PO Box 173 Bangalow
NSW 2479 Australia
info@ntn.org.au

BRIEFING PAPER

Hydraulic Fracturing in Coal Seam Gas Mining: The Risks to Our Health, Communities, Environment and Climate

Prepared by: Dr Mariann Lloyd-Smith and Dr Rye Senjen

April 2011

A Moratorium on Hydraulic Fracturing Chemicals

The National Toxics Network (NTN) calls on federal and state governments to implement a moratorium on the use of drilling and fracturing chemicals ('fracking chemicals') used in the hydraulic drilling and fracturing of coal gas seams and gas shale extraction, until the fracking chemicals have been fully assessed for their health and environmental hazards by the industrial chemicals regulator, the National Industrial Chemical Notification and Assessment Scheme (NICNAS).

NTN's review has found that only 2 out of the 23 most commonly used fracking chemicals in Australia have been assessed by NICNAS. Neither of these 2 chemicals were specifically assessed for their use in hydraulic drilling and fracking.

NTN demands that a comprehensive hazard assessment is carried out for all fracking chemicals used in Australia, including their impacts on human health, their ecotoxicology and environmental fate (air emissions; releases to groundwater and watercourses), as well as a full costing of the long term public burden of the cleanup and remediation of contaminated areas and the impact on the increased landfill capacity needed to deal with the waste products created by these mining methods.

What is Hydraulic Fracturing?

Hydraulic fracturing or 'fracking' is the practice of using high-pressure pumps to inject a mixture of sand, water and chemicals into bore wells in order to fracture rocks and to open cracks ('cleats') present in the coal seams thereby releasing natural gas in the process. A well can be repeatedly 'fracked'.

The social and environmental impact of fracking is an emerging issue of concern around the world, including Australia. It has received widespread community attention in the USA, particularly since the release of the documentary film Gasland[1] and, it is also emerging as an important issue in Europe.

The social and environmental impacts of fracking cut across many issues including: climate change; sustainable/renewable energy; hazardous waste disposal; air, soil and water pollution; and land and water use.

[1] See www.gaslandthemovie.com and www.gasland.com.au

Coal Seam Gas Exploration and Extraction in Australia

With the realities of climate change/chaos upon us, the scramble for sustainable energy sources is rapidly expanding. One potential source of energy in the Australian context is the extraction of gas from coal seam gas (CSG), shale gas, basin-centered gas and tight gas.

Until recently this these types of gas were too expensive to extract and too difficult to produce, but technological innovations such as 'fracking' have made this gas accessible and commercially viable.

Some commentators have compared this 'unconventional' gas extraction to a new gold rush and a way to ensure our energy future. It's estimated that up to 80% of all natural gas wells in the next 10 years will use fracking.[2]

CSG largely consists of methane and is bonded to the surface of coal particles. In comparison, natural gas is found in the space between grains of sandstone or similar types of rock.[3] CSG typically contains very small amounts of other hydrocarbons (propane, butane).

While the interest in CSG stems from its high content of methane, it can also contain carbon dioxide (CO_2), and the amount of CO_2 can vary dramatically. For instance, the Illawarra Coal Measures in NSW may even contain predominantly carbon dioxide.[4] This raises critical questions about CSG and its validity as a 'clean' source of energy for the future.

Australia's coal basin deposits, particularly in Queensland and NSW, contain large resources of CSG. Explorations are also occurring in the Perth and Tasmanian basins. It is estimated that together, these deposits will be larger than the combined conventional gas deposits of Bass Strait, the Cooper Basin and the North West Shelf.[5]

There are already a number of coal seam gas projects in Australia, chiefly in the Surat-Bowen basin in Queensland, but also in NSW. To give an indication of the scale of the proposed operations up to 20,000 - 40,000 wells could be drilled in the Surat and Bowen Basins in the next 20 years alone.[6,7]

By October 2010 there were a reported 72 mining projects at an advanced stage, an increase of 21% since May 2010. Not all of these are CSG deposits, but they do include the development of BG Group's $15 Billion Queensland Curtis Island LNG

[2] Hydraulic Fracturing for Natural Gas Development, Investor Environmental Health Network 2011 IEHN http://iehn.org/overview.naturalgashydraulicfracturing.php

[3] Clark, A. (Dec 2010). Millionaires: not in our backyard. Australian Financial Review (AFR). Available at: http://www.afr.com/p/national/millionaires_not_in_our_backyard_E3sB01Jq0IRg0cYNsu4zvI

[4] Coal bed methane- factsheet, Australian Mining Atlas. Available at http://www.australianminesatlas.gov.au/education/fact_sheets/coal_bed_methane.jsp

[5] Ibid.

