal processes are unfair and that politicians cannot be trusted to protect the community’s interests.\(^\text{13}\)

- Sense of violation of “Mother Earth”
- Grief over loss of “Nature’s gifts of beauty rich and rare”
- Powerlessness to protect one’s natural environment
- Negotiating with companies from an inferior position

For some Australians the degradation and pollution of the land can foster a sense of disempowerment and pessimism.\(^\text{14}\) Australian psychiatrist Glenn Albrecht (2005)\(^\text{15}\) coined the term “Solastalgia” - a loss of solace - to describe the distress that people who are connected to the land feel when their environment is damaged. Affected people can develop unhealthy beliefs that the world is malevolent and uncontrollable.

- Community impacts from rising rents and large numbers of transient workers
- Increased sexual assaults, illicit drugs, and prostitution
- Intimidation by young male mining workers
- The trauma of ill-health

Dubbed the “Boomtown Effect” in the US, for some communities the rapid changes in population, intensive industrialisation, and economic effects due to gas mining result in social ills that can undermine health. There are reports of CSG industrialisation in some Queensland communities leading to: increased rates of crime, drug and alcohol abuse, sexually-transmitted infections, and domestic violence; inadequate supply and quality of housing; increased cost of living; increased community dissatisfaction; increased mental health and social services case loads; and increased hospital admissions.\(^\text{16,17}\)

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In their submission to the NSW Parliamentary CSG Inquiry, the Doctors for the Environment group noted that, “The CSG process can divide previously close-knit rural communities, increasing tension and disharmony, impact on local economies, and threaten other industries. The final common pathway for effects from these impacts may be poorer mental health, with increases in depression and anxiety.”

Emotional distress triggered by the CSG experience can undermine health, but exposure to dangerous chemicals and industrial processes can result in serious physical injuries.

**Physical Health Impacts of Unconventional Gas Mining**

“*The fundamental public health issue is the potential for water contamination by chemicals which could seriously affect human health decades after exposure. Health impacts may arise from the use of fracking chemicals or from the release of hydrocarbons and other contaminants from the coal seams.*”

Professor David Shearman, Emeritus Professor of Medicine, University of Adelaide

Three conditions need to be satisfied for an industrial process to be considered a serious threat to human health. The industry must use dangerous substances. There have to be environmental pathways which potentially bring people into contact with these substances. And it has to be possible for people to be exposed to pollutants in doses sufficient to cause illness. There is abundant evidence that operating CSG gas fields in populated areas satisfies these three criteria.

This report reviews what is known about:

- The identity and health impacts of potentially harmful substances used in gas mining and naturally present in coal and shale gas seams,
- The environmental pathways that make it possible for humans to come in contact with these substances, and
- Cases of illness reasonably attributed to contact with these dangerous substances.

**Dangerous Substances**

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

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

In addition to dangerous substances naturally present in coal and shale seams, unconventional gas mining also involves the use and production of significant quantities of industrial chemicals, as well as dust, particulates, and diesel emissions.

**Industrial Chemicals**

Gas mining companies argue that only a small percentage of drilling and fracking fluids consists of chemicals, but the volume of fluids used creates a considerable chemical load.
EDUCATIONAL MATERIALS ONLY - NOT MEDICAL OR LEGAL ADVICE

The scale of chemical use in a developed gas mining operation was illustrated by a US House of Representatives Committee finding that over a four year period, 14 companies used more than 2,500 hydraulic fracturing products containing 750 chemicals and other components, to make up (excluding water added at the well site) 780 million gallons of hydraulic fracturing products.  

In Australia, in some cases, large quantities of chemical additives are used both at the drilling stage and during hydraulic fracturing. A risk assessment provided to the Queensland Department of Environment and Resource Management (DERM) listed approximately 18,500 kilograms of chemical additive used per well with up to 40% (7,500kg) not recovered.

In Australia, there is no national requirement for public disclosure of all chemicals used in CSG operations, and there is no publicly available comprehensive list of fracking chemicals. The following information regarding the types of chemicals used in unconventional gas mining was compiled from research by the National Toxics Network.

In Australia, drilling fluid can include:

- Viscosifiers (e.g., bentonite, polyacrylamide)
- Weighting agents (e.g., barium sulphate)
- Bactericides/biocides (e.g., glutaraldehyde)
- Corrosion inhibitors (e.g., zinc carbonate, sodium polyacrylate)
- Defoamers (e.g., glycol blends, light aromatic and aliphatic oil, naptha)
- Emulsifiers and demulsifiers
- Lubricants (e.g., chlorinated paraffins)
- Scale inhibitors (e.g., anionic polyacrylamide, acrylamide copolymer)
- Polymer stabilisers (e.g., Sodium sulfite)
- Breakers (e.g., diammonium peroxysulphate, hemicellulase enzyme)
- Salts (e.g., potassium chloride, sodium chloride, calcium chloride)

Hydraulic fracturing fluids usually include:

- Gelling agents (e.g., guar gum, diesel, alkanes/alkenes)
- Gel stabilisers (e.g., Ammonium persulfate)
- Gel breakers (e.g., Ammonium persulfate, sodium persulfate)
- Friction reducers (e.g., polyacrylamide, mixtures of methanol, ethylene glycol)
- Surfactants (e.g., isopropanol, 2-Butoxyethanol /2-BE)
- Biocides (e.g., glutaraldehyde, Tetrakis hydroxymethyl phosphonium sulfate/THPS, 2-Bromo-2-nitro-1,3-propanediol (Bronopol), 2,2-Dibromo-3-nitriolopropionamide)
- Clay stabilisers (e.g., tetramethyl ammonium chloride)
- Buffer fluids and cross-linking agents.

Fracking may also use:

- Corrosion inhibitors (e.g., formamide, methanol, naphthalene, naptha, nonyl phenols, acetaldehyde)
- Scale inhibitors (e.g., ethylene glycols)
- Iron control agents (e.g., citric acid, thioglycolic acid)
- pH adjusting agents (sodium or potassium carbonate)
- Diluted acid to dissolve minerals (e.g., hydrochloric acid, muriatic acid)

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Dust, Particulates and Diesel Emissions

Dust and particulates are created and mobilised by vehicle and construction activity. Dust is especially hazardous when it contains coal seam and mining chemicals from the spraying of dirt roads with waste water, proppants (i.e., sand/silica and chemicals injected into coal and shale seams to keep fissures open), and diesel fumes and exhaust.

Crystalline silica is a common mineral found in sand, clay and stone. Respirable crystalline silica is the portion of silica that is small enough if inhaled to enter the gas-exchange regions of the lungs. The handling of huge quantities of sand during fracking generates dust containing respirable crystalline silica.

Diesel emissions from vehicles, drills, pumps, compressors, generators, and other equipment are created during all phases of the unconventional gas mining process - from exploration through production, processing and transportation. Diesel fumes and exhaust contain: a mix of fine particles; gases such as carbon monoxide; sulfur oxides and nitrogen oxides; and volatile organic compounds including benzene, toluene, ethylbenzene and xylene.

Unconventional gas mining uses a significant volume of diesel for transport. The New York City Department of Environmental Protection estimated that 800 to 2,000 truck trips are needed for a single-well shale gas pad. A report by the University of Manchester’s Tyndall Centre indicated that between 4,300 and 6,600 truck visits occur during pre-production for a six-pad shale gas well arrangement. 10% of the United Kingdom’s gas production would require a total of 2 to 4 million truck journeys. Assuming a maximum concentration of 20 wells on one pad, with six frackings over 30 years, there could be between 38,400 to 172,800 tanker truck trips over the life of the well pad.

Risks to Health

Most chemicals used in unconventional gas mining have not been assessed for their toxicity, persistence, or long-term health impacts. There has been no assessment of new compounds that form when mining chemicals interact with other substances or with natural catalysts such as sunlight, water, air, and radioactive elements.

The US House of Representatives Committee on Energy and Commerce identified over 750 chemical products used in gas mining, with 650 containing hazardous substances including carcinogens, neurotoxins, irritants/sensitisers, reproductive toxins, and endocrine disruptors. Some of these chemicals are dangerous at concentrations below detection limits.

A UK study of chemicals supplied to New York State for shale gas mining found that 58 of the 260 substances listed were a risk to health: 17 were classified as toxic to aquatic organisms, 38 were classified as acute toxins to humans, 8 were known carcinogens, 6 were suspected carcinogens, 7 were classified as mutagenic, and 5 were classified as having reproductive effects.

Colborn, et al.’s (2011) review of chemicals used in US shale gas fracking found that:

“More than 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40-50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations.”

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Dr Colborn, et al. (2011)\textsuperscript{36} commented that:

“Numerous systems, most notably the endocrine system, are extremely sensitive to very low levels of chemicals, in parts-per billion or less. The damage may not be evident at the time of exposure but can have unpredictable delayed, life-long effects on the individual and/or their offspring. Health impairments could remain hidden for decades and span generations.” \textsuperscript{37}

According to Dr Effie Ablett (2013)\textsuperscript{38}, “A few of these chemicals (used in Australian CSG mining) have been studied and listed as possible carcinogens, but most, including those likely to be the most potent carcinogens, remain untested and therefore are largely not taken into account in assessing potential health risks.” Currently legislated “safe” or maximum contamination levels are close to the level of detection for the few known carcinogens listed, and more potent carcinogens such as Poly Aromatic Hydrocarbons “are likely to cause cancer at concentrations that are orders of magnitude below their detectable levels in drinking water”. \textsuperscript{39}

Law (2013)\textsuperscript{40} described how endocrine disrupting chemicals can interfere with hormone action even at very low concentrations, and these effects can be specific to particular stages of a child’s physical development.

Only two of the 23 most commonly used fracking chemicals said to be used in Australia have been assessed by the National Industrial Chemical Notification and Assessment Scheme (NICNAS), and neither of these has been specifically assessed for use in fracking.\textsuperscript{41} Chemicals used by the Australian unconventional gas industry (e.g., glutaraldehyde, brominated biocides, propargyl alcohol, 2-butoxyethanol and heavy naphtha) have been found to be dangerous at concentrations near or below chemical detection limits by the State University of New York.\textsuperscript{42}

Brown (2013)\textsuperscript{43} noted that understanding gas field toxicology is complicated because:

- We have incomplete identification of the chemicals present
- Chemicals can interact with other chemicals in complex unknown ways
- The presence of one agent can greatly increase the toxicity of another agent
- Agents have multiple physiological actions on various target organs
- Health effects of exposure to many chemicals is unknown
- How certain chemicals alter the biological processing of other chemicals is unknown
- Substances that inhibit metabolism or excretion magnify the effects of other chemicals
- Some agents can change the physiologic distribution of other chemicals
- Some agents can cause chemicals that would not normally do so to enter the brain
- Medications can affect the impact of toxic substances

Potentially harmful chemicals used in or liberated by unconventional gas mining include:\textsuperscript{44,45,46}

- \textbf{Volatile Organic Compounds (VOCs)} - Some VOCs are very toxic and bioactive. VOC exposure can cause eye, nose, and throat irritation, headaches, visual disorders, memory impairment, loss of coordination, nausea, and damage to liver, kidneys, and the central nervous system.\textsuperscript{47} The US EPA noted that some VOCs can cause cancer and other serious, irreversible health effects, including neurological problems and birth defects.\textsuperscript{48}

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Some VOCs are known to cause cancer in animals (e.g., methylene chloride), or in humans (e.g., formaldehyde), or are suspected human carcinogens (e.g., chloroform, bromodichloromethane). VOCs are also key ingredients in forming ozone and smog, and fine particle pollution, which is linked to asthma attacks, and other health effects.

- **Benzene, toluene, ethylbenzene, and xylene (BTEX)** - Benzene and toluene are particularly problematic VOCs because they tend to be activated into other substances and impact on certain tissues in unique ways. ⁴⁹ Short-term health effects of exposure include dizziness, headache, loss of coordination, respiratory distress, and skin, eye, and nose and throat irritation. Long-term health effects of exposure to BTEX chemicals include kidney, liver, and blood system damage. Long term exposure to benzene can affect bone marrow, causing anaemia and increasing the risk of leukaemia and diseases such as non-Hodgkin's lymphoma. ⁵⁰ Benzene is a health hazard even in minute quantities. The Australian drinking water guidelines for benzene state that “no safe concentration for benzene in drinking water can be confidently set” so the guideline is set below the level of detection at 1 ppb (the equivalent of a drop of water in a swimming pool) ⁵¹⁻⁵³ US researchers have found an association between exposure to benzene and delivery of a child with birth defects. ⁵⁴ In France, researchers using closeness of residence to a major highway as an approximate measure of exposure to benzene, found a relationship between increased exposure and lighter, smaller children with smaller head circumference. ⁵⁵

- **Poly Aromatic Hydrocarbons (PAH)** - PAHs and their derivatives “are among the most potent carcinogens, having structures that resemble the base pair in DNA and readily intercalating and/or covalently bonding to DNA causing mutation.” ⁵⁶ Neuro-developmental disorders and lowered IQ in babies has been associated with the mother’s exposure to PAHs during pregnancy. ⁵⁷

- **Methanol** - A highly toxic VOC readily absorbed via ingestion, inhalation, and skin exposure. Causes central nervous system depression and degenerative changes in the brain and visual system. In the body methanol is metabolized to formaldehyde and formic acid, and is toxic in very small doses if ingested. Chronic exposure causes headache, insomnia, gastrointestinal problems, and blindness in humans, and hepatic and brain alterations in animals. ⁵⁸ Methanol is highly mobile in soil. Methanol volatilizes from water and once in the air, exists in the vapor phase with a half-life of over 2 weeks. Methanol reacts with photo-chemically produced smog to produce formaldehyde and can also react with nitrogen dioxide in polluted air to form methyl nitrite.

- **Ethylene Glycol** - A human respiratory toxicant and teratogen (i.e., an agent that causes malformation of an embryo or foetus) in animal tests. Associated with increased risks of spontaneous abortion and sub-fertility in female workers. When ethylene glycol breaks down in the body, it forms chemicals that crystallise, collecting in the kidneys and affecting kidney function. It also forms acidic chemicals in the body, affecting the nervous system, lungs and heart. ⁵⁹

- **2-Butoxyethanol** - Readily absorbed and rapidly distributed in the human body. It destroys red blood cells at relatively low levels of exposure; can damage spleen, liver and bone marrow; and cause reproductive problems and birth defects in animals. ⁶⁰
• **Ethoxylated 4-nonylphenol** - A persistent, bio-accumulative, endocrine disruptor which is very toxic to aquatic organisms, and has been found to increase the incidence of breast cancer in lab animals. This chemical mimics estrogen, and can cause the feminization of fish, even at concentrations not detected by normal monitoring of the fluid.  

• **Isopropanol** - A central nervous system depressant that can cause degenerative changes in the brains of lab animals.

• **Formamide** - A teratogen with the potential to affect the unborn child. Can be absorbed into the body by inhalation and through the skin.

• **Naphthalene** - Causes nasal and lung tumours and is listed as a possible human carcinogen. Readily absorbed via oral dose or inhalation. Chronic exposure of workers reported to cause cataracts and damage to the retina.

• **Ammonium persulfate and Sodium persulfate** - Harmful if swallowed, and inhalation or skin contact can cause sensitization. Can irritate the skin and eyes and cause allergic reactions, rashes and eczema. Long-term exposure can affect lung function leading to disease of the airways and/or asthma.

• **Limonene** - A skin sensitiser and respiratory irritant.

• **Glutaraldehyde** - Highly irritating to the eyes, skin, and respiratory tract. Repeated skin contact can cause allergic reactions.

• **Acetaldehyde (Aldehyde)** - Primary acute effect of inhalation exposure is irritation of the eyes, skin, and respiratory tract in humans. At higher exposure levels, erythema, coughing, pulmonary edema, and necrosis may also occur. Acetaldehyde is considered a probable human carcinogen (Group B2). No information is available on the reproductive or developmental effects of acetaldehyde in humans. Acetaldehyde has been shown, in animals, to cross the placenta to the fetus, and animal studies suggest that acetaldehyde may be a potential developmental toxin.

• **Formaldehyde** - Classified as a known human carcinogen by the International Agency for Research on Cancer (IARC) and as a probable human carcinogen by the US EPA. An association between formaldehyde exposure and several cancers, including nasopharyngeal cancer and leukemia, has been found in exposed workers. Exposure occurs primarily via inhalation of gas or vapour, or by skin absorption. When formaldehyde is present in the air at levels exceeding 0.1 ppm, some individuals may experience adverse effects such as watery eyes; burning sensations in the eyes, nose, and throat; coughing and wheezing; nausea; and skin irritation. Some people are very sensitive. Less is known about formaldehyde’s potential long-term health effects. The US EPA classified formaldehyde as a probable human carcinogen under conditions of high or prolonged exposure. The IARC classifies formaldehyde as a human carcinogen. Exposure to formaldehyde may cause leukemia, particularly myeloid leukemia, and possibly nasopharyngeal cancer in humans.
• **Tetrakis (hydroxymethyl) phosphonium sulfate (THPS)** - Toxic to microorganisms, and repeated skin exposure to THPS resulted in severe skin reaction and sensitization in guinea pigs. Identified as a severe eye irritant in rabbits. Has mutagenic potential (in vitro) and cancer potential in rats. No exposure information is available for either humans or organisms in the environment. Little is known about the effects of the break down products of THPS.

• **Methylene chloride** - The second most frequently appearing compound in water around gas drilling sites. A central nervous system (CNS) depressant, it decomposes to phosgene, a very toxic substance, and breaks down to carbon monoxide in the body. Linked to reproductive effects. The short-term effects of methylene chloride inhalation in humans consist mainly of nervous system effects including decreased visual, auditory, and motor functions. The effects of long-term exposure suggest that the CNS is a potential target in humans and animals. Human data are inconclusive regarding methylene chloride and cancer. Animal studies found increases in liver and lung cancer and mammary gland tumors following inhalation of methylene chloride.

• **Fumaric acid** - An irritant of skin and mucous membranes.

• **Persistent Organic Pollutants (POPs)** - Perfluorooctane sulfonic acid, permitted in hydraulic fracturing, and chlorinated paraffins used in drilling fluids, are amongst the most dangerous of all man made chemicals.

• **Carbon monoxide** - Released by incomplete combustion of gas and machinery emissions. Cleared from the body slowly. Episodic exposures to high levels, particularly in children, can produce neurological effects due to the blood’s decreased ability to carry oxygen.

• **Radium** - A very toxic, water-soluble carcinogen associated with increased incidence of bone, liver and breast cancer. Radon, a decay product of radium, is the leading cause of lung cancer amongst non-smokers and the second leading cause of lung cancer amongst smokers.

   “Radon decay elements deposit as a film on the inner surface of inlet lines, treating units, pumps, and valves principally associated with propylene, ethane, and propane processing streams. Because the radioactive materials become concentrated on gasfield equipment, the highest risk of exposure to radioactive substances is to workers who cut and ream pipe, remove solids from tanks and pits, and refurbish gas processing equipment.”

• **Barium, Arsenic, Lead and Fluoride** - Tend to act by replacing normal physiological systems in the body. Consequently, inhibition of calcium is frequently seen, and the substances are likely to be detected in target organs and are difficult to detect in urine. Some compounds of fluoride are not very toxic, but fluorine is a very potent halogen that can cause deep burning of the skin.

• **Dust and Particulates** - Fine particles become hydrated and can absorb soluble toxins present in the surrounding air. When such hydrated fine particles are inhaled, toxic chemicals can be transported deep into the body where they would not otherwise normally penetrate. Particles that fall to the ground can be tracked into the house, where they can be inhaled after vacuuming.
**Silica** - Inhaling silica is a known cause of lung cancer and a suspected contributor to autoimmune diseases, chronic obstructive pulmonary disease and chronic kidney disease. If inhaled into the deep lung it releases a lysosome that initiates progressive scarring. The effects of silica exposure on children or people with compromised lung function are unknown. Symptoms of chronic silicosis include shortness of breath, fatigue, cough, and, in some cases, respiratory failure.