[6] Queensland Government announces gas enforcement team. ABC Rural 23/11/2010. Available at http://www.abc.net.au/rural/news/content/201011/s3074371.htm

[7] Growing concern over coal gas seam plant. ABC Tropical ABC Tropical 23/11/2010. Available at: http://www.abc.net.au/news/stories/2010/11/23/3073726.htm?site=tropic

facility, which draws on CSG deposits.[8] The plant will take coal seam gas from the Surat Basin and pipe it to Gladstone to be super-cooled to create Liquefied Natural Gas (LNG).[9]

Another project in Gladstone was approved in November 2010. The Australia Pacific LNG project is a joint venture between Origin and ConocoPhillips and is also proposing a coal seam gas (CSG) to liquefied natural gas (LNG) plant. It will involve the construction of a 450km gas transmission pipeline from the coal seam gas fields to an LNG plant in Gladstone, which will have a processing capacity of up to 18 million tonnes per annum.[10]

The financial, political and environmental stakes are high. In November 2010 the federal Minister for Sustainability, Environment, Water, Population and Communities approved $35 billion worth of coal gas seam projects in Queensland alone, despite his own Department voicing concerns about the potential serious environmental implications of the projects to the Great Artesian Basin and the Murray-Darling basin.[11,12] The Water Group expressed significant concerns about "the general level of uncertainty associated with these proposals, and the inability of proponents to accurately quantify their individual and collective impacts over the life of their projects." *For a list of companies actively exploring and/or extracting CSG in Australia see Appendix 1.*

Shale Gas

Shale gas is another unconventional gas and is the type of gas that has fuelled the natural gas boom in the USA in the past decade. Interest in this type of gas has spread worldwide with exploration and drilling occurring in Asia, Europe and also Australia.

Shale gas is also produced by fracking. Shale is a fine-grained, sedimentary rock, which is essentially a mix of flakes of clay minerals and tiny bits of other minerals, especially quartz and calcite. The environmental issues associated with shale gas production are similar to CSG fracking.

Beach Petroleum has commenced exploratory drilling for shale gas in the Cooper Basin, South Australia.[13]

---

[8] Clark, A. (Dec 2010). Millionaires: not in our backyard. AFR Available at: http://www.afr.com/p/national/millionaires_not_in_our_backyard_E3sB01Jq0IRg0cYNsu4zvI

[9] BG Group and Coal Seam Gas. Available at: http://www.bg-group.com/OurBusiness/OurBusiness/Pages/BGGroup_and_CoalSeamGas.aspx

[10] Media Release, Australian Pacific LNG project. Available at: http://www.originenergy.com.au/files/APLNG_EIS_20101109.pdf

[11] WATER GROUP ADVICE ON EPBC ACT REFERRALS (QGC referral - 2008/4399, Santos-Petronas referral - 2008/4059 and comments on AP LNG referral - 2009/4974 September 201; Also see http://www.smh.com.au/environment/energy-smart/windsor-plans-new-coal-seam-gas-rules-to-protect-water-20101205-18lej.html

[12] Clark, A. (Dec 2010). Millionaires: not in our backyard. AFR Available at: http://www.afr.com/p/national/millionaires_not_in_our_backyard_E3sB01Jq0IRg0cYNsu4zvI

[13] See www.beachenergy.com.au

Is CSG a Sustainable Source of Energy?

The real environmental and social costs of CSG extraction have not been adequately assessed. According to a recent Cornell University assessment, "Natural gas obtained by the controversial technique of hydraulic fracturing may contribute significantly to greenhouse gas emissions and so should not be considered as a cleaner alternative to coal or oil."[14]

Fracking chemicals have not been adequately assessed for their health and environmental effects and there is a growing concern that they may have significant negative impacts on the environment and surrounding communities. For instance, toxic spills can occur, and air, soil and water may also be polluted with fracking chemicals as a by-product of the CSG extraction process. Contamination of drinking and irrigation water and the destruction of productive farmland are also significant issues that concern the community.

What is BTEX?