**Diesel fumes and particulates** - In 2012 the World Health Organization (WHO) classified diesel engine exhaust as carcinogenic to humans (Group 1) due to an increased risk of lung cancer. Diesel motors emit particles which are very harmful due both to their size and chemical content. If inhaled, fine (PM2.5) particles get into lung tissue and set up inflammatory foci which spread damage throughout the body, including the brain. Ultra-fine particles (PM0.1) can get inside cells and change genetic material. Diesel particles are carried to the brain where they are particularly damaging to young children. Exposure to diesel particles has been associated with lowered IQ in infants and an increase in autistic and antisocial behaviours.

**Ozone** - Produced from mixing VOCs with nitrogen oxides from diesel exhaust. Gas field ozone has created a previously unseen air pollution problem in rural areas, similar to that found in large urban areas, and can spread up to 200 miles beyond the immediate region where gas is being produced. One highly reactive molecule of ground level ozone can burn the deep alveolar tissue in the lungs, causing premature ageing. Chronic exposure can lead to asthma and emphysema, and is particularly damaging to children, active young adults who spend time outdoors, and the aged. As children’s lungs develop in the presence of ozone, alveolar production is reduced, and chronic ozone exposure can result in a child developing brittle lungs like those of an elderly adult.

**Methane** - Methane toxicity is usually thought of in terms of inhalation and the asphyxiation hazard created by the displacement of oxygen, but “we know virtually nothing about how methane might affect people who ingest it.”

There is no doubt that CSG and Shale Gas mining involve the use and liberation of potentially dangerous substances. The following section reviews evidence regarding the potential for humans to come into contact with these hazardous substances via environmental pathways of water, air, and soil contamination.

**Pathways to Human Contamination**

"Under natural conditions, fossil fuels contribute a relatively small volume of PAHs (Poly Aromatic Hydrocarbons) to the environment. Because most coal and oil deposits are trapped deep beneath layers of rock, there is little chance to emit PAHs to the surface environment. For the first time, Coal Seam Gas mining will allow large amounts of these chemicals to be solubilised from coal seams and leached out into ground water, and fracking chemicals to be released into our atmosphere. This poses a new major health risk for NSW, with a possible increase in cancer cases on par with or greater than asbestos.

Dr Effie Ablett, 2013"
Dangerous substances used or liberated by unconventional gas mining can escape into air, soil, and water systems during most stages of the gas production process - from exploration drilling, production testing, well completion, processing, venting, flaring, and waste water storage, through to transportation and supply of the processed gas.

Human exposure to gas industry contaminants can occur in a variety of ways including through direct skin contact with chemicals or wastes, drinking or bathing in polluted surface or bore water, breathing in vapours and contaminated dust particles, and from ingesting tainted foods.

There are many reported incidents of gas mining contaminants being released into the environment by accidental spillage, leaking pipes, and from legal discharges into the atmosphere during such processes as drilling and flaring, and into rivers to dispose of waste water. But beyond these sources of contamination, it looks as if unconventional gas mining technology is fundamentally flawed and unsafe.

Unconventional gas wells are essentially metal pipes inserted into very deep boreholes - about 1,000m for CSG and 3,000m for Shale Gas. Drilling continues horizontally when the well reaches gas-bearing strata. Gas is extracted after water is pumped from the coal seam aquifer to the surface. The resulting depressurising of coal and shale seams inevitably leads to a drop in aquifer water levels closer to the surface. In the “fracking” process, water, silica compounds, and chemicals are injected under high pressure to further fracture the seam to facilitate the release of gas.

To prevent gases from the coal and shale seams escaping into the atmosphere via the borehole, and to protect aquifers from contamination, for the entire vertical length of the well the space between pipe and rock has to be effectively and permanently sealed. This is purportedly achieved by pumping cement into the gap between pipe and rock - two inches wide at the top and three-quarters of an inch wide hundreds of metres down. Any flaw or deterioration over time in the cement barrier or metal pipe provides a potential pathway for contaminants to escape into the environment.

In July 2013, Metgasco workers had to run for their lives when 200 m of bore pipe was forcibly ejected high into the air during decommissioning of a CSG well in Casino. The well had experienced continuously rising pressure during its lifespan due to a loss of well integrity. The Mine Safety Investigation Unit report on the accident noted that, “Loss of integrity...meant that gas under pressure could migrate between the inside and outside of the (well) casing”. Efforts to monitor and control this building pressure had failed in part because there was “insufficient understanding” of the pressure build-up, and the plug used to seal the bore was installed too close to the surface.

**Air Pollution**

During unconventional gas drilling, the evaporation of “flowback” (i.e., the injected fluid that returns to the surface with substances from the coal and shale seams) can cause severe air pollution. Flaring, the burning off of gases, releases hydrogen sulfide, methane and BTX chemicals, as well as metals such as mercury, arsenic and chromium, into the air.

In the US, monitoring of air quality at gas drilling sites over a 12 month period detected 44 hazardous pollutants including methane, methylene chloride, ethane, methanol, ethanol, acetone, propane, formaldehyde, acetaldehyde, and PAHs/naphthalene.
A multi-year air monitoring program in Utah reported elevated levels of ozone near gas mining activities, and concluded that oil and gas operations were responsible for 98-99% of Volatile Organic Compound (VOC) emissions and 57-61% of nitrogen oxide emissions.\(^{85}\)

Colborn et. al. (2012)\(^{86}\) reviewed weekly air sampling results performed 1.1km away from a gas well pad before, during, and after drilling and hydraulic fracturing of 16 wells over the course of a year. Methane, non-methane hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) were detected. As well, methylene chloride, a toxic solvent not reported in products used in drilling or hydraulic fracturing, was detected in 73% of samples, and several times in high concentrations.

In Pennsylvania, a US Health Survey\(^{87}\) collected 34 air tests at 35 households in 9 counties and found VOCs including 2-butane acetone, chloromethane, carbon tetrachloride, trichlorofluoromethane, toluene, methylene chloride, dichlorodifluoromethane, n-hexane, benzene, tetrachloroethylene, 1,2,4-trimethylbenzene, ethylbenzene, trichloroethylene, xylene and 1,2-dichloroethane. The researchers found a strong association between proximity of residence to gas facilities and severity of symptoms including nasal and throat irritation, sinus problems, eyes burning, shortness of breath, difficulty breathing, severe headaches, sleep disturbance, frequent nausea, skin irritation and rashes, and dizziness.

A 2009 air quality study\(^{88}\) in Dish, Texas, a town which has no industrial activity other than nearby gas mining, and can therefore be considered informative of the effects of gas mining,\(^{89}\) found “the presence in high concentrations of carcinogenic and neurotoxin compounds in ambient air and/or residential properties.” “Many of these compounds verified in laboratory analysis were metabolites of known human carcinogens and exceeded both short-term and long-term effective screening levels according to TECQ (Texas Commission on Environmental Quality) regulations. Of particular concern are those compounds with potential for disaster as defined by TECQ”.\(^{90}\)

Queensland Gas Company (QGC) reports to the Australian National Pollutant Inventory indicate that significant quantities of pollutants are being deliberately released into the atmosphere from their CSG operations. These estimates do not include “fugitive” gas emissions that vent into the atmosphere away from company facilities.

Amongst other chemicals and substances, QGC provided the following estimates of air emissions from specific facilities over one year from 2011 to 2012\(^{91}\):

- QGC’s Kenya Processing Plant and Compressor Stations in Tara, QLD - Carbon monoxide (520,000kg), Formaldehyde (methyl aldehyde) (47,000kg), Oxides of Nitrogen (840,000kg), Particulate Matter - 10.0 um (2,700kg), Particulate Matter - 2.5 um (2,700kg), Sulfur dioxide (690kg), Volatile Organic Compounds (110,000kg), Fluoride compounds (17,000kg).

- QGC’s Windibri Processing Plant and Compressor Stations in Condamine, QLD - On-site long term waste storage (17,000kg), Carbon monoxide (500,000kg), Formaldehyde (methyl aldehyde) (42,000kg), Oxides of Nitrogen (850,000kg), Particulate Matter - 10.0 um (8,300kg), Particulate Matter - 2.5 um (8,200kg), Sulfur dioxide (640kg), Volatile Organic Compounds (99,000kg).
Australia’s National Toxics Network\textsuperscript{92} reported that “limited sampling of ambient air undertaken around the Tara estate near CSG activities have detected VOCs, including ethanol, acetone, benzene, toluene, xylene, ethylbenzene, dichlorodifluoromethane, 1,2,4-trimethylbenzene, naphthalene, phenylmaleic anhydride, methyl ethyl ketone, phenol, butane, pentane, hexane.”

Toluene, a neurotoxin was found in the air around a number of Tara homes, and the level of toluene measured in the air above a resident’s water bore\textsuperscript{93} (0.33ppm) was well above the “Chronic Reference Exposure Limits” used for long-term exposure by US states California, Massachusetts and Michigan.

Limited sampling used for a 2013 Queensland Department of Health Report\textsuperscript{94} detected a wide range of VOCs in the air around homes in Tara, and concluded that testing “did provide some evidence that might associate some of the (Tara) residents’ symptoms to exposures to airborne contaminants arising from CSG activities.” In reviewing these findings, Dr Lloyd-Smith\textsuperscript{95} noted that “for many of the chemicals assessed the level of detection used by the laboratories was well above the level set for the protection of health”. Benzene, a confirmed human carcinogen, was detected at levels above the health criteria.

From July to December 2012, the Queensland Government collected air samples over brief periods in summa canisters from Wacambilla, a residential estate in Tara. Dr Lloyd-Smith commented, “Despite the nature of this testing, many VOCs were again detected in the air. While most were below relevant guidelines and the criteria used, the number and type of compounds was diverse.”\textsuperscript{96} Summa canister sampling found the VOCs hexane, propene, chloromethane, dichlorodifluoromethane, methylene chloride, ethanol, acetone, methyl ethyl ketone, acrolein, and vinyl acetate (vinyl acetate exceeded the annual criteria in one case). Passive air samplers also detected VOCs including pentane, hexane, heptane, tetradecane, hexadecane, heptadecane, cyclohexane, 2-methylbutane, 3-methylpentane, 3-methylhexane, methylcyclohexane, tetrachloroethylene, 2-ethyl-1-hexanol, ethylacetate, benzene, toluene, xylene, ethylbenzene, 1,2,4-trimethylbenzene, phenol, benzothiazole, naphthalene, and alphapinene.\textsuperscript{97}

In Australia, many wells in Queensland CSG fields are leaking\textsuperscript{98}, and the final report of the CSG Well Head Safety Program (April 2011) found that more than 120 wells were reported to be leaking methane.\textsuperscript{99} Video of leaking CSG wells in Queensland gas fields and ignitable bores has been shown on the ABC 4 Corners program, “The Gas Rush”\textsuperscript{100} and the 60 Minutes program, “Undermined”\textsuperscript{101}. In the Four Corners program, Scott Lloyd, a Queensland farmer, reported that QGC wells on his property had been leaking since 2006, and gas that was originally coming from the well head was now “coming straight out of the ground all around the site”.\textsuperscript{102}

In Australia, a set of observations and research findings suggest that unconventional gas mining involving large numbers of wells with the associated depressurisation of coal seam aquifers could be causing uncontrollable, landscape scale venting of coal seam gases into the atmosphere. These gases potentially escape into the air via natural cracks and fissures in the rock strata, faulty cement bore casings, existing water bores, aquifers, old uncapped drill holes, cracks created by fracking and horizontal drilling, and direct seepage through the soil and rock strata.

In August 2012, a 30-year-old coal mining exploration hole in a CSG field, west of Dalby, was found to be alight with leaking methane.\textsuperscript{103} In May 2012, Dayne Pratsky’s video\textsuperscript{104} recorded the large-scale venting of coal seam gases along a section of the Condamine River.
Leaking around the CSG wells on Scott Lloyd’s property and in the Condamine River are only visible because the gases are bubbling through water, and the Dalby CSG leak was only detected because it ignited. There is no reason to expect that leaking coal seam gases are confined to the Condamine River, to puddles, or to old mining shafts. Rather, these observations complement research findings indicating that coal seam gases are venting across the countryside in Queensland gas fields.

Scientists from the Southern Cross University (SCU) reported very high levels of methane, CO2, and radon in the atmosphere across landscapes affected by CSG mining near Tara in Queensland.105,106 The presence of methane and radon with a “chemical fingerprint” (i.e., methane-CO2 isotope ratio) confirming that they are from coal seams, can reasonably be interpreted as indicating the presence of other coal seam gases and substances. According to Dr Damien Maher, “We are talking about enrichment (levels of methane) over scales of 10, 15, 30 kilometres. So this suggests that we don’t have just one leaking well, it suggests that we have got wide scale enrichment of atmospheric methane.”107

Global atmospheric methane concentration has risen nearly 160% since pre-industrial times, to a current level of 1.8 ppm.108 Santos and Maher (2012)109 reported atmospheric methane concentrations in the range of 1.78 ppm to 1.94 ppm along the 500 km they drove travelling to the Tara gas fields. In the Tara area, they recorded methane concentrations three times higher than in surrounding countryside, with hotspot concentrations of methane as high as 6.89 ppm - a new “world record” that exceeded the previous highest reading of 2.89 ppm methane recorded in a Siberian gas field.

The SCU researchers reported that the chemical fingerprint of the atmospheric methane emissions in Tara were coal seam gases. Methane concentrations of 53 ppm were recorded over bubbles in the Condamine River, and chemical analysis confirmed that these were CSG.

The Australian SCU scientists also found atmospheric enrichment of radon gas and carbon dioxide in the Tara coal seam gas fields.110 Continuous 24 hour air monitoring at sites inside and outside the gas field indicated a 3-fold increase in maximum radon within the field as compared to outside. Levels of both radon and CO2 were more elevated at night, indicating the need for continuous, rather than discrete sampling of air when testing for gas field pollutants. The researchers concluded that their findings pointed to the possibility that emissions in gas fields could be entering the atmosphere from both point sources, such as leaking wells and infrastructure, and from “enhanced diffuse soil gas exchange processes”, which allow venting through the soil across the landscape.

**Water Pollution**

“However, the people of the Central Coast cannot be sacrificed on the altar of economic expediency. Their entitlement to clean, safe water must be paramount.”...“It is well-known that in the northern Pilliga forest, massive environmental damage was caused by Eastern Star Gas at its Bohena No. 2 drill site as a result of exploration practices. Experiences in the USA, and in the State of Wyoming especially, clearly demonstrate disastrous problems associated with this industry through groundwater loss, contamination and waste water. Water is used extensively in gas exploration, as it is in gas mining and development...This is in a country that is short of water...Therefore the ground water issue is not an irrelevancy or one to be dismissed in a single rhetorical phrase. It is at the very heart of this debate.”

Mr Chris Hartcher, NSW Resources Minister, Parliamentary Speech, 3 May 2005.111

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

Ms A. Bridle’s submission to the Senate Standing Committee Inquiry.\(^{112}\)

The lowering of water tables has been described as “a necessary process and an unavoidable impact associated with the depressurisation of the coal seam” by gas mining company Santos\(^{113}\), and as a “reasonably foreseeable impact” by the Queensland Department of Infrastructure.\(^{114}\)

In 2011 Bill Heffernan, the chairman of the Commonwealth Government Senate Committee said: “We don’t want to look back in 50 years time and regret what we are doing. When the CSIRO tells the committee that we don’t really know the long term impacts on the aquifers - it could take 300 years for some aquifers to recharge - these are all things that need to be understood before the industry goes ahead.”\(^{115}\)

But the impacts of coal seam gas mining on water systems involve more than the lowering of water tables and the depletion of bores used for domestic and agricultural purposes.

According to Shenhua Watermark Coal, a CSG company operating in Australia, “Drill holes or fractures may intersect with one or multiple aquifers potentially mixing groundwater from different strata or altering the groundwater chemistry through exposure to the air, gas, fracking chemicals and drilling fluids or the release of natural compounds like BTEX.”\(^{116}\)

As the Australian Government Senate report concluded, “there is a risk that residues of chemicals used in fracking may contaminate groundwater and aquifers used for human or stock consumption or irrigation. There are examples where water has been contaminated. It is acknowledged that in one case in Australia, fracking resulted in damage to the Walloon Coal measures, causing leakage between that and the Springbok aquifer.”\(^{117}\)

Potential pathways for contamination of ground and surface water include: leakage of drilling fluids from the well bore into near surface aquifers; ineffective, damaged or degraded pipe and cement barriers in well casings; contamination from flow back fluid; accidental spills of fluids or solids at the surface; surface and subsurface blow outs; industrial chemicals used in drilling and fracking remaining underground; naturally occurring contaminants finding their way into drinking water aquifers; and discharge of waste water into surface water or underground aquifers.

Accumulation of contaminants in aquifers can have long-term impacts. Studies on the transport and fate of volatile organic compounds have found that they can persist in aquifers for more than 50 years and can travel long distances, exceeding 10 km.\(^{118}\) “Once a well is drilled, carcinogenic chemicals can leak out for years afterwards, and for wells in the catchment of urban water supplies this poses a huge long-term risk to public health.”\(^{119}\)

There are cases in the US\(^{120,121}\) and in Australia\(^{122,123}\) of gas field pollutants contaminating ground and surface water systems.

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In the US, Osborn et al., (2011) reported “systematic evidence for methane contamination of drinking water associated with shale gas extraction”. In areas with one or more gas wells within 1 km, average (19.2 mg CH4 L⁻¹) and maximum (64 mg CH4 L⁻¹) methane concentrations in drinking-water wells increased with proximity to the nearest gas well, to a level indicating “a potential explosion hazard”. In contrast, dissolved methane samples in neighbouring sites with no gas wells within 1 km, and within similar “geologic formations and hydrogeologic regimes”, averaged only 1.1 mg L⁻¹.

In 2009, the US EPA sampled drinking water wells in Wyoming and detected chemicals in 11 of 39 wells tested, including 2-butoxyethanol, methane, and diesel range organics used in hydraulic fracturing.

A 2013 US EPA investigation of water contamination in 23 drinking water wells near a natural gas extraction site in Pavillion, Wyoming, concluded that both inorganic and organic compounds associated with hydraulic fracturing have contaminated the aquifer at or below the depths used for domestic water supply. These substances included BTEX, iso-propanol, diethylene glycol, triethylene glycol, tert-butyl alcohol and tert-butyl hydroperoxide plus diesel and gasoline organics. Detection of high concentrations of benzene, xylenes, gasoline range organics, diesel range organics, and total purgeable hydrocarbons in ground water samples from shallow monitoring wells near pits indicated that they were a source of shallow ground water contamination. Generally higher levels of dissolved methane were found in domestic wells that were in closer proximity to gas production wells. Residents were advised to use alternate sources of water for drinking and cooking, and to have adequate ventilation when showering.

In Pennsylvania, Jackson et al. (2013) found methane in 115 of 141 shallow residential drinking water wells in an area affected by shale gas mining. Methane was detected in 82% of samples, with average concentrations six times higher for homes less than 1 km from gas wells. Ethane was 23 times higher in homes less than 1 km from gas wells, and propane was detected in 10 water wells, all within approximately 1 km distance. The closer that people lived to a well that had been fracked, the more likely it was that their drinking water was contaminated with methane and other shale seam gases. Isotopic analysis indicated that the methane originated in the shale seams being mined.

In Australia, groundwater systems and bores have been contaminated by CSG operations. The Queensland government reported that during the first six months of 2011 there were forty-five CSG compliance-related incidents, including twenty-three spills of CSG water during operations, four uncontrolled discharges of CSG water, three exceedances of discharge limits, three overflows of storage ponds, and other incidents of BTEX contamination.

Testing performed by the Queensland Department of Natural Resources and Mines found toluene and methane in a resident’s private water bore. In 2010, BTEX chemicals were found in 5 of 14 monitoring bores in gas fields near Dalby, with benzene being detected at levels between 6 to 15 times the Australian Drinking Water Guidelines (1 ppb).

The ABC Four Corners program aired on 21 February 2011 reported an incident in which a bore was contaminated by CSG pollutants. As a result of persistent enquiries by resident Anne Bridle, gas company QGC admitted that it had “unintentionally provided a route for water in the aquifer, as well as the coal measures to enter the well.”

In addition to accidental contamination of groundwater, in Australia CSG mining pollutants have also been legally and illegally discharged into surface water systems.
In at least two Queensland CSG projects, permits have been given for release of CSG waste water into the Murray Darling river system.