BTEX stands for benzene, toluene, ethylbenzene, xylene. BTEX compounds can contaminate soil and groundwater. BTEX are commonly found in the products used in the drilling stage of hydraulic fracturing. BTEX are also components of the volatile compounds found in the coal gas seams. The fracking process itself can release BTEX from the natural-gas reservoirs, which may allow them to penetrate into the groundwater aquifers or volatilise into air. As a consequence people may be exposed to BTEX by drinking contaminated water, breathing contaminated air or from spills on their skin.[15]

BTEX chemicals are hazardous in the short term causing skin irritation, central nervous system problems (tiredness, dizziness, headache, loss of coordination) and effects on the respiratory system (eye and nose irritation). Prolonged exposure to these compounds can also negatively affect the functioning of the kidneys, liver and blood system. Long-term exposure to high levels of benzene in the air can lead to leukemia and cancers of the blood.[16]

In October 2010, traces of BTEX chemicals were found at an Arrow Energy fracking operation in Queensland. Arrow Energy confirmed that benzene, toluene, ethylbenzene and xylene had been found in well water associated with its coal-seam gas operation at Moranbah, west of Mackay[17].

An underground coal gasification project, a joint venture between Origin and the multinational ConocoPhillips, near Kingaroy Queensland, was also temporarily shut down when benzene and toluene were detected.[18]

---

[14] Robert Howarth (2010) Preliminary Assessment of the Greenhouse Gas Emissions from Natural Gas obtained by Hydraulic Fracturing, http://www.damascuscitizens.org/GHGemissions_Cornell.pdf

[15] Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Interaction Profile for Benzene, Toluene,Ethylbenzene and Xylene (BTEX). U.S. Department of Health and Human Services, Public Health Service.

[16] Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Interaction Profile for Benzene, Toluene,Ethylbenzene and Xylene (BTEX). U.S. Department of Health and Human Services, Public Health Service.

[17] Contamination fear fails to stop project, http://www.theaustralian.com.au/national-affairs/contamination-fear-fails-to-stop-project/story-fn59niix-1225950389968

[18] Cancer chemical found at western Queensland gas site, http://www.couriermail.com.au/business/cancer-chemical-found-at-gas-site/story-e6freqmx-1225940922665

Queensland has banned the use of BTEX chemicals in fracking fluids. The NSW Government recently announced it would examine banning the use of BTEX chemicals in 'situations which may pose risk to groundwater'.[19]

Are Fracking Fluids Safe?

"Chemicals are used at most stages of the drilling operation to reach and release the natural gas from gas coal seams – to drill the bore hole, to facilitate the actual boring, to reduce friction, to enable the return of drilling waste to the surface, to shorten drilling time, and to reduce accidents. After drilling has been completed, hydraulic fracturing is used to release the trapped gas by injecting approximately 2.5 million litres or more of fluids, loaded with toxic chemicals, underground under high pressure."[20]

Fracking fluid consists of water, sand and chemicals that are combined and injected into the coal seam at high pressure. The fracking fluid includes chemicals and additives that aid the fracturing process (e.g. viscosifiers, surfactants, pH control agents) as well as biocides that inhibit biological fouling and erosion.

Many of the chemicals and compounds that make up fracking fluids are either acutely toxic or have chronic toxicity to humans, animals and/or the environment. Companies argue that the full identity and composition of fracking fluids cannot be publicly disclosed as the information is a trade secret and involves commercial-in-confidence data.

A recent paper on the use of fracking chemicals[21] lists nearly a thousand products involved in natural gas operations (including CSG) in the USA, but only a small percentage have CAS Registry Numbers [22] listed on Material Safety Data Sheets (MSDS). Without a CAS number it is very difficult to search for health and environmental data about a chemical.

MSDS are also a limited source of information as they often only provide rudimentary human health data and little, if any, information on the environmental fate of the chemical or its effects on the environment and ecosystems. *For more information on MSDS see Appendix 2.*

In 2010, a coal seam gas-drilling site near Lismore NSW, run by Metgasco, was permitted to use fracking after supplying only a generic list of hazardous materials safety guidelines.[23]

[19] Tough New Rules for Coal Seam Gas Exploration 19.12.2010 News Release, Premier of NSW

[20] Theo Colborn, Carol Kwiatkowski, Kim Schultz, Mary Bachran, Natural Gas Operations from a Public Health Perspective, *International Journal of Human and Ecological Risk Assessment,* September 4, 2010. Available at:http://www.endocrinedisruption.com/files/NaturalGasManuscriptPDF09_13_10.pdf

[21] ibid

[22] CAS registry numbers are unique numerical identifiers assigned by the Chemical Abstracts Service to every chemical described in the open scientific literature.