As Lloyd-Smith and Senjen (2011) reported, in a permit for one CSG company,

“The release of treated water into the Condamine River was authorised for a period of 18 months at a maximum volume of 20 megalitres (ML) per day. Over 80 chemical compounds as well as radionuclides were listed in the permit and included a range of persistent, bioaccumulative toxic substances such as nonylphenols, bisphenol A (BPA), chlorobenzenes, bromides, lead, cadmium, chromium, mercury, BTEX. There was no requirement for an assessment of the cumulative load or the potential to contaminate sediment, plants, aquatic species and/or animals prior to release.”

“The permits allowed the release of an unquantified and unassessed mixture of persistent toxic chemicals into a river used for irrigation and farming without any prior assessment of the cumulative chemical load or its possible long-term impacts on water quality, sediment, soil, stock and ecosystems.”

Lloyd-Smith and Senjen (2011) calculated that for the 18 month period the CSG company was authorised to discharge the following quantities of chemicals and substances into the Condamine River - BPA (2.298 tonnes), bromide (76.65 tonnes), chlorobenzenes (20.148 tonnes), monochloramine (32.85 tonnes), nitrate (5,475 tonnes), uranium (219kg), toluene (8.76 tonnes), xylene (6.57 tonnes), ethylbenzine (3.285 tonnes), benzene (10.95kg), cyanide (876kg) and lead (109.5kg).

Ten thousand litres of CSG waste water leaked into the environment at the Narrabri CSG Project operated by Eastern Star Gas - an incident that gas mining company Santos failed to report. In the Northern Rivers, Metgasco was fined by the NSW EPA after the company over a year illegally dumped at least 1,300,000 litres of CSG water into the Richmond River via the Casino sewage plant. When Metgasco was ordered to draw down an over full CSG dam in Casino they had no option for reducing the level of waste water, so the NSW Government permitted them to discharge a further five million litres into the Richmond River.

Analysis of soil and water contaminated by wastewater spills in the Pilliga CSG operations in NSW found high levels of salts, and a variety of heavy metals including arsenic, lead and chromium, as well as petrochemicals. Sampling of CSG released water from Bohena Creek in the Pilliga Forest detected methane at the Eastern Star Gas discharge site at 68 micrograms per litre (ug/l), whereas it was not detected in the upstream control sample.

The CSG industry has touted the use of reverse osmosis filtration technology to render gas mining waste water safe for discharge into the environment, even though this form of filtration cannot remove all dangerous contaminants. Chemicals that are unable to be successfully treated by reverse osmosis filtration include bromoform, chloroform, naphthalene, nonylphenol, octylphenol, dichloroacetic acid, trichloroethylene, tris (2-chloroethyl)-phosphate, and water soluble substances such as the methanol and ethylene glycol are also poorly removed. A 2011 report showed that even after reverse-osmosis treatment, CSG wastewater being released into waterways in Queensland contained a range of toxic substances, including boron and cadmium.
Soil Pollution

Soil contamination by gas mining contaminants can occur accidentally, via spillage or leakage of chemicals and wastewater, and deliberately, by spraying wastewater onto roads and disposing of drilling muds in landfills or by spraying them on agricultural or rural lands.

Morning dew on pastures is an unassessed potential pathway for gas mining air contaminants to pollute soils and to enter the human food chain. Nothing is known about the nature, quantity, or range of distribution of gas mining air pollutants that are dissolved in and transported by dew. Wind can deposit dust containing dried sediments from waste water ponds onto soils.

The transmission of dangerous substances to crops and livestock, and the ultimate potential impacts on the quality of food for human consumption, is unstudied and unknown.

Toxicologist, Dr David Brown (2013) observed that finer particulates transported on the breeze from gas mining activities can be directly inhaled, whereas coarser particulates tend to fall to the ground where they are available for transportation into homes on shoes. Brown (2013) noted that vacuuming of the contaminated floor can mobilise these particulates into the air where they can be breathed in. Dr Brown recommended that people should not be allowed to wear shoes into residences in areas affected by gas mining.

Cases of Human Disease Associated with Gas Mining

Unconventional gas mining pollutants have complex differential health effects on individuals depending on such factors as: the toxicity of the pollutant; the concentration, duration and frequency of exposure; and the vulnerability of exposed people. Continuous monitoring of air quality, rather than discrete sampling, is necessary because weather conditions can affect the concentration of polluted air by a factor of up to 20 times, such that a reading of 2 parts per million (ppm) could be 200 ppm at a different time during the day.

People with existing health problems, gas industry workers, children, and people who tend to be active outdoors are particularly vulnerable. Gas industry workers are at particular risk of exposure to pollutants absorbed through the skin and via inhalation, and their families can be exposed to hazardous substances transported home on clothing. Workers who do not wear appropriate protective clothing or use respirators and dosimeters, are potentially exposed to a greater unassessed risk.

In August 2008, Cathy Behr, an emergency room nurse in Colorado, almost died after treating a gas worker who had been splashed in a fracking fluid spill. A few days after Behr had stripped the man and stuffed his clothes into plastic bags she lay in hospital in critical condition suffering multiple organ failure.

Esswein et al., (2013), from the US National Institute for Occupational Safety and Health, collected 111 personal breathing zone samples at 11 gas drilling sites in 5 states and found that at every site full-shift samples exceeded occupational permissible exposure limits for crystalline silica air pollution, in some cases, by 10 or more times occupational health criteria. The level of exposure was sufficient to overwhelm the maximum use concentration ratings for the air-purifying respirators that workers typically wore.

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Children are more at risk from gas mining pollutants than are adults, and due to their higher rates of exposure, children are often the first members of a family to become ill.\textsuperscript{159,160} Children living in gas mining affected areas have been likened to “sentinels”\textsuperscript{161}, because their falling ill is likely to be the first indication of harm to human health. Relative to adults, children are closer to the ground and are more likely to be active outside. Children drink more water, breathe more air, and eat more food per kilo of body weight then do adults. Children have a longer “shelf-life”, and their living longer than adults puts them at greater risk from illnesses such as cancer that develop many years after exposure to a pollutant.\textsuperscript{162}

As was the case with thalidomide, a child is particularly sensitive to harm when exposed to pollutants during critical stages of physical development. There is little research examining the health impact of exposure to gas mining pollutants during critical developmental periods. A child’s health can be affected by its mother’s exposure during pregnancy, and even by the exposure of its mother and father prior to the child’s conception.\textsuperscript{163} Hill (2013)\textsuperscript{164} found that infants born to mothers, who during pregnancy lived within 2.5 km of a shale gas well in Pennsylvania, weighed less and were more likely to have a low birth weight. Paulson (2013)\textsuperscript{165} noted that children growing up in more polluted environments have smaller lungs at maturity, and this can make them more vulnerable to respiratory illnesses later in life.

Animals tend to suffer more direct exposure to environmental pollutants, and have shorter life and reproductive cycles, than humans. Illness in cows, horses, poultry, and other wildlife can foreshadow impacts to human health.

Bamberger and Oswald (2012) investigated the impact of gas drilling on animal health in six US states, and documented cases of reproductive (e.g., irregular cycles, failure to breed, stillbirths), neurological (e.g., seizures, incoordination, ataxia), gastrointestinal (e.g., vomiting, diarrhea), and dermatological (e.g., hair and feather loss, rashes) problems among livestock exposed to gas mining contaminants.\textsuperscript{166} Bamberger\textsuperscript{167} described cases of cows that died within one hour after exposure to diluted fracking fluid, while other cattle nearby who were not exposed remained healthy. Bamberger noted that no one is testing the quality of beef and agricultural produce that comes out of gas field affected farming areas, and she queried the safety of feeding pigs and chickens with the rendered flesh of animals that grazed pastures in such areas.

In a case described by Bamberger and Oswald (2012)\textsuperscript{168}, reports of local animal deaths following gas drilling prompted a doctor to order tests that led to a diagnosis of arsenic poisoning in a child who had been exposed to misted wastewater (misting is used in the US to accelerate evaporation of wastewater). The child, who lived less than 1 mile from a well pad, became unwell with fatigue, severe abdominal pain, sore throat and backache, and after admission to hospital six months later with delirium tested positive for arsenic poisoning. The families of this child and another family 1 mile away were monitored and urine tests revealed high levels of phenol, a metabolite of benzene, which was consistent with their reported symptoms of headaches, fatigue, nosebleeds, rashes, loss of smell and hearing. The affected people were advised to move away. Those who did get better, while those who stayed got worse.

Health researchers are reporting similar symptom clusters across diverse communities that live near unconventional gas operations. US researcher Ronald Bishop (2011)\textsuperscript{169} tentatively identified as “down-winder’s syndrome”, symptoms reported in studies in Texas\textsuperscript{170} and Wyoming\textsuperscript{171}, which included irritated eyes, sore throat, frequent intense headaches, nosebleeds, skin rashes, peripheral neuropathy, lethargy, nausea, reduced appetite and mental confusion.

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Steinzor et al (2013)\textsuperscript{172} investigated symptoms suffered by people living in proximity to gas facilities in Pennsylvania. The 25 most prevalent individual symptoms among all participants were increased fatigue (62\% of respondents), nasal irritation (61\%), throat irritation (60\%), sinus problems (58\%), eyes burning (53\%), shortness of breath (52\%), joint pain (52\%), feeling weak and tired (52\%), severe headaches (51\%), sleep disturbance (51\%), lumbar pain (49\%), forgetfulness (48\%), muscle aches and pains (44\%), difficulty breathing (41\%), sleep disorders (41\%), frequent irritation (39\%), weakness (39\%), frequent nausea (39\%), skin irritation (38\%), skin rashes (37\%), depression (37\%), memory problems (36\%), severe anxiety (35\%), tension (35\%), and dizziness (34\%). Many symptoms showed a strong statistical association between the rate of symptom reporting and how close affected people lived to oil and gas facilities.

Illnesses, including cancer, which can take years to develop, have been associated with exposure to gas mining pollutants. Lefall et al. (2010)\textsuperscript{173} compared nationwide cancer mortality statistics with the incidence of cancer in three New York counties that had a distinctively rural character and a history of intensive gas and oil industry activity. Based on nation-wide statistics from 1950 to 1994 for 55 different types of cancer, women in these three counties were consistently in the top bracket for deaths caused by cancer of breast, cervix, colon, endocrine glands, larynx, ovary, rectum, uterus and vagina. Men from the same region were consistently in the highest statistical bracket for deaths caused by bladder, prostate, rectum, stomach, and thyroid cancers.\textsuperscript{174}

In Texas, emissions from shale gas operations are being checked for contaminants after blood and urine samples taken from household residents near shale wells revealed that toluene was present in 65\% of those tested and xylene present in 53\%.\textsuperscript{175}

In Australia, the residents of estates near Tara on the Western Downs of Queensland have become involuntary subjects in a de facto experiment on the health effects of living amongst CSG gas fields. Gas drilling commenced in the area in 2006, and since 2008 residents have been complaining of symptoms that, as Dr Helen Redmond noted, are similar to the symptoms reported in communities living near US gas fields.\textsuperscript{176}

In 2013 medical tests found a high level of hippuric acid, a metabolite produced following exposure to toluene, in the blood of a young boy who lived in the Tara estates.\textsuperscript{177} In 2013, Dr Geralyn McCarron obtained information from 113 people (48 younger than 18 years, 65 adults) from 35 households in the Tara residential estates and the Kogan/Montrose region, and from three families who had left the area.\textsuperscript{178,179} 58\% of surveyed residents reported that their health was definitely adversely affected by CSG mining, and a further 19\% were uncertain. The reported symptoms were outside the scope of what would be expected for a small rural community, and resembled the “down-winder’s syndrome” found in overseas communities exposed to gas mining pollutants.

In the McCarron (2013) Tara study, there were reported increases across all age groups in coughing, chest tightness, rashes, difficulty sleeping, joint pains, muscle pains and spasms, and nausea and vomiting. Approximately one third of 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 the children were reported to suffer eye irritation. A range of symptoms were reported which can be related to neurotoxicity (i.e., damage to the nervous system), including severe fatigue, weakness, headaches, numbness and paraesthesia (i.e., abnormal sensations such as pins and needles, burning or tingling).
The illnesses of children documented in the McCarron (2013) study were cause for particular concern. Approximately a third of all 48 children to age 18 years (15/48) reported symptoms of paraesthesia. Almost all the 31 children aged 6-18 were reported to suffer from headaches, and for over half of these children the headaches were severe. Parents of a number of young children reported twitching or unusual movements, and clumsiness or unsteadiness.

For the 31 children aged 6 to 18 years there was a marked change in reported symptoms following the commencement of CSG mining in the area. Before mining, 90% never and 10% only occasionally suffered nosebleeds, while after mining 32% occasionally and 29% often suffered nosebleeds. Before mining, no child reported constant severe headaches, and only 3% reported often suffering severe headaches. After CSG, 36% reported often and 13% reported constantly suffering severe headaches. Before CSG, no child reported often or constantly suffering skin irritation, but after CSG 19% reported often and 29% reported constantly suffering skin irritation. Before CSG, 97% of children reported that they never experienced symptoms of paraesthesia. After CSG, 22% and 10% of children respectively reported occasionally and often experiencing paraesthesia symptoms. 97% of children reported that they never suffered nausea prior to CSG, and after CSG 23% reported often and 3% reported constant symptoms of nausea.

A before and after CSG mining comparison was not possible for the 17 youngest children in the 0 to 5 age group. The health concerns reported by parents of these children included (with number of children suffering the symptom in parentheses): twitching and unusual movements (6), poor colour/blueness of mouth or limbs (6), blood from the nose (9), headaches (8), tingling/numbness/ pins and needles (5), unusual clumsiness or unsteadiness in children who were walking (5), unexplained inconsolable crying (10), rashes (11), unusual irritability (10), unusual lethargy (7), eye irritation (11), streaming eyes (8), cough (5), difficulty breathing (2), sore limbs (6), muscle spasms (3), and burning nose (7).

Statistics inform thinking about health risks, but they can dull our emotional sensitivity to the suffering borne by real families and their children. Parents’ comments about their children’s health problems in Tara provide a disturbing glimpse into what life is like for families who have to live among heavily industrialised gas fields.

What peace of mind is possible for parents in a place where children come in from playing outside with nosebleeds if the wind comes from a particular direction, or where an adolescent suffers nosebleeds every day for three months? What is the quality of life for the Tara children and adults who have to avoid going outdoors?

For many of the children surveyed in Tara it is now normal to wake out of sleep with headaches, and an infant was reported to wake screaming, feeling that he has to dip his fingers in water. Some children constantly rub their fingers and complain of ants in their hands. Eye and skin irritation, sometimes so severe that children feel as if they could rip their skin, has become a constant background complaint. Infants, children and adults alike suffer from headaches, some of which are so intense that they have been investigated with CT scans and lumbar puncture. For many residents, extreme fatigue and having difficulty focusing and concentrating are persistent debilitating symptoms. Undiagnosed coughs, repeated diagnosis of “flu”, pneumonia, pleurisy and exacerbation of asthma are recurring experiences.

Senses of taste and smell, tuned by evolution, protect us from potentially dangerous foods and substances, and the detection of odours as a potential health issue has been investigated.\textsuperscript{180}
In Tara, residents reported that their symptoms were worse when odours were present, and some people could identify distinct individual odours at different times, variously described as “rotten eggs, sickly sweet, like pine tarsal, acetone, creosote, after burn from cigarette lighter.” Many people noted an association between their symptoms and the wind blowing from CSG waste water ponds. Some people commented on the link between road spraying and their symptoms. Children and adults complained of a recurring metallic taste which made them nauseous.

The children surveyed in Tara miss a lot of school. Sleep disturbance is endemic within the families surveyed, and many people directly related their sleep problems to the noise and vibrations from CSG traffic, drilling operations, and compressor stations. For others, sleep was disturbed by the constant strain of living and dealing with the impact of CSG on their lives, and the helplessness they felt from being unable to protect their children from illness.

The situation in Tara provides compelling evidence that operating gas fields in populated areas poses a significant risk to human health. It is undeniable that the gas mining industry uses and liberates many dangerous substances from coal seams. In Tara, the potential for humans to come into contact with these dangerous substances via contaminated air, water, and soil is substantial and well documented. In fact, these pathways to contamination are guaranteed by government policies which permit discharges of large quantities of dangerous substances into the environment. The health problems of the Tara residents mirror the “downwinder’s syndrome” seen across gas field affected communities in the US, and are consistent with the effects of exposure to pollutants known to be present in the local environment. People who live where unconventional gas is mined and processed pay a high price.

**Protecting Your Family’s Health**

Governments and industry plan to massively expand unconventional gas mining, and protecting your family’s health is going to be an ongoing challenge.

Be informed, keep yourself up-to-date regarding local developments, and take action as soon as you can. Keep a written, dated record of observations you make, actions you take, or any other things that might be relevant.

**Understand the health risks**

To better protect your family’s health you need to understand the nature of the risks so that you can recognise potential dangers. You have read the current report, and you can download copies of many of the referenced research papers, videos, and other information. There are also many other avenues to do your own research.

**Assess the level of threat - Do you need to be concerned?**

Once you understand the nature of the threat, do your own risk assessment. Ask whether there is any real chance that your family’s health could be affected by unconventional gas mining now or in the future. Generally, the risk is greater for people who work in the industry and for people who live near to gas mining operations. The level of risk is likely to be highest in areas of intense gas mining activity, and minimal where there has been no gas mining and none is planned. In many areas, such as the Northern Rivers which has about 60 capped CSG wells but no current mining, the level of risk needs to be assessed case-by-case.
In assessing risk you might consider the following questions: How near are you to gas mining operations such as wells, processing plants, evaporation ponds, compressor stations, vents or flares? Are any local active or capped wells leaking coal seam gases? (Tip - Look for bubbles around the well when it is raining and the ground is wet) Do you live upstream or downstream from gas fields? Do you ever notice odours when the wind is coming from a gas field?

Remove or avoid dangers

Think about how you can minimise your family’s exposure to gas field pollutants and other potentially harmful industrial processes. For example, you might insulate your house against noise, avoid outside odours, use air conditioners during odour events, leave foot wear outside the house, avoid raising dust within the house, use damp cloths for dusting, consider using hepa filters on your vacuum cleaner, test the quality of the water you use for drinking and showering, use first pass filters for collected rain water, filter drinking water, etc.

You might consider writing to your local member of parliament and to the Government to express your concerns and to ask that they require proper risk assessments and health impact studies before approving CSG or Shale Gas developments. If they have not already received this report, perhaps you could send them a copy.

If you are harmed, seek prompt treatment

The current report and many of the referenced resources will be sent to medical practitioners. If your doctor has not received this information, you might pass it onto them.

Nurse/practitioner Ms Denise DeJohn from the South West Pennsylvania Environmental Health Project[^18] recommended that individuals keep a health diary in which they record health issues and associated environmental conditions (e.g., wind direction, odours, time of showering etc). Ms DeJohn advised patients not to request from their doctor a battery of tests because it is not possible to know which chemicals are involved, some chemicals have no specific identifying tests, and the half life of many chemicals is too short to catch with testing.

Use the Health Questionnaires

The Health Impacts Report and associated questionnaires are educational materials only, and are not any form of medical or legal advice. You might use these materials to help you assess gas mining risks to health, and to plan how you can better protect your family from possible harm.

You should discuss with your family doctor any concerns that you have about your mental or physical health, including any symptom in the questionnaires or change in your health status. These self-help risk assessment materials are not a substitute for any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community.

No guarantee is given or implied that the completed questionnaires carry any legal weight, and you should seek professional legal advice for any concerns that you have.
EDUCATIONAL MATERIALS ONLY - NOT MEDICAL OR LEGAL ADVICE

If repeated at intervals, should gas development occur, the questionnaires can provide either ongoing reassurance of a clean bill of health, or alternatively early recognition of a significant change in health status.

You might consider reviewing the questionnaires at least once a year, or more frequently if there are changes in gas field activities in your area. You might also consider having your dated completed questionnaires signed and witnessed by someone who could attest to the accuracy of your responses. It is important that you give your doctor any information that might assist diagnosis. Discussing changes in your health status could allow this information to be recorded in your medical files.

The report and associated questionnaires are provided free of charge in the interests of community health. You can copy and distribute this document provided that the materials are reproduced in full, without alteration and with all citations and references, and no fee is charged.

Copies of these materials and many of the referenced publications are available for download by clicking the links on Page 41 “Selected References on Gas Mining Health Impacts”.

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Symptom Checklist

The Symptom Checklist is educational material only, and is not any form of medical assessment, advice or treatment. This checklist is intended to be used as a tool for self-directed assessment and management of possible health risks associated with exposure to unconventional gas mining pollutants and processes. The information you record in this checklist could potentially be useful in alerting you to any change in your health status. In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommended that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters.

The Symptom Checklist is provided free of charge in the interests of community health. You can copy and distribute this checklist provided that it is reproduced in full. Please note that there is no Medicare item for a doctor to review the Symptoms Checklist or any other associated questionnaire or checklist.


The symptoms in the checklist are grouped in no particular order, and do not represent any comprehensive or characteristic listing of symptoms associated with exposure to gas field pollutants and processes. The full nature and extent of acute and long-term health impacts from operating gas fields in populated areas are uncertain. It is reasonable to assume that exposure to gas field pollutants and processes could result in symptoms of illness that are not represented in this symptom checklist.

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<th>No</th>
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<td>Skin rashes</td>
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<td>Pealing skin</td>
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<td>Skin irritation - discomfort, sensitivity, itch, inflammation of skin without visible rash.</td>
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<td>Pins and needles</td>
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<td>Paraesthesia (abnormal sensations such as burning or tingling)</td>
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<td>Chest discomfort</td>
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<td>Shortness of breath</td>
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<td>Lethargy</td>
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<td>Symptom</td>
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<td>Severe fatigue</td>
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<td>Feeling weak</td>
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<td>Nasal irritation</td>
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<td>Burning nose</td>
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<td>Running or streaming eyes</td>
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<td>Eye irritation</td>
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<td>Sore limbs</td>
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<td>Mild headaches</td>
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<td>Severe headaches</td>
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<td>Spontaneous nose bleeds</td>
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<td>Disturbed sleep</td>
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<td>Insomnia</td>
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<td>Waking at night in distress</td>
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<td>Depressed mood</td>
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<td>Severe anxiety and tension</td>
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<td>Frequent irritability</td>
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<td>Feelings of helplessness &amp; hopelessness</td>
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<td>Lumbar pain</td>
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<td>Muscle aches and pains</td>
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<td>Muscle spasms</td>
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<td>Numbness</td>
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<td>Nausea</td>
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<td>Memory problems</td>
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<td>Difficulty concentrating</td>
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<td>Dizziness</td>
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<td>Nausea</td>
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<td>Vomiting</td>
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<td>Metallic taste in the mouth</td>
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<td>Twitching &amp; unusual movements</td>
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<td>Poor colour/blueness of mouth or limbs</td>
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<td>Clumsiness or unsteadiness</td>
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<td>Constantly rubbing fingers</td>
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<td>Sensations of ants in hands</td>
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Name: ___________________________      Date of Birth: ___________      Date: ___________

Signed by: ________________________      Name of witness: ________________________

Date: ___________      Signature of witness: ________________________
Exposure to Gas Mining Questionnaire

The exposure to Gas Mining Questionnaire is educational material only, and is not any form of legal advice or medical assessment, advice or treatment. The questionnaire might assist you in self assessing your potential exposure to risks associated with unconventional gas mining activities, and could be useful in the medical diagnosis of any change in your health status.

In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters.

The Exposure to Gas Mining questionnaire is provided free of charge in the interests of community health. You can copy and distribute this checklist provided that it is reproduced in full. Please note that there is no Medicare item for a doctor to review this questionnaire or any other associated checklists or materials.

Name: Date of Birth: Date:
Signed by: Name of witness:
Date: Signature of witness:

***
Have you worked in the gas, coal or oil mining industries? (Circle one) YES / NO
If YES, when, how long, and what did you do in the mining industry?

Have you worked with toxic substances? (e.g., agricultural or industrial chemicals) YES / NO
If YES, please give details:

Do you live near gas drilling activities? YES / NO
If YES, approximately how close do you live?

What are the type(s), location(s) or name(s) (if known) of the gas extraction or processing operations you live near? (e.g., drilled wells, capped wells, compressor station, pipeline, waste water pond, refinery):

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The approximate date(s) that well drilling activities began near to where you live:

Approximately when did the different stages of drilling activities occur and what stages are they in at present (e.g., seismic testing, drilling, fracking, flaring, well capping etc):

Have there been any incidents such as spills that have occurred near to where you live?

YES / NO

If so, please describe the incident(s) with approximate date(s):

Do you live within 300m of a road used to service a drilling site? YES / NO

Do you live near a road that has been sprayed with CSG waste water? YES / NO

WATER  (Mark with tick √)

Water in my home is from: private bore __ town water __ rainwater tank __ creek/river __

My drinking water is from: private bore __ town water __ rain tank __ creek/river __

filtered tap __ bottled __

My cooking water is from: private bore __ town water __ rain tank __ creek/river __

filtered tap __ bottled __

My water for bathing is from: bore __ rain tank __ town water __ creek/river __ other __

Water for my animals is from: bore __ rain tank __ town water __ creek/river __ other __

Have you noticed changes in your water? YES / NO

If YES, specify visible changes, tastes and odours and when the changes occurred:

Has your water ever been tested by a laboratory? YES / NO

If YES: Date(s) Who tested?

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AIR

Do you experience unusual odours in the air? YES / NO

If YES, when did you notice them the first time?

How frequently do you experience them?

Please describe the odours:

If you know or suspect where or what facility the odours are coming from, please describe:

Have you had any laboratory testing of either your indoor or outdoor air? YES / NO

If YES: Date(s): Who tested:

♦
CSG Concerns Questionnaire

The CSG Concerns Questionnaire is educational material only, and is not any form of medical assessment, advice or treatment. The questionnaire could help you to self-assess the level of stress you are experiencing in relation to potential stressors associated with unconventional gas mining activities. The information you record in this questionnaire could potentially be useful in helping you to better understand factors that could be contributing to symptoms of emotional distress. In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters.

The CSG Concerns Questionnaire is provided free of charge in the interests of community health. You can copy and distribute this checklist provided that it is reproduced in full. Please note that there is no Medicare item for a doctor to review this or any other associated questionnaire or checklist.

The concerns listed in this checklist are grouped in no particular order, and do not represent any comprehensive or characteristic listing of concerns that people have regarding gas field industrialisation. The acute and long-term mental health impacts associated with operating gas fields in populated areas are uncertain and largely unstudied. It is reasonable to assume that this list of concerns is incomplete and does not represent a typical, or any individual’s experience.

Please note that there is no specific Medicare item for a doctor to review this or other related checklist and questionnaires.

Name: Date of Birth: Date:

Signed by: Name of witness:

Date: Signature of witness:

◆
### Concerns About CSG and Shale Gas Mining

*Please use the following scale to rate the level of stress you feel regarding CSG or Shale Gas activities:*

<table>
<thead>
<tr>
<th>Stress Rating (0 – 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 -------- 1 -------- 2 -------- 3 -------- 4 -------- 5 -------- 6 -------- 7 -------- 8</td>
</tr>
<tr>
<td>No Problem</td>
</tr>
<tr>
<td>Health symptoms I am experiencing</td>
</tr>
<tr>
<td>Health symptoms that family members or friends are experiencing</td>
</tr>
<tr>
<td>Health of my animals</td>
</tr>
<tr>
<td>Quality of my water</td>
</tr>
<tr>
<td>Quality of the air</td>
</tr>
<tr>
<td>Odours</td>
</tr>
<tr>
<td>Noise</td>
</tr>
<tr>
<td>Traffic</td>
</tr>
<tr>
<td>Personal safety, or safety of family members or friends</td>
</tr>
<tr>
<td>Loss of control over access to property</td>
</tr>
<tr>
<td>Loss of right to quiet enjoyment of property</td>
</tr>
<tr>
<td>Diminished quality of lifestyle</td>
</tr>
<tr>
<td>Noise and light pollution</td>
</tr>
<tr>
<td>Loss of land value</td>
</tr>
<tr>
<td>Lack of adequate compensation</td>
</tr>
<tr>
<td>Compromised livelihood from loss of productive agricultural land</td>
</tr>
<tr>
<td>Politicians’ attitudes</td>
</tr>
<tr>
<td>Damage to privately owned assets and small business</td>
</tr>
<tr>
<td>Sense of violation of “Mother Earth”</td>
</tr>
</tbody>
</table>
Please use the following scale to rate the level of stress you feel regarding CSG or Shale Gas activities:

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Problem</td>
<td>Mild Stress</td>
<td>Moderate Stress</td>
<td>Severe Stress</td>
<td>Very Severe Stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

_Sense of powerlessness to protect your natural environment_  
Stress rating =

_Grief over loss of “Nature's gifts of beauty rich and rare”_  
Stress rating =

_Guilt over inability to avoid harm_  
Stress rating =

_Powerlessness from negotiating with powerful companies_  
Stress rating =

_Guilt over effects on neighbours from signing access agreements_  
Stress rating =

Further comments:
The DASS-21 Questionnaire

The Depression Anxiety Stress Scale-21 (DASS-21) is a standardised assessment of symptoms of emotional distress used by health professionals.

The DASS may be administered and scored by non-psychologists, but decisions based on particular score profiles should be made only by experienced clinicians or physicians who have carried out an appropriate clinical examination.

As used here, the DASS-21 questionnaire is educational material only, and is not any form of medical assessment, advice or treatment. The questionnaire is to be used as a tool for self-directed assessment and management of possible health risks associated with exposure to unconventional gas mining pollutants and processes. The information you record in this checklist could potentially be useful in alerting you to any change in your emotional functioning. In all cases, you should discuss any concerns that you have about symptoms or your mental or physical health with your family doctor. It is recommend that you avail yourself of any health impact assessment program, baseline data survey, or any other government service that addresses the health impacts of gas mining in your community. No guarantee is given or implied that the completed questionnaire carries any legal weight, and you should seek professional legal advice for any concerns that you have regarding legal matters. Please note that there is no Medicare item for a doctor to review this or any other associated questionnaire or checklist.

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Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0  Did not apply to me at all  
1  Applied to me to some degree, or some of the time  
2  Applied to me to a considerable degree, or a good part of time  
3  Applied to me very much, or most of the time

<table>
<thead>
<tr>
<th>Statement</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  I found it hard to wind down</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>2  I was aware of dryness of my mouth</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>3  I couldn't seem to experience any positive feeling at all</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>4  I experienced breathing difficulty (eg, excessively rapid breathing,</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>breathlessness in the absence of physical exertion)</td>
<td></td>
</tr>
<tr>
<td>5  I found it difficult to work up the initiative to do things</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>6  I tended to over-react to situations</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>7  I experienced trembling (eg, in the hands)</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>8  I felt that I was using a lot of nervous energy</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>9  I was worried about situations in which I might panic and make a fool</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>of myself</td>
<td></td>
</tr>
<tr>
<td>10 I felt that I had nothing to look forward to</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>11 I found myself getting agitated</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>12 I found it difficult to relax</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>13 I felt down-hearted and blue</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>14 I was intolerant of anything that kept me from getting on with what</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>I was doing</td>
<td></td>
</tr>
<tr>
<td>15 I felt I was close to panic</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>16 I was unable to become enthusiastic about anything</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>17 I felt I wasn't worth much as a person</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>18 I felt that I was rather touchy</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>19 I was aware of the action of my heart in the absence of physical</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>exertion (eg, sense of heart rate increase, heart missing a beat)</td>
<td></td>
</tr>
<tr>
<td>20 I felt scared without any good reason</td>
<td>0 1 2 3</td>
</tr>
<tr>
<td>21 I felt that life was meaningless</td>
<td>0 1 2 3</td>
</tr>
</tbody>
</table>
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Is CSG Safe?

A Failed Public Debate in the Interests of Community Health

QGC’s Kenya CSG Plant and Gasfield – Tara, Queensland


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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>On the Gas Industry</td>
<td>4</td>
</tr>
<tr>
<td>Is CSG Clean and Green?</td>
<td>5</td>
</tr>
<tr>
<td>On the Composition of Northern Rivers CSG</td>
<td>5</td>
</tr>
<tr>
<td>On the Composition of Metgasco’s CSG Waste Water</td>
<td>10</td>
</tr>
<tr>
<td>On CSG Pollution in Queensland and Northern Rivers Gas Fields</td>
<td>12</td>
</tr>
<tr>
<td>On the Safety of the CSG Industry</td>
<td>15</td>
</tr>
<tr>
<td>Scientific “Proof” and Experimental Design</td>
<td>16</td>
</tr>
<tr>
<td>The Australian Institute of Petroleum (AIP) Health Watch Program</td>
<td>17</td>
</tr>
<tr>
<td>AGL’s Camden Northern Expansion Environmental Health Impact Assessment</td>
<td>20</td>
</tr>
<tr>
<td>The Public Health England Report on Health Impacts of Shale Gas Mining</td>
<td>23</td>
</tr>
<tr>
<td>The Queensland Government CSG Health Report</td>
<td>24</td>
</tr>
<tr>
<td>Discussion, Implications and Recommendations</td>
<td>30</td>
</tr>
<tr>
<td>Mr Henderson’s Parting Statements</td>
<td>32</td>
</tr>
<tr>
<td>Appendix A – Mr Peter Henderson’s 29 November 2013 letter</td>
<td>36</td>
</tr>
<tr>
<td>Appendix B – Mr Peter Henderson’s 24 January 2014 letter</td>
<td>39</td>
</tr>
</tbody>
</table>

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Is CSG Safe?
A Failed Public Debate in the Interests of Community Health


Introduction

Heavily industrialised gas fields are being established in populated areas across Australia with little public discussion of potential health risks. When development could negatively affect the health of generations to come, the community is entitled to an open debate based on scientific evidence and rational argument. My recent dialogue with Metgasco CEO Mr Peter Henderson initiated a much-needed public discussion about the potential health impacts of gas field industrialisation in the Northern Rivers.

On 14 November 2013 Metgasco’s CEO Mr Peter Henderson and Community Relations Manager Mr Stuart George attended a 90 minute meeting with Kyogle Mayor Danielle Mulholland, Kyogle Shire Council General Manager Mr Arthur Piggott, and myself as a community representative and policy adviser. Mr Henderson called the meeting to promote Metgasco’s plans to develop gas fields in the Northern Rivers. Mr Henderson said that if the yet-to-be drilled Bentley gas well is successful, Metgasco will establish a gas field there and build a pipeline along Kyogle’s Lions Road to transport gas to the export market. After the 14 November 2013 meeting, Mr Henderson e-mailed me and offered to follow up on “health concerns” that I raised at the meeting.

In subsequent correspondence, I asked Mr Henderson to provide the scientific evidence for his claims that: a) CSG operations have been proved to be safe; b) the CSG mined in the Northern Rivers is pure methane and contains no impurities, or any substance other than some water that requires processing; and c) there is no benzene in coal seams in the Northern Rivers. I also asked Mr Henderson if he could reconcile the situation in Queensland gas fields, where significant quantities of hazardous substances are discharged into the environment, with his claim that any future processing of CSG in the Northern Rivers would produce no significant waste or pollution.

Mr Henderson responded to the above requests in a letter dated 29 November 2013. A copy of this letter is attached to this paper as Appendix A.

Mr Henderson’s responding to my request for evidence to support the claims about the safety of the CSG industry that he made at the meeting with Kyogle’s Mayor was a welcome first step in an important debate that contrasts two very divergent viewpoints.

In my “Self-help Risk Management Tools: A Report on the Health Impacts of CSG and Shale Gas Mining”2, I concluded that there is a high probability of potentially catastrophic health impacts from operating gas fields in populated areas. My review of the scientific literature indicated that air, water and soil pollution from unconventional gas mining creates a complex mix of persistent, bio-accumulative, toxic, carcinogenic, mutagenic, teratogenic, and endocrine disrupting substances, some which can seriously injure human health even in minute quantities.

---

In marked contrast, Mr Henderson argued that the CSG industry has been proven to be in all ways safe, and operating gas fields in the Northern Rivers could not expose people to dangerous substances capable of causing illness.

I have considered the arguments and reports cited in Mr Henderson’s 29 November 2013 letter and, in my opinion, there was no relevant scientific evidence there to support Mr Henderson’s claims regarding the “proven” safety the CSG industry and the composition of local coal seam gas and CSG waste water. Further, Mr Henderson did not explain why CSG processing in the Northern Rivers would not result in pollution similar to that produced by Queensland CSG gas fields and processing plants.

In his 29 November 2013 letter, Mr Henderson did not provide any primary data for the Northern Rivers, but instead cited Australian Gas Light’s (AGL) Camden Environmental Health Impact Assessment (EHIA)³ as a source of relevant information regarding the chemical composition of coal seam gas.

In my opinion, there was nothing in Mr Henderson’s 29 November 2013 letter, or the studies and reports he cited, to contradict the conclusion of my risk assessment report⁴ that there is a high level risk of potentially catastrophic health impacts associated with operating gas fields in populated areas.

Mr Henderson received a pre-publication copy of this paper and was invited to provide a response to be attached to this document. Mr Henderson was also asked if he would be willing to participate in further public discussion about the potential health impacts of operating gas fields in populated areas. Mr Henderson’s response, dated 24 January 2014, is attached to this paper as Appendix B.

The following discussion presents and comments on Mr Henderson’s claims regarding the safety of the CSG industry and the nature of coal seams, CSG, and CSG wastewater in the Northern Rivers.

On the Gas Industry

Mr Henderson began his 29 November 2013 letter with the following statements about the energy needs of the community:

“NSW and Northern Rivers residents need energy for heating, lighting and cooking in their homes and to power domestic appliances. We all need transport fuels and in the workplace our jobs depend on reliable energy supplies to power equipment and to provide heating and cooling. Our lives depend on reliable energy supplies.”

Most people would agree that our community needs reliable supplies of energy, but it does not follow that operating gas fields in populated areas is necessary, desirable, or safe.

The issue is not “gas versus no gas”. The vitally important question is whether it is safe to operate heavily industrialised gas fields where people live.

---


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Is CSG Clean and Green?

In his 29 November 2013 letter, Mr Henderson wrote that:

“Exports of natural gas from Australia are helping less developed countries to reduce the extent of air pollution and associated illness.”

The gas mining industry argues that natural gas is a clean fuel because when burnt it creates less carbon dioxide than coal. But this benefit for consumers is offset by the creation of potentially dangerous air, water and soil pollution where the gas is mined and processed.

On the Composition of Northern Rivers CSG

In his 29 November 2013 letter, Mr Henderson wrote:

“Our coal seam gas is almost pure methane. The natural gas we produce from our coal seams is about 98% methane, with very small amounts of ethane (another colourless, odourless and non-toxic hydrocarbon gas), carbon dioxide and nitrogen. Gas chromatograph data for our coal seam gas shows virtually no hydrocarbons heavier than ethane. By inspection, there is absolutely no reason for concern in terms of metals, volatile organics or BTEX chemicals. For your information, the gas we found in our Kingfisher exploration well (a conventional gas field) has a similar composition to our CSG. It has a little more ethane and propane than our CSG but gas chromatograph data shows hydrocarbons no heavier than pentane and, again by inspection, provides no reason for concern. Our coal seam gas meets specifications for sales gas, it does not need to be treated to be sold into the gas market. It might need to have small quantities of water removed to be distributed in a large pipeline system.”

“Should you wish to explore the wealth of data that is available on websites you will find that gas produced from other Australian coal seams is also primarily methane, with very low concentrations of any hydrocarbons heavier than ethane. For example, we draw your attention to AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October, 2013, provides further information to support high methane levels and correspondingly low levels of heavier hydrocarbons in its gas. Again, by inspection, there is no reason for concern about volatile organic compounds, BTEX or metals. This information can be found on the AGL website.”

In his letter, Mr Henderson stated that local CSG consists of methane, ethane, carbon dioxide, nitrogen and “virtually no hydrocarbons heavier than ethane”. I note that a definition of “virtually” is “in essence or effect but not in fact”.

It is not clear whether Mr Henderson’s statement, “By inspection, there is absolutely no reason for concern in terms of metals, volatile organics or BTEX chemicals” indicates that none of these potentially dangerous substances is present in local coal seam gas, or that he is personally unconcerned when he looks at chemical assay reports.