[23] http://www.smh.com.au/environment/toxins-found-at-third-site-as-fracking-fears-build-20101118-17zfv.html

Are Fracking Chemicals 'Household Chemicals'?

Industry representatives often claim that fracking chemicals are safe because they are similar to 'food additives' and are used in 'household products'. NTN believes these claims are misleading for several reasons. Firstly, there has been no comprehensive hazard assessment of the chemical mixtures used in fracking fluids and their impacts on the environment or human health. A number of the chemicals used in fracking fluids would never be permitted as food additives or in household products due to their toxicity. Industry secrecy about fracking fluids means it is impossible to know exactly what chemicals are being used in order to assess their safety (See Tables 1 & 2 below).

An analysis of the available environmental health data for 980 chemical products used in the gas industry in the USA found that [24]:

- A total of 649 chemicals were used in the 980 products. Specific chemical names and CAS numbers could not be determined for 286 (44%).

- Less than 1% of the total composition of the product was reported on the MSDS for 421 of the 980 products (43%), less than 50% of the composition was reported for 136 products (14%), and between 51% and 95% of the composition was reported for 291 (30%) of the products. Only 133 products (14%) had information on more than 95% of their full composition.

Using health data identified on the MSDS, in government toxicological reports, and in the medical literature, health effects were identified for the remaining 362 chemicals with CAS numbers:

- Over 78% of the chemicals are associated with skin, eye or sensory organ effects, respiratory effects and gastrointestinal or liver effects. The brain and nervous system can be harmed by 55% of the chemicals. Symptoms include burning eyes, rashes, coughs, sore throats, asthma-like effects, nausea, vomiting, headaches, dizziness, tremors, and convulsions.

- Between 22% and 47% of the chemicals were associated with possibly longer-term health effects such as cancer, organ damage, and harm to the endocrine system.

- 210 chemicals (58%) are water-soluble while 131 chemicals (36%) are volatile; i.e., they can become airborne. Because they can be inhaled, swallowed, and also reach the skin, the potential for exposure to volatile chemicals is greater.

- Over 93% of the volatile chemicals can harm the eyes, skin, sensory organs, respiratory tract, gastrointestinal tract or liver, 86% can cause harm to the brain and nervous system, 72% can harm the cardiovascular system and blood, and 66% can harm the kidneys.

---

[24] Chemicals in Natural Gas Operations, Health Effects Spreadsheet and Summary TEDX 2011, Available at http://www.endocrinedisruption.com/chemicals.multistate.php.The Endocrine Disruption Exchange (TEDX) maintains a publicly available database of the potential health effects of chemicals used during natural gas operations. It is available for download in an Excel file format for easy searching and sorting

No Australian Assessment of Fracking Chemicals

Australia's industrial chemical regulator, the National Industrial Chemical Notification and Assessment Scheme (NICNAS), has assessed only 2 out of the 23 most commonly identified compounds used in fracking fluids in Australia. Yet, hydraulic fracturing in Australia involves very large quantities of fracking fluids.

Environmental authorisations by Queensland regulators identified that in one CSG operation, approximately 18,500kg of additives were to be injected during the hydraulic fracturing process in each well, with only 60% recovered and up to "40% of the hydraulic fracturing fluid volume would remain in the formation, and this would correspond to 7,400kg of chemicals per injection well".[25]

Table 1. Chemicals Used in Fracking Fluids in Australia

Note: This list of chemicals and their uses was consolidated from the MSDS provided by gas companies and verified by industry sources.

Additive Type	Main Compound(s)	Purpose
Diluted Acid	Hydrochloric Acid, muriatic acid	Dissolves minerals
Biocides	Glutaraldehyde, Tetrakis hydoxymethyl phosphonium sulfate /THPS	Eliminates bacteria in water
Breaker	Ammonium persulfate/ sodium persulfate	Delayed break gel polymer
Corrosion Inhibitor	n,n-dimenthyl formamide, mixtures of methanol, naphthalene naptha, nonyl phenol and secret data	Asset protection
Friction Reducer	Mineral oil	Reduces friction
Gel	Guar gum	Thickens water
Iron Control	Citric acid	Prevent metal oxides
KCl	Potassium chloride	Brine solution
pH Adjusting Agent	Sodium or potassium carbonate	Maintains pH
Scale Inhibitor	Ethylene glycol	Prevents scale deposits in pipe
Surfactants	Isopropanol	Affects viscosity of fluid
Crosslinker	Ethylene glycol	Viscosity of fracking fluid