As Mr Henderson suggested, I read AGL’s EHIA\(^5\), but could find nothing there to support his claim that AGL’s, and by implication Metgasco’s, CSG was “almost pure methane” with no other substance worthy of “concern”.

---

\(^5\) AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October 2013

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The following table from AGL’s EHIA presents data from testing of coal seam gas at their Camden operation.

Table 4.5 Screening Level Review of Fugitive Emissions from Proposed Wells – Northern Expansion.\(^6\)

<table>
<thead>
<tr>
<th>Component of CSG (all compounds detected)</th>
<th>Composition from Analysis (%)(a)</th>
<th>Predicted Worst-case Downwind Air Concentration At well head (within 5 m)</th>
<th>50 m from well</th>
<th>Screening Level Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total gas release as CO₂ equivalent</td>
<td>100% - 0.025 gas emission</td>
<td>22000 μg/m³</td>
<td>1678 μg/m³</td>
<td>NA</td>
</tr>
<tr>
<td>Methane</td>
<td>90%</td>
<td>19000 μg/m³ or 0.005%</td>
<td>1510 μg/m³ or 0.0002%</td>
<td>&gt;0.5% in buildings Y 6% explozive risk</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>up to 5%</td>
<td>1100 μg/m³ or 0.00006%</td>
<td>33.9 μg/m³ or 0.000005%</td>
<td>NA - Negligible contribution to ambient levels</td>
</tr>
<tr>
<td>Oxygen</td>
<td>1.5%</td>
<td>300 μg/m³ or 0.00005%</td>
<td>25 μg/m³ or 0.000002%</td>
<td>Negligible contribution to ambient level</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>3.2%</td>
<td>704 μg/m³ or 0.00004%</td>
<td>54 μg/m³ or 0.000003%</td>
<td>0.5% in buildings Y</td>
</tr>
<tr>
<td>Argon</td>
<td>&lt;1%</td>
<td>&lt;220 μg/m³ or 0.00001%</td>
<td>&lt;17 μg/m³ or 0.000001%</td>
<td>NA - Negligible contribution to ambient levels</td>
</tr>
<tr>
<td>Ethane</td>
<td>&lt;0.2%</td>
<td>&lt;48 μg/m³</td>
<td>&lt;3 μg/m³</td>
<td>NA - TLV = 1 220 000 μg/m³ (AGC/HH), HSDB does not report effects in the low studies available at higher levels of exposure. No public health guideline</td>
</tr>
<tr>
<td>Propane</td>
<td>&lt;0.01%</td>
<td>&lt;2.2 μg/m³</td>
<td>&lt;0.17 μg/m³</td>
<td>NA - TLV = 1 800 000 μg/m³ (AGC/HH), HSDB lists no effects in other studies up to this level of exposure. No public health guideline available</td>
</tr>
<tr>
<td>Acetone</td>
<td>180 μg/m³ or 0.000009%</td>
<td>0.0018 μg/m³</td>
<td>0.00013 μg/m³</td>
<td>30000 μg/m³ based on chronic public health guideline from ATSDR</td>
</tr>
<tr>
<td>Ethanol</td>
<td>550 μg/m³ or 0.00003%</td>
<td>0.0058 μg/m³</td>
<td>0.00060 μg/m³</td>
<td>10 000 μg/m³ based on chronic public health guideline from OEHHA</td>
</tr>
<tr>
<td>Hecane</td>
<td>200 μg/m³ or 0.000007%</td>
<td>0.0015 μg/m³</td>
<td>0.00012 μg/m³</td>
<td>700 μg/m³ based on chronic public health guideline from USEPA*</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>260 μg/m³ or 0.000006%</td>
<td>0.0018 μg/m³</td>
<td>0.00013 μg/m³</td>
<td>6000 μg/m³ based on chronic public health guideline from USEPA*</td>
</tr>
<tr>
<td>TPH C5-C10 aliphatics</td>
<td>3420 μg/m³ or 0.00001%</td>
<td>0.022 μg/m³</td>
<td>0.0017 μg/m³</td>
<td>18400 μg/m³ based on chronic public health guideline from TPHCWG</td>
</tr>
<tr>
<td>TPH &gt;C8-C10 aliphatics</td>
<td>40600 μg/m³ or 0.00002%</td>
<td>0.18 μg/m³</td>
<td>0.013 μg/m³</td>
<td>10000 μg/m³ based on chronic public health guideline from TPHCWG</td>
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<tr>
<td>TPH C11-C12 aliphatics</td>
<td>4770 μg/m³ or 0.00007%</td>
<td>0.015 μg/m³</td>
<td>0.0012 μg/m³</td>
<td>1000 μg/m³ based on chronic public health guideline from TPHCWG</td>
</tr>
</tbody>
</table>

Note. “TPH” means Total Petroleum Hydrocarbons.

\(^6\) AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October 2013, Page 39

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The Report of Analysis of a sample of CSG on the following Page 8 of this paper is from Appendix A of the AGL EHIA.

I note that the “LOR”, or “Limit of Reporting”, figures used in the following AGL EHIA Report of Analysis represent arbitrary cut-off points for reporting the presence and quantity of the indicated substance. According to the Wisconsin Analytical Detection Limit Guidance and Laboratory Guide for Determining Method Detection Limits⁷,

“Reporting Limit is an arbitrary number below which data is not reported. The reporting limit may or may not be statistically determined, or may be an estimate that is based upon the experience and judgement of the analyst. Analytical results below the reporting limit are expressed as ‘less than’ the reporting limit. Reporting limits are not acceptable substitutes for detection limits unless specifically approved by the Department for a particular test”. (Page 2, bold type in original).

The AGL EHIA “Report of Analysis” of Camden coal seam gas reported the presence, above the “limit of reporting”, of ethanol, dichloromethane, hexane, cyclohexane, heptane, styrene, benzene, toluene and ethylbenzene.

Significant differences are apparent when Mr Henderson’s claims about the composition of Northern Rivers CSG are compared to data in Table 4.5 and the “Report of Analysis” in the AGL EHIS. For example, Mr Henderson claimed that local CSG “is about 98% methane”, while AGL reported that their CSG is 90% methane. More importantly, AGL reported the presence in their CSG of many substances other than methane, including BTEX chemicals and other Volatile Organic Compounds (VOCs).

In his 29 November 2013 letter, Mr Henderson did not provide any direct data to support his claim that benzene does not exist in coal seams.

I note that the Queensland Government’s Department of Environment and Heritage Protection website advises that “BTEX compounds are found naturally in crude oil, coal and gas deposits and therefore they can be naturally present at low concentrations in groundwater near these deposits.”

In regards to the presence of benzene and other BTEX chemicals in coal seams, the AGL EHIS noted that:

“There are have been (sic) a few detections of low concentrations of benzene, toluene, ethylbenzene and xylene (BTEX) in production water. BTEX is not used for any aspect of the process (drilling, hydraulic fracturing or maintenance), however a review of the nature of the target coal seam by CSIRO (Volk et al. 2011) has identified the likely presence of low levels of BTEX in the target coal seam aquifer. The small number of low level detections reported from some existing wells is consistent with the presence of BTEX in the target coal seam aquifer.”⁸

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⁸ AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 Oct 2013, Pg 60.
# Report of Analysis of CSG from Appendix A of AGL’s EHIA, 30 October 2013

**Australian Government**  
**National Measurement Institute**

---

## REPORT OF ANALYSIS

**Report No.:** V0013_2017  
**Client:** AGL  
**Date Sampled:** 12-Sep-2013  
**Date Received:** 17-Sep-2013  
**Sampled by:** CLIENT

### Laboratory Reg. No.: NV1300002  
### Method: VOG

### Client Sample Ref.: RPP120913  
### Matrix: Air Canisters  
### Date Analyzed: 10-Sep-2013

### Lab. Reference No.: 21.9.13.5.55  
### Canister No.: F1905  
### Receipt Vac./Press. (Hg): -0  
### Dilution: 20

<table>
<thead>
<tr>
<th>Compound</th>
<th>Level LOR ppbv</th>
<th>Level LOR ug/m³</th>
<th>Level LOR ug/m³</th>
<th>CAS Number</th>
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<tr>
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<td>2</td>
<td>3</td>
<td>3</td>
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<tr>
<td><strong>Dichlorodifluoromethane</strong></td>
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<td>10</td>
<td>10</td>
<td>75-68-4</td>
</tr>
<tr>
<td><strong>Chloromethane</strong></td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>74-98-3</td>
</tr>
<tr>
<td><strong>1,2-Dichloroethane</strong></td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>75-55-1</td>
</tr>
<tr>
<td><strong>1,2-Dichloroethene</strong></td>
<td>&lt;2</td>
<td>&lt;3</td>
<td>&lt;3</td>
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<td><strong>Bromomethane</strong></td>
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<td>30</td>
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<tr>
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<tr>
<td><strong>Acrolein</strong></td>
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<td>10</td>
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<tr>
<td><strong>Ethanol</strong></td>
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<td>5</td>
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<td><strong>2-Propanol</strong></td>
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<tr>
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<td>10</td>
<td>75-09-4</td>
</tr>
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<td>10</td>
<td>10</td>
<td>75-25-4</td>
</tr>
<tr>
<td><strong>Dichloromethane</strong></td>
<td>2</td>
<td>20</td>
<td>20</td>
<td>75-09-2</td>
</tr>
<tr>
<td><strong>1,1,2-Trichloroethane</strong></td>
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<td>20</td>
<td>20</td>
<td>75-13-1</td>
</tr>
<tr>
<td><strong>Carbon disulfide</strong></td>
<td>&lt;2</td>
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<td>&lt;3</td>
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<td><strong>Trifluoroethene</strong></td>
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<td><strong>Methyl tert-butyl ether (MTBE)</strong></td>
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<td>7</td>
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<td><strong>Vinal acetate</strong></td>
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<td>7</td>
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<td><strong>2-Butanone (MBO)</strong></td>
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<td><strong>cis,trans-2-Dichloroethylene</strong></td>
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<td>8</td>
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<td><strong>Hexane</strong></td>
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<td>20</td>
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<tr>
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<td>&lt;3</td>
<td>&lt;3</td>
<td>109-99-0</td>
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<td>10</td>
<td>10</td>
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<tr>
<td><strong>Benzenene</strong></td>
<td>&lt;20</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>71-43-2</td>
</tr>
</tbody>
</table>

---

*A.G.L.’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30/10/2013, App A.  
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### Educational Material Only

#### Gas Submission 21

<table>
<thead>
<tr>
<th>Compound</th>
<th>ppm</th>
<th>%</th>
<th>ppm</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon tetrachloride</td>
<td>2</td>
<td>&lt;2</td>
<td>10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>2</td>
<td>74</td>
<td>7</td>
<td>250</td>
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<tr>
<td>1,2-Dichloropropane</td>
<td>2</td>
<td>&lt;2</td>
<td>9</td>
<td>&lt;9</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
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<td>&lt;2</td>
<td>10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Trichloroethene</td>
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<td>&lt;2</td>
<td>10</td>
<td>&lt;10</td>
</tr>
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<td>1,4-Dioxane</td>
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<td>&lt;7</td>
</tr>
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<td>Heptane</td>
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<td>8</td>
<td>&lt;66</td>
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<tr>
<td>Methyl methacrylate</td>
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<td>cis-1,3-Dichloropropene</td>
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<td>&lt;8</td>
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<td>trans-1,3-Dichloropropene</td>
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<td>&lt;8</td>
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<td>Tetrahydrofuran</td>
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<td>Ethylbenzene</td>
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<td>9</td>
<td>&lt;30</td>
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<td>Bromoform</td>
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<td>10</td>
<td>&lt;20</td>
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<td>m- &amp; p-Xylenes</td>
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<td>&lt;20</td>
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<td>&lt;20</td>
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<td>Benzyl chloride</td>
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<td>&lt;10</td>
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<td>10</td>
<td>&lt;10</td>
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<td>Hexachlorobutadiene</td>
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<td>Naphthalene</td>
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**Internal Standard: BDM (%Rec.)**

<table>
<thead>
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<th>ppm</th>
<th>%</th>
<th>ppm</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>102</td>
<td>102</td>
</tr>
</tbody>
</table>

**Internal Standard: 1,4-DFB (%Rec.)**

<table>
<thead>
<tr>
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<th>%</th>
<th>ppm</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>105</td>
<td>105</td>
<td>105</td>
</tr>
</tbody>
</table>

---

Robert Crouch  
Chemist  
Accreditation No. 199  
29-Sep-13

---

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Results relate only to the sample(s) tested.

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The issue of the presence or absence of benzene as a CSG pollutant in the Northern Rivers is further highlighted by a comparison of Mr Henderson’s description of Metgasco’s waste water with data provided by AGL from their Camden operation.

**On the Composition of Metgasco’s CSG Waste Water**

In his 29 November 2013 letter, Mr Henderson claimed that Metgasco’s CSG waste water is suitable, without treatment, for stock watering, and with removal of some salt, for irrigation and human consumption.

Specifically, Mr Henderson wrote that:

“A thorough analysis of our CSG produced water shows that it meets Australian Drinking Water Guidelines, apart from its salt levels, which are about 1/10 of the level in sea water. Bioassay (acute toxicity) testing has provided further and broader confirmation that the CSG water is not toxic. We have a range of studies to demonstrate that our water, after some salt removal, is suitable for irrigation. It is suitable for stock watering, even without salt removal.”

Mr Henderson provided no primary data to support his claims about Metgasco’s CSG waste water, but offered his personal opinion regarding the significance of the analyses in the “range of studies” he has access to. In the absence of any local data, I examined the AGL EHIA that Mr Henderson referred to for information about the composition of CSG waste water from AGL’s Camden operation.

The following table Table 7.2 from the AGL EHIA presents an analysis of chemicals in AGL’s Camden CSG waste water. In Table 7.2, substances highlighted in grey were present in CSG waste water at levels exceeding Australian drinking water guidelines.

The pollutants in AGL’s CSG waste water that exceeded Australian drinking water guidelines included arsenic, strontium, barium, nickel, lead, bromine, iodine, fluoride, methane, naphthalene, benzo(b)fluoranthene, benzo(a)pyrene, benzene, and Total Petroleum Hydrocarbons (TPHs) in the range C10 to C36. The maximum readings for arsenic, barium, benzene and the TPHs exceeded drinking water standards by 10 or more times, and naphthalene exceeded the drinking water standard threefold.

I note that AGL reported a reading of 10 micrograms per litre in the maximum recording of benzene in their waste water - a level ten times greater than the 1 µg/L drinking water standard.

The substantial variations between minimum and maximum readings evident in AGL’s CSG waste water assays indicate that multiple analyses are needed to accurately assess the chemical composition of CSG and CSG waste water.

Unfortunately, only minimum and maximum levels of chemicals are reported in Table 7.2 of AGL’s EHIS, and there is no information regarding the number and distribution of readings that were within the minimum to maximum range.

It is not known what analyses or standards Mr Henderson is using to support his claims that CSG wastewater in the Northern Rivers is safe and free of dangerous pollutants even without processing.
Table 7.2 from AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October 2013.\textsuperscript{10}

<table>
<thead>
<tr>
<th>Analyte grouping/Analyte</th>
<th>Units</th>
<th>Range of Concentrations in Produced Water</th>
<th>Drinking Water Guideline</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
<td>Health Based</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>0.020</td>
<td>2000</td>
<td>--</td>
</tr>
<tr>
<td>Sulfate as SO₄⁻ Turbidimetric</td>
<td>mg/L</td>
<td>1</td>
<td>202</td>
<td>--</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>93</td>
<td>1310</td>
<td>--</td>
</tr>
<tr>
<td>Metals and Inorganics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>0.07</td>
<td>16</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.13</td>
<td>0.01</td>
</tr>
<tr>
<td>Boron</td>
<td>mg/L</td>
<td>&lt;0.05</td>
<td>0.20</td>
<td>4</td>
</tr>
<tr>
<td>Strontium</td>
<td>mg/L</td>
<td>0.151</td>
<td>10.2</td>
<td>9.3</td>
</tr>
<tr>
<td>Barium</td>
<td>mg/L</td>
<td>0.049</td>
<td>36.6</td>
<td>2</td>
</tr>
<tr>
<td>Beridium</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.001</td>
<td>0.08</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>Cobalt</td>
<td>mg/L</td>
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<td>0.001</td>
<td>0.0047</td>
</tr>
<tr>
<td>Uranium</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.002</td>
<td>0.017</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/L</td>
<td>&lt;0.005</td>
<td>0.012</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.026</td>
<td>2</td>
</tr>
<tr>
<td>Manganese</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.13</td>
<td>0.5</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.138</td>
<td>0.05</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.004</td>
<td>0.02</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>0.026</td>
<td>0.01</td>
</tr>
<tr>
<td>Selenium</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Vanadium</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>&lt;0.005</td>
<td>0.074</td>
<td>47</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/L</td>
<td>&lt;0.05</td>
<td>15.4</td>
<td>11</td>
</tr>
<tr>
<td>Bromine</td>
<td>mg/L</td>
<td>&lt;0.1</td>
<td>8.7</td>
<td>2</td>
</tr>
<tr>
<td>Iodine</td>
<td>mg/L</td>
<td>&lt;0.1</td>
<td>0.8</td>
<td>0.16</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/L</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.001</td>
</tr>
<tr>
<td>Silica</td>
<td>mg/L</td>
<td>&lt;0.1</td>
<td>40.7</td>
<td>--</td>
</tr>
<tr>
<td>Fluoride</td>
<td>mg/L</td>
<td>&lt;0.1</td>
<td>3.9</td>
<td>16</td>
</tr>
<tr>
<td>Ammonia as N</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>11.3</td>
<td>30</td>
</tr>
<tr>
<td>Nitrite as N</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>0.42</td>
<td>3</td>
</tr>
<tr>
<td>Nitrate as N</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>0.18</td>
<td>50</td>
</tr>
</tbody>
</table>

\textsuperscript{10} AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October 2013, Table 7.2, Page 59-60.
On CSG Pollution in Queensland and Northern Rivers Gas Fields

At the 14 November 2013 meeting, and in my subsequent correspondence, I asked Mr Henderson if he could reconcile the known discharges of pollution in Queensland gas fields with his claim that processing in Northern Rivers CSG gas fields would result in no significant waste products or pollution.

In response to Mr Henderson’s request for further information regarding my reference to pollutants in Queensland gas fields, my 20 November 2013 e-mail to Mr Henderson included the following information from Lloyd-Smith and Senjen (2011)\(^\text{11}\) and data provided by CSG companies to the Australian National Pollutant Inventory.

In my 20 November 2013 email to Mr Henderson, I replied:

“Referring to Queensland CSG operations, Lloyd-Smith and Senjen (2011) wrote: ‘Permits are provided for the release of wastewater produced in association with the fracturing process. In one authorisation for one CSG company (i.e., Schedule C, Australian Pacific LNG Pty Ltd Environmental Authority No. PEN100067807) the release of treated water into the Condamine River was authorised for a period of 18 months at a maximum volume of 20 megalitres (ML) per day.’”

“Over 80 chemical compounds as well as radionuclides were listed in the permit and included a range of persistent, bioaccumulative toxic substances such as nonylphenols, Bisphenol A (BPA), chlorobenzenes, bromides, lead, cadmium, chromium, mercury, BTEX.”

“There was no requirement for an assessment of the cumulative load or the potential to contaminate sediment, plants, aquatic species and /or animals prior to release. While release limits were included for the listed compounds, the majority of these were not based on the ANZECC water guidelines as many of the chemicals were not listed in the ANZECC guidelines or were marked as having insufficient data to set a water quality guideline.”

“Table 3 provides volumes and quantities of a selection of compounds permitted for release into the Condamine River over an 18 month period.”

Table 3. Waste Water Permit (Total as Release rate X 20ML X 547.5days/18mths)

<table>
<thead>
<tr>
<th>Chemical compound</th>
<th>Release rate/day</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPA</td>
<td>200g/ML</td>
<td>2,298KG (2.298 tonnes)</td>
</tr>
<tr>
<td>Bromide</td>
<td>7,000g/ML</td>
<td>76,650KG (76.65 tonnes)</td>
</tr>
<tr>
<td>Total Chlorobenzenes</td>
<td>1,840g/ML</td>
<td>20,148KG (20.148 tonnes)</td>
</tr>
<tr>
<td>Monochloramine</td>
<td>3,000g/ML</td>
<td>32,850KG (32.85 tonnes)</td>
</tr>
<tr>
<td>Nitrate</td>
<td>50,000g/ML</td>
<td>5,475,000KG (5,475 tonnes)</td>
</tr>
<tr>
<td>Uranium</td>
<td>20g/ML</td>
<td>219KG</td>
</tr>
<tr>
<td>Toluene</td>
<td>800g/ML</td>
<td>8,760KG (8.76 tonnes)</td>
</tr>
<tr>
<td>Xylene</td>
<td>600g/ML</td>
<td>6,570KG (6.57 tonnes)</td>
</tr>
<tr>
<td>Ethylbenzine</td>
<td>300g/ML</td>
<td>3,285KG (3.285 tonnes)</td>
</tr>
<tr>
<td>Benzene</td>
<td>1g/ML</td>
<td>10.95KG</td>
</tr>
<tr>
<td>Cyanide</td>
<td>80g/ML</td>
<td>876KG</td>
</tr>
<tr>
<td>Lead</td>
<td>10g/ML</td>
<td>109.5KG</td>
</tr>
</tbody>
</table>

My 20 November 2013 e-mail to Mr Henderson also included the following information from the Australian National Pollutant Inventory.


© Dr W Somerville 2014
2011/2012 National Pollutant Inventory reports of Total Air Pollution for:
A) ARROW ENERGY (DAANDINE) PL, Daandine Gas Field - Dalby, QLD;
B) QGC P/L, Kenya Processing Plant and Compressor Stations – Tara, QLD; and
C) QGC P/L, Windibri Processing Plant & Compressor Stations-Condamine, Qld.

<table>
<thead>
<tr>
<th>Substance</th>
<th>A) Arrow Dalby Air Total (kg)</th>
<th>B) QGC Tara Air Total (kg)</th>
<th>C) QGC Condamine Air Total (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic &amp; compounds</td>
<td>0.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beryllium &amp; compounds</td>
<td>0.013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadmium &amp; compounds</td>
<td>0.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>140,000</td>
<td>520,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Chromium (III) compounds</td>
<td>3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper &amp; compounds</td>
<td>1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluoride compounds</td>
<td>8.9</td>
<td>17,000</td>
<td></td>
</tr>
<tr>
<td>Formaldehyde (methyl aldehyde)</td>
<td>13,000</td>
<td>47,000</td>
<td>42,000</td>
</tr>
<tr>
<td>Lead &amp; compounds</td>
<td>1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury &amp; compounds</td>
<td>0.0027</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nickel &amp; compounds</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxides of Nitrogen</td>
<td>210,000</td>
<td>840,000</td>
<td>850,000</td>
</tr>
<tr>
<td>Particulate Matter 10.0 um</td>
<td>13,000</td>
<td>2,700</td>
<td>8,300</td>
</tr>
<tr>
<td>Particulate Matter 2.5 um</td>
<td>73</td>
<td>2,700</td>
<td>8,200</td>
</tr>
<tr>
<td>Polycyclic aromatic hydrocarbons</td>
<td>0.044</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>190</td>
<td>690</td>
<td>640</td>
</tr>
<tr>
<td>Total Volatile Organic Compounds</td>
<td>30,000</td>
<td>110,000</td>
<td>99,000</td>
</tr>
<tr>
<td>On-site long term waste storage</td>
<td>17,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Air Total = Air Point + Air Fugitive

In his 29 November 2013 letter, Mr Henderson did not directly address the apparent disparity between the documented discharge into the environment of pollutants in Queensland gas fields and his claim that CSG processing in the Northern Rivers would involve no significant pollution. Instead, Mr Henderson wrote:

“Your comment ‘When we export coal we do so with its impurities. But with gas the impurities are taken out here and they are dumped on the environment and the local community’ is simply incorrect and unnecessarily alarmist. The air emissions you quote for Queensland CSG operations are mainly from engine exhausts, no different in nature from any other engine exhausts, including cars, tractors and farm equipment. The emissions are not ‘impurities’ removed from the gas.” (Italics in original)

It is not clear why Mr Henderson described as “simply incorrect” my comment that impurities are removed from coal seam gas in Australia and dumped on local environments and communities. Presumably, CSG wastes in the form of drilling chemicals and muds, flared and vented gases, fugitive emissions, evaporations from waste water ponds, produced water from coal seams, contaminants removed by reverse osmosis filtration, impurities filtered from the gas, and pollutants created during processing, are not exported overseas, and are therefore discharged into local environments.
On their website, QGC describes their compressor and processing stations as removing “impurities” from CSG prior to transport via pipeline. As these impurities are not exported overseas, they presumably contribute to the pollutants discharged into the air as documented in QGC’s reports to the National Pollutant Inventory (see above).

It is not clear what Mr Henderson means by his comment that the documented air pollution from Queensland CSG gas fields and compressor/processing stations is “mainly from engine exhausts, no different in nature from any other engine exhausts, including cars, tractors and farm equipment”. In regards to the health impacts of CSG operations, it seems irrelevant whether the pollutant or dangerous substance that people are exposed to originated in the coal seam, was added by the miners, or entered the environment as a result of the burning of fossil fuels during processing of the gas.

**On the Safety of the CSG Industry**

In regards to the “proven” safety of the CSG industry, in his 29 November 2013 letter Mr Henderson wrote:

“Contrary to points you have previously raised, the safety of CSG and the broader oil and gas industry has been examined and demonstrated.”

“….our industry has a proven and safe track record over a number of decades.”

“CSG has operated in Australia for nearly 20 years without health problems. AGL’s CSG project at Camden, on the outskirts of Sydney, has been operating safely for nearly 13 years with 144 wells drilled in the Macarthur Region.”

“CSG in Australia has operated in Australia for nearly 20 years, without any health concerns. There are now about 4000 wells drilled, without health concerns.

“The industry is heavily regulated and there are numerous studies to demonstrate health and safety.”

“The CSG and petroleum industry is heavily regulated and must pass stringent health, safety and environmental checks before developments can proceed. There are numerous studies available to show that CSG operations represent a low health risk to the community.”

In his 29 November 2013 letter, Mr Henderson cited the Australian Institute of Petroleum’s (AIP) Health Watch program, the Queensland Government’s report on health problems in Tara, AGL’s Camden Northern Expansion Project Environmental Health Impact Assessment, and the recent Public Health England report, as providing scientific support for his claim that the CSG industry has been proved to be safe.

In my opinion, Mr Henderson’s arguments, and the studies he cited, do not provide scientific evidence to support his claim that the CSG industry has been proved to be safe. Rather, there is much in the studies and reports cited by Mr Henderson to support my assessment that there is a high level risk of potentially catastrophic health impacts associated with operating industrialised gas fields in populated areas.
A discussion of what constitutes scientific “proof”, and the questions that various kinds of studies can address, will be followed by a brief review of what the AIP Health Watch program, the Queensland Government’s CSG Health Report, AGL’s Camden Northern Expansion Project EHIP, and the Public Health England Report tell us about the safety of the CSG industry.

**Scientific “Proof” and Research Design**

Findings from randomised, controlled experimental trials are the closest that scientists can come to “proof” that some “intervention” (e.g., a medical treatment, living near a CSG gas field etc) has or does not have an effect. The basic requirement is that data obtained from “experimental” subjects, both before and after they are exposed to the “intervention”, is compared with pre- and post-test data obtained from “control” subjects who are similar to the experimental subjects, except that they do not experience the intervention.

For instance, to prove the efficacy and/or safety of a new medication, health data obtained before and after “experimental subjects” take the medication are compared with corresponding results obtained from “control subjects” who take a convincing “placebo” or “sugar pill” fake medication. If and only if these conditions are satisfied, can it be concluded that a medication is effective and/or safe.

If the experimental trial only obtains pre-test and post-test data from subjects who take the new medication, with no control group, then it can not be concluded that any observed changes are due to the effects of the medication. A comparison with control group subjects is necessary to rule out the influence of such extraneous factors as natural change over time, random events, and the expectations of subjects.

The “burden of proof” is on the pharmaceutical company that wants to sell a new, potentially hazardous medication to the public, and well-designed, controlled outcome studies are essential to scientifically demonstrate the safety and efficacy of their product.

By contrast, the CSG industry has not collected the very pre-drilling “baseline” health data that is essential if they are to demonstrate that their operations are safe. It is not up to the community to prove that CSG mining is harmful “beyond a reasonable doubt”. The onus is on corporations that seek to profit from operating gas fields in populated areas to prove that their operations are safe.

The essential experiment that is needed to demonstrate the safety of the CSG industry would compare health data, taken before and after gas drilling commences, from a community exposed to CSG pollutants, with health data obtained from a similar community that is not exposed to CSG operations. No other experimental design is capable of approaching scientific “proof” that operating CSG gas fields in populated areas is safe.

The reports and studies cited by Mr Henderson in his 29 November 2013 letter provide useful scientific information, some of which is relevant to the CSG industry, but none of these documents include data obtained pre- and post-drilling, or from an appropriate control group. Consequently, none can provide scientific “proof” that the CSG industry is safe.

Nonetheless, the materials cited by Mr Henderson do provide scientific data that is relevant for the assessment of CSG-related health risks.
Following are brief reviews of what the AIP Health Watch program, the Queensland Government’s CSG Health Report, AGL’s Camden Northern Expansion Project EHIP, and the Public Health England Report, do and do not tell us about the safety of the CSG industry.

The Australian Institute of Petroleum (AIP) Health Watch Program

The AIP Health Watch program is a prospective cohort study of all-cause mortality and cancer incidence, and a case-control study of leukaemia and benzene exposure, for 20,000 past and current employees in the petroleum industry. The recently released, 14th Health Watch Report12, provided an updated comparison of illness and cause of death statistics for petroleum industry employees compared with age-adjusted data for the Australian population. The study does not investigate acute health effects from working in the petroleum industry.

In his 29 November 2013 letter, Mr Henderson suggested that the AIP Health Watch program provided scientific evidence to support his claim that the CSG industry has been proven to be safe. Mr Henderson wrote:

“The people most exposed to petroleum are healthy. The people probably most exposed to hydrocarbon gases and liquids, including substances such as BTEX which are naturally found in crude oil, are those who work in oil refineries and conventional natural gas processing plants. The AIP Health Watch program, which has been in operation since 1980 and is run by Monash University, shows that workers in the petroleum and natural gas production industry have better health than the general Australian community and are less likely to die of the diseases common causing death - including cancer, heart and respiratory conditions.”

On a number, but not all, of the cancer and death statistics reported in the AIP Health Watch study, participating petroleum industry employees enjoyed better health outcomes than age-matched people in the general population. Nonetheless, this research does not indicate that working in the petroleum industry is either good or bad for your health - nor does it have any direct relevance to the question of whether the CSG industry is safe for workers and the public.

The AIP Health Watch study’s “prospective cohort” design does not compare employees’ pre-employment to post-employment changes in health with matched people in a control group. Consequently, the study can tell us some useful things about the health risks associated with working in the petroleum industry, but it cannot “prove” that working in the petroleum industry is safe or unsafe.

The 14th AIP Health Watch report is based on data obtained from petroleum industry employees who joined the study before the year 2000 and who had worked in the industry for five or more years. Consequently, there are likely to be few, if any, CSG industry employees contributing data to the study. Nonetheless, the research does provide some insights into the potential health risks of the CSG industry.

Throughout its history, the AIP Health Watch study has reported generally better health and mortality statistics for petroleum industry workers compared to age-adjusted figures for the Australian population. The Health Watch researchers attribute this result to the effects of a “selection bias” known as “The Healthy Worker Effect”.

As the Health Watch researchers explained:

“One cause of the ‘healthy worker effect’ is the relative social and economic advantage of employed people, especially for people with relatively secure employment. Unemployed people as a whole tend to have lower socioeconomic status. This commonly correlates with lower income, fewer years of education, lower health status and higher age-adjusted mortality rates than employed people. Hence when the mortality of occupational cohorts is compared with that of the general population, the mortality rate is higher in the latter because it includes many socially disadvantaged people. Another factor is that people with life-threatening conditions, such as cancer, tend not to seek or obtain employment after diagnosis: this further lowers the mortality rate in the workforce compared with the general population, especially in the years immediately following recruitment of members of the cohort into Health Watch.”

The sample of subjects in the AIP study was further biased towards healthier people because:

- Data was only included after the employee worked for five years in the industry, thereby excluding people who left due to illness before they completed five years employment;
- The Health Watch participants had a low average lifetime tobacco use compared with the general population; and
- Prospective petroleum industry employees underwent health checks before they were employed.

Participants in the AIP study are likely to enjoy better cancer and mortality outcomes than the corresponding age group in the Australian population because they were selected from the beginning to be healthier than the average.

But does working in the petroleum industry have a beneficial, deleterious, or neutral effect on health?

According to the 14th AIP Health Watch report, when compared to the general population, for petroleum industry employees:

- “The chance of contracting cancer is similar for men and women … as for all Australians”, but mortality from cancer is significantly reduced for male employees;
- “(For men) Two cancers, mesothelioma and melanoma, have been and are still occurring at statistically significantly higher rates than in the general population. Prostate cancer is also in statistically significant excess”;
- “Prostate cancer incidence in the cohort is now statistically significantly higher than in the general population, however prostate cancer mortality remains similar to that of the general population”;
- “There were 14 cases of melanoma in women. The incidence is slightly higher than in the general female population, but the increase is not statistically significant”;
- “There were ten cases of lung cancer among women. This rate was slightly higher than the general female population…”;
- “….This updated analysis now shows an almost identical risk of bladder cancer compared to the general population”;

• “There was a statistically significant lowering of lung cancer, liver cancer and cancers of the lip, oral cavity and pharynx and COPD which is probably a result of less tobacco consumption by members of the cohort than by the reference population”;
• “Bladder and kidney cancers in the cohort remain similar to the general population, as does multiple myeloma”;
• “Cancer mortality is also lower for men in all occupational groups investigated compared to the general population and is statistically so except for Terminal Operators and Maintenance workers”;
• “Leukaemia, kidney and bladder cancers were also elevated in the driver group compared with office only workers but only statistically significantly so for bladder cancer”; and
• “The findings of this study (the case controlled study) provide strong evidence for an association between previous benzene exposure in the Australian petroleum industry and an increased risk of leukaemia.”

Given that the selection of participants in the AIP study was biased towards people who are healthier than average, findings that, relative to the general population, petroleum industry employees have: a similar chance of contracting cancer; a statistically significant increased incidence for men of mesothelioma, melanoma, and prostate cancer; and similar rates of bladder and kidney cancers, are causes for concern and warrant further investigation.

Due to its design, the AIP study cannot determine whether working for a minimum of five years in the petroleum industry is good or bad for an employee’s health. It could well be that employees would have been healthier if they had not worked in the industry.

As the authors of the 14th AIP report noted:

“There is an argument for using a reference population composed of workers with similar demographic characteristics including the likelihood of obtaining and retaining employment rather than the general population”.

That is to say, the study needs a genuine control group, matched on relevant characteristics, to enable more informative analyses of the obtained results.

The AIP study provides some information about the health of petroleum industry employees, but tells us nothing about the health impacts of petroleum and gas industries on the general population. I note that, in this regard, in the USA, Lefall et al. (2010)15 compared nationwide cancer mortality statistics with the incidence of cancer in three New York counties that had a distinctively rural character and a history of intensive gas and oil industry activity. Based on nation-wide statistics from 1950 to 1994 for 55 different types of cancer, women in these three counties were consistently in the top bracket for deaths caused by cancer of breast, cervix, colon, endocrine glands, larynx, ovary, rectum, uterus and vagina. Men from the same region were consistently in the highest statistical bracket for deaths caused by bladder, prostate, rectum, stomach, and thyroid cancers.16

AGL’s Camden Northern Expansion Environmental Health Impact Assessment

In his 29 November 2013 letter Mr Henderson cited the AGL Camden EHIS\textsuperscript{17} as evidence that the CSG industry has been proven to be safe. Specifically, Mr Henderson wrote that:

“AGL’s CSG project at Camden, on the outskirts of Sydney, has been operating safely for nearly 13 years with 144 wells drilled in the Macarthur Region.”

“We recommend that you take the time to read the huge amount of material that is available to the public in relation to the Queensland CSG projects and to AGL’s recent Camden Northern Expansion Project Environmental Health Impact Assessment. AGL’s study, which covers the full spread of potential health risks, concludes that its proposed Camden Northern Expansion would have posed low and acceptable risks to community health and to air, groundwater and surface water.”

After studying AGL’s EHIA, I could find no evidence there to support Mr Henderson’s claim that AGL’s CSG project at Camden “has been operating safely for nearly 13 years” or that the CSG industry has been proven to be safe.

I could find no health data in the AGL EHIA which compared the health status of local residents prior to, and following the setting up of AGL’s gas fields in Camden, even though such data would be essential to establish the safety of the Camden CSG operation. I could not find any reference to any health data collected during 13 years of operations.

The AGL EHIA is “…a screening level health risk assessment that assesses the likelihood and severity of risks to human health.”\textsuperscript{18} That is to say, the AGL EHIA is not a real-world study of health impacts, and is not concerned with health data obtained from potentially affected people. The AGL EHIA is an assessment of risks in a possible future, and is based on certain assumptions, computer modelling and health guidelines, rather than real-life data.

As the authors of the AGL EHIA explained:

“The EHIA presented in this report is a desk-top assessment. The term desk-top is used to describe that the EHIA has not involved the collection of any additional data over and above that which has been provided from Project specific EA technical studies, or studies undertaken for existing operations within the CGP or community consultation.”\textsuperscript{19}

“The EHIA assessment presented in this report is largely qualitative, with some aspects addressed in a quantitative manner, and has been conducted for the purpose of summarising all the environmental health impacts that may be associated with the proposed Project, evaluating those impacts (on a qualitative or quantitative basis where relevant) and where an impact has been identified, determining if it can be mitigated through existing or other management measures.”\textsuperscript{20}

\textsuperscript{17} Environmental Health Impact Assessment – Camden Northern Expansion Project, Prepared for AGL Energy Limited, 30 October 2013.

\textsuperscript{18} Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October 2013, Page 1.

\textsuperscript{19} Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October 2013, Page 3.

\textsuperscript{20} Ibid.
The AGL EHIA does not include any controlled outcome study or data that could support the claim that CSG mining has been proven to be safe. The AGL EHIA can only support a claim that, on the basis of certain assumptions, in the opinion of the authors, there is a certain level of potential risk to human health.

Like other CSG risk assessments, the AGL EHIS assumes that gasfield industrialisation takes place in an ideal world, free of accidents, misadventure and negligence - where all works are carried out "in accordance with best practice, as well as the current policies and codes of practice". ²¹

The limitations of such "desk-top" assessments as the AGL EHIA become apparent in the real world where, even with stringent regulation and best practice engineering, wells leak and 200 metres of bore pipe can be blown high into the air, CSG wastewater is dumped into rivers, and even AGL’s risk assessment procedures can break down.

In March 2013 the NSW Environment Protection Authority (EPA) fined AGL for not maintaining its emissions monitoring equipment. ²² In the August 2013 "Undertaking to the Environment Protection Authority" ²³, the EPA expressed “concern” that in 2007 AGL’s emissions monitoring equipment began to break down, and by 2009 all their monitoring equipment had stopped operating.

AGL provided false information to the EPA in Annual Returns from 2006 to 2011, and its publicly available 2007 to 2011 Annual Environmental Performance Reports included the “false and misleading” statement that, “Full results of the continuous emissions monitoring for the reporting period are kept on file”. “AGL advised that the non-reporting was due to oversight combined with a lack of understanding by AGL staff regarding the significance of the equipment breakdown”. ²⁴

A serious limitation of CSG health impact risk assessments like the AGL EHIA and the Public Health England Report is their lack of health data obtained from people actually exposed to CSG operations, and their reliance on “guidelines” to determine the potential health risk posed by individual pollutants.