[25] Coal Seam Hydraulic Fracturing Fluid Risk Assessment. Response to the Coordinator-General Requirements for Coal Seam Gas Operations in the Surat and Bowen Basins, Queensland. Golder Associates 21 October 2010

Table 2. NICNAS Status of Chemicals Used in Fracking Fluids

Note: The following list of chemicals and CAS numbers was compiled from MSDS provided by three companies involved in hydraulic fracturing in Queensland and NSW.

Chemical	CAS RN	AICS Status*
Tetramethylammonium Chloride	75-57-0	Pub/NA
Potassium carbonate	584-08-7	Pub/NA
Methanol	67-56-1	Pub/NA
Isopropanol	67-63-0	Pub/NA
Propargyl alcohol	107-19-7	Pub/NA
Formamide	75-12-7	Pub/NA
Ethoxylated 4-nonylphenol	26027-38-3	Pub/NA
Heavy aromatic naphtha	64742-94-5	Pub/NA
Pine oil	8002-09-3	Pub/NA
Naphthalene	91-20-3	Pub/NA; PEC Candidate list
Citric acid anhydrous	77-92-9	Pub/NA
Hemicellulase Enzyme Concentrate	9025-56-3	Pub/NA
Tetrakis(Hydroxymethyl) Phosphonium Sulphate	55566-30-8	Pub/NA
Sodium persulfate	7775-27-1	Pub/Ass; Declared PEC
Guar gum	9000-30-0	Pub/NA
Ethylene glycol	107-21-1	Pub/NA
Sodium hydroxide	1310-73-2	Pub/NA
Diethylene glycol	111-46-6	Pub/NA
2-Bromo-2-nitro-1,3-propanediol	52-51-7	Pub/NA
Alcohols, C12-14	80206-82-2	Pub/NA
Tris(2-hydroxyethyl) amine	102-71-6	Pub/NA; PEC Candidate list
2-Butoxyethanol	111-76-2	Pub/Ass; Declared PEC
Cristobalite (silica)	14464-46-1	Pub/NA

*AICS = Australian Inventory of Chemical Substances; Pub = public AICS; NA = not assessed; Ass = assessed; PEC = priority existing chemical

Other chemicals listed in fracking chemical products without CAS Numbers include:

- Alkanes / Alkenes (Multiple CAS)
- Oxylalkylated alcohol(s)
- Fatty alcohol
- Oxylalkylated alkanolamine(s)
- Silicone(s)
- Surfactant(s)

Health and Environmental Risks of Some Fracking Chemicals

Note: The following information was compiled from publically available sources including International Program on Chemical Safety, INCHEM www.inchem.org, US Agency for Toxic Substances & Disease Register www.atsdr.cdc.gov, Material Safety Data Sheets and NICNAS literature. Health data and sources for 560 fracking chemicals is available for download at http://www.endocrinedisruption.com/chemicals.multistate.php

Tetrakis(hydroxymethyl)phosphonium sulfate (THPS)

Tetrakis(hydroxymethyl)phosphonium sulfate (THPS) acts as a biocide, that is a chemical that is toxic to the microorganisms and is used as anti-fouling agent. THPS has shown mutagenic potential (in vitro) and cancer potential in rats (NOAEL 3.6 mg/kg). Repeated skin exposure to THPS resulted in severe skin reaction and caused skin sensitization in guinea pigs. TPHS was also identified as a severe eye irritant in rabbits. [26] Little is known about the effects of the break down products of THPS. The reported acute toxicity values for algae are less than 1 mg/litre (NOEC 0.06mg/litre). No exposure information is available for either humans or organisms in the environment; hence no quantitative risk assessment has been made.[27]

Sodium Persulfate

Exposure to sodium persulfate via inhalation or skin contact can cause sensitization, i.e., after initial exposures individuals may subsequently react to exposure to very low levels of that substance. Exposure to sodium persulfate also causes skin rashes and eczema as well as allergies that may develop after repeated exposures. Sodium p. ersulfate is irritating to eyes and respiratory system and long-term exposure may cause changes in lung function (i.e. pneumoconiosis resulting in disease of the airways) and/or asthma.