For many CSG pollutants, guidelines for safe levels of exposure do not exist, are inadequately researched, or only provide toxicity ratings which do not address all potential health impacts. For the compounds listed in AGL’s EHIS Table 4.5 and “Report of Analysis” for air emissions (see Pages 6, 8&9 above) and Table 7.2 for waste water (see Pages 11&12 above), where available, “screening level guidelines” were derived from a variety of sources.

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²⁴ Ibid.
As the authors of the AGL EHIS explained in Appendix 3 of their report:

“It is noted that a number of chemicals have very limited data available and hence the studies available have been further evaluated for the purpose of determining the potential for adverse health effects to be of significance.”

“It is noted that there are a number of chemicals where no suitable human health guidelines are available or relevant, hence the evaluation of these chemicals has been undertaken on a qualitative basis only.”

If “health guidelines” are to be used as criteria for ignoring the possible effect of a detected pollutant, then the validity, reliability and interpretation of guideline cut-off levels become vitally important.

In CSG health impact assessments such as the AGL EHIS, the ultimate conclusion that there is likely to be a minimal health impact from exposure to a large number of CSG pollutants newly introduced into an environment, is based on a procedure that only considers possible impacts of individual substances one at a time.

As the authors of the AGL EHIS explained the process:

“Once an estimate of exposure has been developed it was compared to appropriate National or International health protective guidelines to determine if the Project poses a risk with regard to each of the hazards. If the exposure from the Project is less than the guideline then there is no unacceptable risk. If the exposure from the Project may be larger than the guideline there is potential for unacceptable risk which can be addressed by refining the worst case assumptions or by recommending control/ management measures be included in the Project.”

That is to say, in the AGL EHIA it is assumed that if any one of the many substances is present at a level below the adopted guideline cut-off point, then the health impact of that substance can be ignored. This process is based on the dubious assumption that there is no cumulative, interactive, or magnifying effects when people are exposed to a complex mix of dangerous substances that are poorly understood, and some of which can damage health even in minute doses.

The simultaneous exposure to numerous dangerous substances could present a greater risk to health than exposure to individual substances by themselves. While it might be safe to consume a particular substance at a dose of say 1/10th of a recommended health guideline, the level of risk increases in an unknown manner when a number of substances are consumed even if each of them constitutes only a 1/10th dose of a recommended guidelines dose.

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The appropriateness and usefulness of this procedure is seriously undermined by the limited data and lack of guidelines for many chemicals, and the poor understanding of accumulative and synergistic effects that many of these chemicals and their metabolites can have on human physiological systems.

As US toxicologist Dr David Brown (2013)\(^{28}\) explained, gas field toxicology is complicated because:

- We have incomplete identification of the chemicals present
- Chemicals can interact with other chemicals in complex unknown ways
- The presence of one agent can greatly increase the toxicity of another agent
- Agents have multiple physiological actions on various target organs
- Health effects of exposure to many chemicals is unknown
- How certain chemicals alter the biological processing of other chemicals is unknown
- Substances that inhibit metabolism or excretion magnify the effects of other chemicals
- Some agents can change the physiologic distribution of other chemicals
- Some agents can cause chemicals that would not normally do so to enter the brain
- Medications can affect the impact of toxic substances

**The Public Health England Report on Health Impacts of Shale Gas Mining\(^{29}\)**

As recommended by Mr Henderson in his 29 November 2013 letter, I read the Public Health England (PHE) Report on the potential health impacts of shale gas mining in the UK, but could find nothing there to support Mr Henderson’s claim that the CSG industry has been proven to be safe.

Like AGL’s Camden EHIA, the PHE report is a “desktop” exercise in risk assessment, based on a particular set of assumptions, health guidelines applied to individual substances in a complex mix of pollutants, and a belief that regulation can ensure the safety of people who live amongst gas fields. The risk assessment design of the PHE report precludes it from providing scientific evidence to support the claim that the CSG industry has been proven to be safe.

I note that the authors of the PHE report concluded that, “Where potential risks have been identified in the literature, the reported problems are typically a result of operational failure and the poor regulatory environment”, and UK regulations will “minimise the potential for pollution risk to human health.”\(^{30}\)

Significantly, the authors of the PHE report recommended that: a) “to facilitate the assessment of the impact of shale gas extraction on the environment and public health” the UK shale gas industry carry out the kind of baseline monitoring that is lacking in Australian CSG operations; and that b) “emission inventories”, which already exist in Australia, be established to provide important information needed for proper assessment of health risks.

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The Queensland Government CSG Health Report\textsuperscript{31}

In his 29 November 2013 letter, Mr Henderson cited the March 2013 Queensland Department of Health CSG Report as evidence that the CSG industry has been proved to be safe. As Mr Henderson wrote:

“In March, 2013, the Queensland Government published a report which assessed health complaints from the Tara area and concluded that the available evidence does not support the concern among some residents that excessive exposure to emissions from CSG activities is the cause of the symptoms reported.”

I note that the Queensland Department of Health report also concluded that the information it relied on from the Darling Downs Public Health Unit (DDPHU) investigation “did provide some evidence that might associate some of the residents’ symptoms to exposures to airborne contaminants arising from CSG activities.”

Like my recent report on the health impacts of CSG and shale gas mining\textsuperscript{32}, the Queensland Department of Health Report is an exercise in risk assessment based on the evaluation of available evidence that people have been exposed to CSG pollutants in doses sufficient to cause illness. Due to their design and the lack of any pre-drilling to post-drilling health data, neither investigation is capable of providing scientific “proof” that the CSG industry is or is not safe. Both reports can only generate probabilistic statements, based on specified evidence and assumptions, which assess the likely degree of risk to health.

The methodological, technical and analytical inadequacies of the Queensland CSG Health study have been discussed by Dr Geralyn McCarron\textsuperscript{33} and Dr Mariann Lloyd-Smith\textsuperscript{34}, and the reader is directed to these papers for detailed analyses of this report.

My report on the health impacts of CSG and shale gas mining\textsuperscript{35} and the Queensland Department of Health Report reached different conclusions regarding the probability of deleterious health impacts. Whereas the Queensland Department of Health report concluded that a “clear link” was not evident between the health complaints of some Tara residents and exposure to CSG pollutants, I concluded that there was a high probability of potentially catastrophic impacts from operating gas fields in populated areas.

In my opinion, the differing conclusions reached in my and the Queensland Department of Health assessments were due primarily to the different medical and environmental data that was available to, and used for, each report.


\textsuperscript{34} Lloyd-Smith, Mariann (2013) No clean bill of health for CSG: A Critique of the Queensland Department of Health’s Report on the Health Impacts of CSG Activities on the Tara Community, National Toxics Network.


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The Queensland Health Department risk assessment was based on:

- The Darling Downs Public Health Unit (DDPHU) investigation of 56 people who attended GPs and hospitals in the Tara region or who registered CSG related health complaints with a government phone service;
- A report by Dr Keith Adam based on “direct participation” with 15 people in person and two by telephone who attended clinics at Tara Hospital on 11–12 October 2012;
- Environmental Resources Management Australia Pty Ltd’s (ERM) 13 air samples collected at nine residential sites in the Tara Estates from 11 to 19 July 2012; and
- Environmental monitoring from July–December 2012 at the Wicambilla Estates by Environmental Monitoring and Assessment Sciences.

My report on the health impacts of CSG and shale gas mining was based on information including:

- A review of the scientific literature on substances used, and liberated during, mining of gas from coal and shale seams;
- A review of the scientific literature on the contamination of air, water and soil systems by gasfield pollutants;
- A review of the scientific literature concerning the health impacts of exposure to CSG and shale gas pollutants;
- Dr Geralyn McCarron’s (2013)\(^{36,37}\) study on the health status of 113 people from 35 households in the Tara residential estates and the Kogan/Montrose region;
- CSG company reports to the 2013 Australian National Pollutants Inventory; and
- A 2013 medical test finding of a high level of hippuric acid, a metabolite produced following exposure to toluene, in the blood of a boy who lived in the Tara estates.\(^{38}\)

As Dr Geralyn McCarron (2013) pointed out, the Queensland CSG health study did not consider the case of a boy whose blood tests indicated the presence of hippuric acid:

“Toluene metabolites found at high levels in a child in a non-occupational context is worrying, taking into account the short half-life i.e. toluene is quickly metabolised. This should have prompted investigation by the health department as a matter of urgency. Toluene is a known neurotoxin, an irritant and a suspected reproductive toxin that can be absorbed via inhalation. It is known to be associated with coal seam gas and has been found repeatedly in air samples in the residential estates. No action was taken by the health department.”\(^{39}\)

The Queensland CSG Health study relied on face-to-face interactions with 71 people, while my study referred to Dr Geralyn McCarron’s (2013) survey of 113 people in the Tara area.

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\(^{38}\) McCarthy, J. (2013). Testing Times ahead for residents of Tara as boy found with hippuric acid in system, Sunday QLD, 6 January 2013.


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Another difference between my report on the health impacts of gas mining and the Queensland CSG Health Study was the data used to evaluate the likelihood that people who live near gas fields are being exposed to pollutants in sufficient doses to cause illness.

The Queensland CSG Health investigation relied on a limited number of potentially biased air samples. In the Queensland health study residents were instructed to take canister air samples when they smelled odours. This procedure was likely to bias results towards more samples being taken during the daytime, rather than at night when people were more likely to be indoors and pollutant levels are generally higher. The Queensland health study assumed that sampling when odours were present would guarantee the samples were taken when problematic pollution was at a maximum concentration, even though there are no grounds for assuming that the presence of the most dangerous pollutants is associated with odours.

By contrast, my assessment of potential health impacts from exposure to gas field pollutants also took account of recently available data from the Australian National Pollutant Inventory (ANPI) as well as from environmental sampling of air and water.

It was notable that data presented in the Queensland Health Study and the AGL Camden EHIS demonstrate a wide range of results when environmental testing involves multiple air or water samples obtained from the one site. For example, in the Queensland Health study benzene readings from one site varied from <4.3 μg/m³ in the daytime to 25 μg/m³ at night. The wide variation in results indicates that adequate assessment of CSG pollution requires continuous sampling over extended periods of time to take into account fluctuations due to such factors as time of day, weather conditions, and season.

As the authors of the Queensland Health study commented:

“However, the air monitoring program had important limitations. The total monitoring period was nine days, the methodology resulted in limits of reporting for some analytes that were substantially higher than reference air quality criteria and the monitoring was not designed to identify short-term peaks or troughs in air concentrations. It is considered a more strategic air quality monitoring program could be implemented to provide more useful information on the impacts of the CSG industry, if any, on ambient air quality in the region.”

The problems inherent in the use of “guidelines” to evaluate the potential health impacts of exposure to a complex mix of pollutants by considering each pollutant one at a time have been discussed above in relation to the AGL Camden EHIS.

The combined health effects of simultaneous exposure to many pollutants, even if each is present in concentrations below a chosen “standard”, is entirely unknown. This issue is especially important for interpreting the Queensland CSG Health report because testing of air samples over brief periods of time in a residential estate in Tara detected a diverse range of compounds including the VOCs hexane, propene, chloromethane, dichlorodifluoromethane, methylene chloride, ethanol, acetone, methyl ethyl ketone, acrolein, vinyl acetate, pentane, heptane, tetradecane, hexadecane, heptadecane, cyclohexane, 2-methylbutane, 3-methylpentane, 3-methylhexane, methylcyclohexane, tetrachloroethylene, 2-ethyl-1-hexanol, ethylacetate, benzene, toluene, xylene, ethylbenzene, 1,2,4-trimethylbenzene, phenol, benzothiazole, naphthalene, and alpha-pinene.⁴⁰

While environmental sampling can evaluate the presence of CSG pollutants at a particular place and time, the Australian National Pollutant Inventory (ANPI) contributes to the assessment of the risk of human contamination by providing data that quantifies the overall volume of pollutants that gas mining companies release each year into the atmosphere and local environments.

For instance, from the National Pollutant Inventory data we know that during 2011/2012:

- Arrow Energy’s Daandine Gas Field released into the air substances including 140,000 kg of Carbon monoxide, 13,000 kg of Formaldehyde, 210,000 kg of Oxides of Nitrogen, 13,073 kilograms of Particulate Matter, and 30,000 kg of Volatile Organic Compounds (VOCs); and

- QGC’s Kenya CSG processing plant and compressor station in Tara released into the air 520,000 kg of carbon monoxide, 47,000 kg of formaldehyde, 840,000 kg of oxides of nitrogen, 5400 kg of Particulate Matter, 17,000 kg of fluoride compounds, 110,000 kg of VOCs, while 17,000 kg of waste was in long-term on-site storage.

The National Pollutant Inventory data makes it possible to estimate the scale of the total load of air pollutants that are discharged into local environments by specific CSG operations such as gas fields and compressor and processing plants. The CSG industry is being massively expanded in Queensland - QGC estimate that they will have 24 CSG compressor/processing plants operating by the end of 2014 - and National Pollutant Inventory data enables informed estimates of the environmental pollution that will be produced when these gas fields are fully developed.

As well as discharges into the air, the total environmental burden of pollutants from CSG operations includes air, water, and soil contamination from drilling chemicals and muds, flared and vented gases, fugitive emissions, evaporations from waste water ponds, produced water from coal seams, and substances removed by filtration.

Once the total environmental burden of pollutants is known, the scientific task is to determine the ability of local soil, water, and air systems to dissipate, process, and render inert the known quantities of persistent, bio-accumulative, teratogenic, mutagenic, carcinogenic, endocrine-disrupting, and toxic substances that will be regularly discharged into the local environment, often within earshot of where people live. Such empirical analyses could then inform debate about whether operating industrialised gas fields in populated areas constitutes a minimal or, as I argue, a high level risk of potentially catastrophic health impacts.

In his letter of 29 November 2013 Mr Henderson cited a comment about employee health from the Queensland Government report as support for his claim that CSG has been proved to be safe. Mr Henderson wrote:

“To quote from the Darling Downs Public Health Unit report, one of the reasons for dismissing a link between CSG and reported health problems is ‘the lack of evidence of employees working within the CSG industry having similar symptoms. If community members were experiencing symptoms due to CSG activities, it would be highly likely for workers in the industry to be reporting similar and probably more severe effects due to their likely much higher exposure’”. (Italics in original)
In this “worker good health” argument, the validity of the conclusion depends on the truth of the supporting premises. This argument takes the form:

- Premise 1 - Workers have a much greater exposure to CSG pollutants than the public,
- Premise 2 - There is no evidence that CSG workers experience symptoms,
- Conclusion - Therefore, there is no link between exposure to CSG pollutants and symptoms reported by the public.

The first premise - that CSG workers have a much greater exposure to pollutants than residents who live amongst gas fields - might appear reasonable, but is not necessarily true. The Queensland CSG Health study does not cite any scientific research that compares the exposure to pollutants of local residents, and especially of children, who live amongst the gas fields 24 hours a day, seven days a week, with the exposure of workers selected to be of good health, who work shifts, often on a fly-in/fly-out basis, and who have access to worker health and safety training and protective equipment.

The second premise - that there is no evidence that CSG workers experience symptoms - begs the question as to whether this lack of evidence indicates that workers truly are not experiencing health problems, or that their health problems are not being reported, or are being reported to their family doctors rather than to their employers’ medical personnel.

As Dr Penny Hutchinson, author of the Darling Downs Public Health Unit Investigation in the Queensland Health Report, commented:

“Similarly there have been no reported presentations by employees of the mining companies with symptom patterns similar to those described by the residents. There are multiple potential reasons for this including:

- the employees are not experiencing symptoms,
- employees are presenting to health-care providers outside the local area (many mining employees work fly in/fly out or drive in/drive out rosters so they leave the local area and return to their usual place of residents between working shifts),
- employee concerns that if they report similar symptoms to those in the community it may jeopardise their employment.”\(^{41}\)

I note that there is anecdotal evidence that CSG industry workers have experienced health problems similar to those reported by Tara residents. In her 2013 report, Dr Geralyn McCarron observed that:

“Of the 113 people surveyed, 4 worked in the CSG industry. Two of these were involved in infrastructure construction and although both had ongoing skin irritation, neither believed their health was impacted. One person, after 4 months employment in a CSG facility, began to develop severe symptoms in their hands and feet. After biopsy they were eventually diagnosed with neuropathy (nerve damage) and can no longer work. The fourth worker also has a symptomatic neuropathy which has been, without tests, diagnosed as carpal tunnel. They also suffer from severe fatigue, headaches and nausea.”\(^{42}\)

\(^{41}\) Hutchinson, P. (2013) The Darling Downs Public Health Unit Investigation into the health complaints relating to Coal Seam Gas Activity from residents residing within the Weemilla Estates, Tara, Queensland, July to November 2012, FINAL REPORT, January 2013.

\(^{42}\)
Dr Geralyn McCarron further reported that:

“Following the publication of the Queensland Government’s health report and Lawrence Springborg’s assertion that CSG workers have had no health problems, a person previously employed on CSG drilling rigs in a different area of Queensland was so disgusted that they contacted the Gasfields Support Group to relate their story. That data is not included in the numbers for this study. This worker’s ill health included nosebleeds, spasms of the hands and extreme difficulty breathing, making it impossible to continue work. Their comment was: “They wiped their hands of me.”” (Italics in original)

Mr Henderson’s 29 November 2013 letter included an unfortunate reference to the Queensland CSG Health study to support his claim that the CSG industry has been proved to be safe. Mr Henderson wrote that:

“The Queensland Government report highlighted concerns with Tara drinking water because it was contaminated by faecal matter, not hydrocarbons.”

Mr Henderson’s statement is problematic because the association of “faecal matter” with “drinking water” is likely to create a degree of disgust in the reader, and this emotion contributes to the potency of the implications that the statement carries about the hygiene of the Tara residents and the causes of their medical problems. Further, Mr Henderson’s statement benefits from the authority of the Queensland Government but, in my opinion, does not properly represent the findings of the Queensland CSG Health study.

In regards to sampling of water, the Queensland Health CSG Report noted:

“Samples were collected from potable drinking water sources (all nine lots) and ponds and surface water sites (five lots)… According to the ERM report, all properties reported use of roof-harvested water for drinking and most household purposes. Two properties reported use of on-site ponds or surface water created by a dam for washing and bathing.”

“Two rainwater tanks were reported to contain E.coli, but all tanks had some type of microbial contamination as demonstrated by the other testing. The presence of microbes is expected in both roof-harvested water and untreated surface water. Further microbial analysis would be needed to identify potential health hazards.”

As noted in the Queensland Health CSG report, the presence of microbes in roof harvested water used for drinking is nothing unusual for rural areas. In my opinion, the finding of E.coli in two rainwater tanks does not justify Mr Henderson’s claim that the Queensland Government report “highlighted concerns with Tara drinking water because it was contaminated by faecal matter, not hydrocarbons”.

Discussion, Implications and Recommendations

After attending Mr Peter Henderson’s presentation at the 14 November 2013 meeting with Kyogle’s Mayor, I understand why some local government councillors and business people, who have the community’s best interests at heart, could support Mr Henderson’s plans for the gas field industrialisation of the Northern Rivers.

Mr Henderson’s account of what the CSG industry offers the Northern Rivers is very attractive – a proven safe, “clean and green” development with no downside, and economic benefits with no costs. And the Northern Rivers is special because our coal seams do not contain benzene, and the gas and CSG waste water are safe to use straight out of the ground.

For gas industry executives and employees, and others looking to profit from gas mining, Mr Henderson’s claims that the CSG industry is in all ways safe and beneficial have potent commercial implications. The costs involved in meeting legal obligations to manage risk are greatly reduced - if there is no risk there is nothing to manage. When there is no danger, government regulations to protect health and the environment become unnecessary.

If members of local councils and regulatory authorities believe that local CSG wastewater is safe for use with minimal processing, then “a problem becomes a product”. The issue of how to safely dispose of CSG wastewater disappears because the water can be sold as fit for human and agricultural use.

Mr Henderson’s claims about the safety of the CSG industry and the nature of coal seam gas and waste water in the Northern Rivers were presented as facts about the real world, and are therefore testable by empirical evidence and rational argument.

In my opinion, Mr Henderson has not provided any direct or credible evidence that:

- CSG compressor and processing plants in the Northern Rivers would not create the pollution seen in Queensland gas fields;
- The CSG industry is proven safe;
- Northern Rivers CSG does not contain any impurities;
- There is no benzene in coal seams; and
- Metgasco’s CSG waste water is fit, without treatment, for use with stock, and with the removal of some salt, suitable for irrigation and human consumption.