Ethylene Glycol

Exposure to ethylene glycol via inhalation or skin contact can irritate the eyes, nose and throat. It is a human respiratory toxicant. Among female workers, exposures to mixtures containing ethylene glycol were associated with increased risks of spontaneous abortion and sub-fertility.[28] Ethylene glycol is a teratogen (i.e., an agent

[26] NTP Study Reports, Abstract for TR-296 - Tetrakis(hydroxymethyl)phosphonium sulfate (THPS) (CASRN 55566-30-8) and Tetrakis(hydroxymethyl)phosphonium chloride (THPC) (CASRN 124-64-1

[27] Environmental Health Criteria 218 Flame Retardants: TRIS(2-BUTOXYETHYL) PHOSPHATE, TRIS(2-ETHYLHEXYL) PHOSPHATE and TETRAKIS(HYDROXYMETHYL) PHOSPHONIUM SALTS United Nations Environment Programme, the International Labour Organisation, and the World Health Organization, and produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals. World Health Organization Geneva, 2000

[28] Adotfo Correa, Ronald H. Gray, Rebecca Cohen, Nathaniel Rothman, Faridah Shah, Hui Seacat and Morton Com, Ethylene Glycol Ethers and Risks of Spontaneous Abortion and Subfertility, American Journal of Epidemiology Vol. 143, Issue 7 Pp. 707-717.

that causes malformation of an embryo or foetus) in animal tests. Ethylene Glycol is on the U.S. EPA list of 134 priority chemicals to be screened as an endocrine disrupting substance (EDC).

2-Butoxyethanol

2-butoxyethanol was declared a Priority Existing Chemical (PEC) under Australia's regulatory National Industrial Chemicals Notification and Assessment Scheme.[29] The assessment of 2-butoxyethanol showed it is highly mobile in soil and water and has been detected in aquifers underlying municipal landfills and hazardous waste sites in the US. It is recommended that waste 2-butoxyethanol not be disposed of to landfill because of its high mobility, low degradation and its demonstrated ability to leach into and contaminate groundwater.

While high doses of 2-butoxyethanol can also cause reproductive problems and birth defects in animals, it is not known whether 2-butoxyethanol can affect reproduction or cause birth defects in humans. Animal studies have shown exposure to 2-butoxyethanol can cause hemolysis (destruction of red blood cells that results in the release of hemoglobin). The International Agency for Research on Cancer has not classified 2-butoxyethanol as to its human carcinogenicity as no carcinogenicity studies are available.

Ethoxylated 4-nonylphenol

Ethoxylated 4-nonylphenol (NPE) is a persistent bioaccumulative endocrine disruptor, which has been detected widely in wastewater and surface waters across the globe. Canada classified NPE metabolites as toxic.[30] The European Union classifies nonylphenol as very toxic to aquatic organisms, which may cause long-term adverse effects in the aquatic environment.[31] In the aquatic environment, NPE metabolites can cover organisms with a soap-like coating that inhibits them from moving and causes the organism to become stupefied and lose consciousness. NPE also disrupt normal hormonal functioning in the body and thus are considered endocrine disrupting chemicals. NPE mimics the natural hormone estradiol and binds to the estrogen receptor in living organisms. Exposure to NPE changes the reproductive organs of aquatic organisms.[32] Sexual deformities were found in oyster larvae exposed to levels of nonylphenol (NP) that are often present in the aquatic environment.[33] A 2005 study found that exposure to NP increases the incidence of breast cancer in lab mice.[34] The intermediary chemicals formed from the initial degradation of NPE are much more persistent than the original compound.

---

[29] Declared Priority Existing Chemical (PEC). Full report at www.nicnas.gov.au/Publications/CAR/PEC/

[30] Environment Canada 2001 Nonylphenol and its Ethoxylates: Priority Substance Lists Assessment Report. Minister of Public Works and Government Services

[31] European Union 4-Nonylphenol (branched) and Nonylphenol Risk Assessment Report. Institute for Health and Consumer Protection, European Chemicals Bureau Volume 10,

[32] Gray, M., and C. Metcalfe. 1997.Induction of Testis-Ova in Japanese Medaka (Oryzias Latipes) Exposed to p-Nonylphenol. *Environmental Toxicology and Chemistry*, No. 16, Issue 5, p. 1082.