In his letter, Mr Henderson stated that, “Communities deserve sensible and open debate about the best ways to achieve our energy needs and balance any potentially competing interests”.

To progress this “sensible and open debate”, in my opinion, it would be useful if Mr Henderson made public chemical assays, with detail similar to the assays provided by AGL in their Camden EHIS, to support his claims about the nature and safety of CSG operations in the Northern Rivers.

In his letter Mr Henderson wrote, “Your exaggerated and incorrect comments do nothing to encourage such debate. They do no more than create unjustified fear.”
Everyone prefers good news to bad, but when difficult issues have to be confronted, it is sometimes better to be anxious now than sick and sorry later.

Anxiety is a natural protective emotion that operates to warn us of the presence of danger. Anxiety that works well motivates people to take action to reduce the risk of harm. For the first time, heavily industrialised gas fields are being established where people live, work, and raise children, and the implications for community health are profound. The community confronts a potential health crisis reminiscent of that created by the asbestos industry.

In the 1930s it was known that asbestos caused cancer, but the industry thrived with government support until it was banned in 2003. Profits reaped over decades were never discounted to reflect the true costs in suffering, illness and death borne by the community. Today, asbestos is widely distributed throughout the environment and will continue to be a health hazard into the future.

Gas field industrialisation of the Northern Rivers has the potential to produce dangerous pollution that will impact on health for generations to come. In the interests of protecting community health, there is an urgent need for an expanded public debate on the safety of the industry.

On the basis of the scientific evidence detailed in my report on the health impacts of CSG and shale gas mining\(^{46}\), I concluded that there is a high probability of potentially catastrophic health impact from operating gas fields in populated areas. In my opinion, there is nothing in Mr Henderson’s letter that contradicts my conclusion, and there is much in the references he cites to support my assessment.

Democracy and the giving of informed consent depend on citizens and their political representatives having access to accurate evidence-based information. Citizens are entitled to express their opinions and beliefs but, in my opinion, claims about the safety of the CSG industry that purport to be factual need to be supported by scientific evidence.

Mr Henderson received a pre-publication copy of this paper and was invited to provide a response which would be attached to the document when it was made public. Mr Henderson was also asked if he would be willing to participate in further public discussion about the potential health impacts of operating gas fields in populated areas.

In a letter dated 24 January 2014, Mr Henderson responded to my analysis of the arguments and scientific evidence that he presented in his 29 November 2013 letter. Mr Henderson declined the invitation to further debate CSG health impacts. Mr Henderson’s 24 January 2014 letter is attached to this paper as Appendix B.

Mr Henderson’s Parting Statements

In my opinion, in his 24 January 2014 letter Mr Henderson did not provide any relevant scientific evidence or reasoned argument to support his claims that: the CSG industry is proven to be safe; local CSG and CSG waste water contain no dangerous substances and are fit for human, animal and agricultural use with minimal to no processing; and that the CSG industry in the Northern Rivers would involve none of the documented pollution produced by CSG operations in Queensland.

Rather, Mr Henderson provided debatable statements of personal opinion. For instance, Mr Henderson wrote:

“As a final comment, we note that your paper refers to the “healthy worker effect” and the association between unemployment and lower health status and higher mortality rates. If you are genuinely interested in the health of the Northern Rivers people, shouldn’t you be promoting an industry that provides secure employment and income security for landholders? Surely, job security, supplementary income for farmers and a reliable energy supply go a long way to reducing stress, more than offsetting any discomfort associated with change.”

My concerns go well beyond being “interested in the health of the Northern Rivers people”. I have lived in the Northern Rivers most of my life - raising a family and working as a farmer and as a health professional. I know that this region “abounds in nature’s gifts of beauty rich and rare” and, for good reasons, I strongly believe that, if protected, our natural resources of sweet water, clean air, and healthy communities will ensure the prosperity of this region for generations to come.

I do not believe that the coal seam gas industry can provide “secure employment and income security for landholders”. Short-term construction jobs and limited payments to farmers will not offset the loss of land values and the long-term economic damage done to agricultural, tourism, residential, and other industries that otherwise have a bright future in this area.

The stress from being forced to live and raise families amongst gas fields is not mere “discomfort associated with change”. “Change” is not desirable in itself - it can be good or bad, depending on what is lost and what is gained. For most citizens, the change brought about by gasfield industrialisation would result in profound personal, social, and economic losses. Imposing the CSG industry on rural communities is a radical experiment in social and environmental engineering that violates the conservative principle of protecting that which already exists and is truly precious.

In his 24 January 2014 letter, Mr Henderson stated:

“More importantly, you continue to maintain an alarmist position when you conclude that ‘there is high probability of potentially catastrophic health impacts for operating gas fields in populated areas’. This position has no credibility whatsoever.”

“By inspection, any reasonable person can look at the data and conclude that there is no substance to your position. Apart from the succinct response we made to your first paper, please note that:

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“The oil and gas industry has operated on a large scale all around the world for more than 100 years – it is not new or unusual. In the USA there are currently more than 1,000,000 producing oil and gas wells. These wells produce the full range of hydrocarbons (oil and gas), not just methane. (Our CSG wells produce essentially just methane. Methane is not toxic. It occurs naturally and is also produced from compost bins and cows. People are exposed to it as part of their everyday lives.)

These USA oil and gas wells have been drilled in rural areas and in areas much more highly populated than the exploration licences we have in the Northern Rivers region.”

Regarding Mr Henderson’s statements, I note that:

- Mr Henderson’s “response” in his 29 November 2013 letter may have been “succinct” (i.e., expressed in few words) but, in my opinion, it failed to provide any credible scientific evidence to support his claims about the “proven safety” of the CSG industry, or the pure quality of CSG and CSG waste water in the Northern Rivers;

- The oil and gas industry may have operated “all around the world for more than 100 years”, and there may be more than 1 million producing oil and gas wells in the US, but the development of unconventional gas fields involving thousands of wells across extensive areas of populated, previously rural countryside, is a recent phenomenon;

- Breathing methane in low doses may not be toxic, even though the health effects are unknown, but the dangerous substances liberated, used, and produced by the CSG industry constitute a real and serious threat to human health;

- Denying the existence of scientific evidence which indicates a high level risk of potentially catastrophic health impacts from operating gas fields in populated areas, does not mean that the industry is safe - ignoring the science does not make the danger go away.

In his 24 January 2014 letter, Mr Henderson stated:

“Where is the catastrophic health impact associated with all these USA wells? The answer is that there is no catastrophic health impact. A similar review of the 4000 CSG wells drilled in Queensland over the past 20 years also shows that there is no health concern.”

The answer to Mr Henderson’s question, “Where is the catastrophic health impact”, is to be found in the rapidly growing body of research that documents the health impacts of living near gas fields. The full extent and severity of the health impact will become evident in the health status of children conceived and born in gas fields, who develop while being exposed to gasfield pollutants, and who mature to have families of their own.

For example, a recently published study by Kassotis, Tillitt, Davis, Hormann, and Nagel (2013) found a strong association between unconventional gas mining and the presence of endocrine-disrupting chemicals (EDCs) in water systems used for human consumption.

Kassotis et al (2013) found that water samples taken from drilling sites within a 10,000 well gas field in Garfield County, Colorado, as well as the Colorado River which takes run-off from the gas field, showed moderate to high levels of endocrine-disrupting chemical (EDC) activity, while samples from sites in Colorado and Missouri with little drilling showed little EDC activity.

About 100 chemicals used in gas mining are known or suspected to be endocrine-disrupting. The researchers reported, for the first time, estrogenic, anti-estrogenic, and anti-androgenic activity in a subset of 12 chemicals used in natural gas operations (i.e., ethylene glycol monobutyl ether, 2-ethylhexanol, ethylene glycol, diethanolamine, diethylene glycol methyl ether, sodium tetraborate decahydrate, 1,2-bromo-2-nitropropane-1,3-diol, n,n-dimethyl formamide, cumene, styrene, bronopol and naphthalene). One of the twelve chemicals exhibited estrogenic activity, eleven had anti-estrogenic activity, and ten had anti-androgenic activity.

Research indicates that exposure to EDCs increases the risk of reproductive, metabolic, neurological, and other diseases, especially in children, by interfering with the body’s response to the reproductive hormones estrogen and testosterone. Research has linked EDC exposure to infertility (decreased sperm quality and quantity), impaired gonadal development (including undescended testis), reproductive tract deformities (including hypospadias - a congenital defect in which the urinary meatus is on the underside of the penis), cancer, and birth defects (including decreased anogenital distance).

Kassotis et al (2013) noted that a particular concern with exposure to EDCs is the potential for additive effects of mixtures of chemicals that act through a common biological pathway, even when each chemical in the mixture is present at levels below an observed effect threshold. Laboratory experiments have shown a wide range of effects at environmentally relevant, low concentrations that were not predicted by traditional risk assessments from high-dose testing. EDCs may be of particular concern during critical windows of child development when exposure can alter normal development.

In his 24 January 2014 letter, Mr Henderson brought to an end our discussion on CSG health impacts in the following manner:

“NSW has a plethora of approval processes and regulations that Metgasco and other gas exploration and production companies must comply with if we are to explore and develop gas.”

“The processes and regulations allow and promote community participation and awareness and are designed to ensure that health, safety and environmental risks are managed acceptably. We will continue to work within this approval and regulatory environment. We are also committed to transparency and community consultation and will continue to discuss safety, health and environment issues accordingly. We are not, however, willing to participate in the poorly managed public discussions that have occurred in the Northern Rivers over recent years. Instead, we ask you to respect the

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49 Silva E, Rajapakse N, Kortenkamp A. Something from “nothing” – eight weak estrogenic chemicals combined at concentrations below NOECs produce significant mixture effects. Environmental Science,Technology. 2002;36(8):1751–1756.
approval and regulatory processes that exist and to participate in the associated review processes. If you are not happy with them you should approach the relevant NSW government ministers and justify changes to the processes and regulations.”

That is to say, Mr Henderson and Metgasco are “committed to transparency and community consultation and will continue to discuss safety, health and environment issues”, but only within the Government’s “approval and regulatory environment”, and not via participation in “poorly managed public discussions” in the Northern Rivers.

And so this CSG health debate ended before it got very far.

Mr Henderson indicated that he will not engage in further public discussion of the scientific “evidence” that he says he has to support the claims about the safety of the CSG industry he made to Kyogle’s Mayor. Instead, Mr Henderson recommended that I “participate in the associated review processes” and take any grievances that I might have to the relevant Minister.

As detailed above, in my opinion, Mr Henderson has provided no credible scientific evidence to support his claims that the CSG industry has been “proven” to be safe, or that local CSG and CSG waste water contain no benzene or any other dangerous substances, and are fit for human, animal and agricultural use with minimal processing. I do not know why Mr Henderson claimed that CSG compressor stations and processing plants in the Northern Rivers would not produce the documented pollution created by CSG processing in Queensland. I do not understand why Mr Henderson believes that Northern Rivers’ gas, wastewater, and CSG processing are uniquely “clean” with no potential to pollute.

Mr Henderson has not retracted any of his specific claims about the safety of the CSG industry in the Northern Rivers. It seems reasonable to expect that he could repeat these claims in the future while promoting his business.

As I understand Mr Henderson’s position, his compliance with a “plurality of approval processes and regulations” satisfies his obligations to provide evidence for his claims about the safety of local CSG operations.

Consequently, the Northern Rivers community will have to rely on the NSW Government to provide the scientific evidence that justifies the claims about safety that Mr Henderson presented as fact while promoting his CSG business to Kyogle’s Mayor.

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Appendix A

29 November 2013

Dr Wayne Somerville
Clinical Psychologist
PO Box 744
Kyogle, NSW 2474

Cc: Councillor Danielle Mulholland, Mayor - clrdanielle.mulholland@kyogle.nsw.gov.au

Dear Dr Somerville,

NSW and Northern Rivers residents need energy for heating, lighting and cooking in their homes and to power domestic appliances. We all need transport fuels and in the work place our jobs depend on reliable energy supplies to power equipment and to provide heating and cooling. Our lives depend on reliable energy supplies.

Natural gas from coal seams currently meets a third of eastern Australia’s gas supply needs and our industry has a proven and safe track record over a number of decades. Exports of natural gas from Australia are helping less developed countries to reduce the extent of air pollution and associated illness.

Communities deserve sensible and open debate about the best ways to achieve our energy needs and balance any potentially competing interests. Your exaggerated and incorrect comments do nothing to encourage such debate. They do no more than create unjustified fear.

Contrary to points you have previously raised, the safety of CSG and the broader oil and gas industry has been examined and demonstrated.

- **Methane is not toxic** As any science student knows, methane, the major component of coal seam gas, is a colourless, odourless gas and is not toxic. It is used for heating every day in hundreds of thousands of homes and in thousands of industries, without adverse health impacts. Methane is also produced naturally from many sources including compost heaps and cattle. Methane gas seeps naturally from the ground. People have been exposed to coal and hence coal seam gas for centuries. It has been liberated in considerable quantities from coal mines. This is not new.

- **Our coal seam gas is almost pure methane** The natural gas we produce from our coal seams is about 98% methane, with very small amounts of ethane (another colourless, odourless and non-toxic hydrocarbon gas), carbon dioxide and nitrogen. Gas chromatograph data for our coal seam gas shows virtually no hydrocarbons heavier than ethane. By inspection, there is absolutely no reason for concern in terms of metals, volatile organics or BTEX chemicals. For your information, the gas we found in our Kingfisher exploration well (a conventional gas field) has a similar composition to our CSG. It has a little more ethane and propane than our CSG but gas chromatograph data shows hydrocarbons no heavier than pentane and, again by inspection, provides no reason for concern.

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Our coal seam gas meets specifications for sales gas, it does not need to be treated to be sold into the gas market. It might need to have small quantities of water removed to be distributed in a large pipeline system.

Our gas quality data is consistent with measurements of CSG water quality. A thorough analysis of our CSG produced water shows that it meets Australian Drinking Water Guidelines, apart from its salt levels, which are about 1/10 of the level in sea water. Bioassay (acute toxicity) testing has provided further and broader confirmation that the CSG water is not toxic. We have a range of studies to demonstrate that our water, after some salt removal, is suitable for irrigation. It is suitable for stock watering, even without salt removal.

Should you wish to explore the wealth of data that is available on websites you will find that gas produced from other Australian coal seams is also primarily methane, with very low concentrations of any hydrocarbons heavier than ethane. For example, we draw your attention to AGL’s Environmental Health Impact Assessment – Camden Northern Expansion Project, 30 October, 2013, provides further information to support high methane levels and correspondingly low levels of heavier hydrocarbons in its gas. Again, by inspection, there is no reason for concern about volatile organic compounds, BTEX or metals. This information can be found on the AGL website.

Your comment “When we export coal we do so with its impurities. But with gas the impurities are taken out here and they are dumped on the environment and the local community” is simply incorrect and unnecessarily alarmist. The air emissions you quote for Queensland CSG operations are mainly from engine exhausts, no different in nature from any other engine exhausts, including cars, tractors and farm equipment. The emissions are not “impurities” removed from the gas.

- The people most exposed to petroleum are healthy

The people probably most exposed to hydrocarbon gases and liquids, including substances such as BTEX which are naturally found in crude oil, are those who work in oil refineries and conventional natural gas processing plants. The AIP Health Watch program, which has been in operation since 1980 and is run by Monash University, shows that workers in the petroleum and natural gas production industry have better health than the general Australian community and are less likely to die of the diseases commonly causing death - including cancer, heart and respiratory conditions. You can find more about this at:


The following Queensland Government website provides details about BTEX exposure sources and levels.


- CSG has operated in Australia for nearly 20 years without health problems AGL’s CSG project at Camden, on the outskirts of Sydney, has been operating safely for nearly 13 years with 144 wells drilled in the Macarthur Region.

CSG in Australia has operated in Australia for nearly 20 years, without any health concerns. There are now about 4000 wells drilled, without health concerns.

In March, 2013, the Queensland Government published a report which assessed health complaints from the Tara area and concluded that the available evidence does not support the concern among some residents that excessive exposure to emissions from CSG activities is the
cause of the symptoms reported. To quote from the Darling Downs Public Health Unit report, one of the reasons for dismissing a link between CSG and reported health problems is

"the lack of evidence of employees working within the CSG industry having similar symptoms. If community members were experiencing symptoms due to CSG activities, it would be highly likely for workers in the industry to be reporting similar and probably more severe effects due to their likely much higher exposure."

The Queensland Government report highlighted concerns with Tara drinking water because it was contaminated by faecal matter, not hydrocarbons.

- The industry is heavily regulated and there are numerous studies to demonstrate health and safety

The CSG and petroleum industry is heavily regulated and must pass stringent health, safety and environmental checks before developments can proceed.

There are numerous studies available to show that CSG operations represent a low health risk to the community. We recommend that you take the time to read the huge amount of material that is available to the public in relation to the Queensland CSG projects and to AGL’s recent Camden Northern Expansion Project Environmental Health Impact Assessment. AGL’s study, which covers the full spread of potential health risks, concludes that its proposed Camden Northern Expansion would have posed low and acceptable risks to community health and to air, groundwater and surface water. You should also be aware of the recent Public Health England report which found that shale gas extraction emissions are a low to risk to public health.

Dr Somerville, the comments you have made in the media and in your report “CSG and Your Health” demonstrate that you have little understanding of the CSG industry and the technical and safety issues involved. Your comments about catastrophic health impacts do nothing for your credibility.

The community deserves intelligent, informed debate, not alarmist comments.

Yours sincerely

Peter J Henderson
Managing Director and CEO
24 January 2014

Dr Wayne Somerville
Clinical Psychologist
P.O. Box 744
Kyogle, NSW 2474

Dear Dr Somerville,

Thank you for the opportunity to read your latest paper (Is CSG safe, A Public Debate in the Interests of Community Health) and comment.

We are disappointed that you continue to exhibit a poor understanding of the petroleum industry and the approval and regulatory processes that we must comply with. More importantly, you continue to maintain an alarmist position when you conclude that “there is high probability of potentially catastrophic health impacts for operating gas fields in populated areas”. This position has no credibility whatsoever.

By inspection, any reasonable person can look at the data and conclude that there is no substance to your position. Apart from the succinct response we made to your first paper, please note that:

- The oil and gas industry has operated on a large scale all around the world for more than 100 years – it is not new or unusual.

- In the USA there are currently more than 1,000,000 producing oil and gas wells. These wells produce the full range of hydrocarbons (oil and gas), not just methane. {Our CSG wells produce essentially just methane. Methane is not toxic. It occurs naturally and is also produced from compost bins and cows. People are exposed to it as part of their everyday lives.}

- These USA oil and gas wells have been drilled in rural areas and in areas much more highly populated than the exploration licences we have in the Northern Rivers region.

Where is the catastrophic health impact associated with all these USA wells? The answer is that there is no catastrophic health impact.

A similar review of the 4000 CSG wells drilled in Queensland over the past 20 years also shows that there is no health concern.

NSW has a plethora of approval processes and regulations that Metgasco and other gas exploration and production companies must comply with if we are to explore and develop gas.

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The processes and regulations allow and promote community participation and awareness and are designed to ensure that health, safety and environmental risks are managed acceptably. We will continue to work within this approval and regulatory environment. We are also committed to transparency and community consultation and will continue to discuss safety, health and environment issues accordingly. We are not, however, willing to participate in the poorly managed public discussions that have occurred in the Northern Rivers over recent years. Instead, we ask you to respect the approval and regulatory processes that exist and to participate in the associated review processes. If you are not happy with them you should approach the relevant NSW government ministers and justify changes to the processes and regulations.

As a final comment, we note that your paper refers to the “healthy worker effect” and the association between unemployment and lower health status and higher mortality rates. If you are genuinely interested in the health of the Northern Rivers people, shouldn’t you be promoting an industry that provides secure employment and income security for landholders? Surely, job security, supplementary income for farmers and a reliable energy supply go a long way to reducing stress, more than offsetting any discomfort associated with change.

Yours sincerely

Peter J Henderson
Managing Director and CEO

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