[33] Nice, H., D. Morritt, M. Crane and M. Thorndyke. 2003. Long-term and Transgenerational Effects of Nonylphenol Exposure At a Key stage in the Development of Crassostrea gigas. Possible Endocrine Disruption? *Marine Ecology Progress Series,*Vol. 256, p. 293.

[34] Acevedo, R., P. Parnell, H. Villanueva, L. Chapman, T. Gimenez, S. Gray, and W. Baldwin. 2005. The Contribution of Hepatic Steroid Metabolism to Serum Estradiol and Estriol Concentrations of Nonylphenol Treated MMTVneu Mice and Its Potential Effects on Breast Cancer Incidence and Latency. *Journal of Applied Toxicology* Volume 25, Issue 5, pages 339–353, September/October 2005

Naphthalene

Based on the results from animal studies, which demonstrated nasal and lung tumours in lab animals, the International Agency for Research on Cancer (IARC) concluded that naphthalene is a possible human carcinogen, and the US Department of Health and Humans Services (DHHS) concluded that naphthalene is reasonably anticipated to be a human carcinogen.

Naphthalene causes lung toxicity in mice, either by injection or inhalation. Naphthalene can cause cataracts in humans, rats, rabbits and mice. Animal studies suggest that naphthalene is readily absorbed following oral or inhalation exposure. Although no data are available from human studies on absorption of naphthalene, the detection of metabolites in the urine of workers indicates that absorption does occur, and there is a good correlation between exposure to naphthalene and the amount of 1-naphthol excreted in the urine.

Humans accidentally exposed to naphthalene by ingestion develop haemolytic anaemia (damage or destruction of red blood cells). Symptoms of hemolytic anemia include fatigue, lack of appetite, restlessness, and pale skin. Exposure to large amounts of naphthalene may also cause nausea, vomiting, diarrhea, blood in the urine, and a yellow color to the skin.

Isopropanol

Isopropanol is reproductive toxin and irritant. It is a central nervous system depressant and prolonged inhalation exposure of rats can produce degenerative changes in the brain.[35]

Formamide

Formamide is a teratogen with the potential to affect the unborn child. The substance is irritating to the eyes and the skin and may cause effects on the central nervous system. It can be absorbed into the body by inhalation, through the skin and by ingestion. It is harmful by all exposure routes.

Other Risks Associated with CSG Fracking

There are other chemical risks associated with the extraction and production of coal seam gas. These include:

Ozone

Ozone is produced by fugitive emissions mixing with nitrogen oxides from the exhaust of diesel-driven, mobile and stationary equipment to produce ground-level ozone. Ozone combined with particulate matter less than 2.5 microns produces smog (haze). Gas field produced ozone in the USA has created a serious air pollution problem similar to that found in large urban areas, and can spread large distances (up to approx. 300km) beyond the immediate region where gas is being produced. [36]

[35] International Agency for Research on Cancer (IARC) - Summaries & Evaluations ISOPROPANOL
[36] The Endocrine Disruption Exchange http://www.endocrinedisruption.com/chemicals.introduction.php

Flare stacks and flare pits

Gas flare or flare stacks are used in gas wells (and chemical plants, landfills, oil wells etc.) to 'dispose' of waste gas. Flares act as a safety system to manage excess gas pressure and can be used in an emergency to help burn off excess gas. Gas flares contribute significantly to local air pollution and flares are a significant global contributor to greenhouse gas emissions (0.5% of all anthropogenic carbon dioxide emissions).[37] Over 250 toxins have been identified as being released from flaring including carcinogens such as benzopyrene, benzene, carbon di-sulphide (CS2), carbonyl sulphide (COS) and toluene; metals such as mercury, arsenic and chromium; sour gas with H2S and SO2; nitrogen oxides (NOx); carbon dioxide (CO2); and methane (CH4) which contributes to the greenhouse gases.[38]

Flare pits are the earthen pits constructed beneath the flare stacks to contain any fluids produced from the flaring of the gas associated liquid hydrocarbons and brine water. The soil surrounding these pits is typically hydrocarbon and salt contaminated. These fluids mix with other toxic chemicals and are hazardous to birds and wildlife. Wildlife may die from the inhalation of toxic hydrogen sulphide gas (if the flare igniter is faulty), or by direct incineration in the flare stack. At minimum, anti-perching devices for birds should be installed.[39]

Evaporation ponds

Extraction of CSG typically involves pumping the water used in the extraction process plus any associated fracking fluid into large ponds for evaporation. These ponds may cover a large area and will subsequently need to be remediated and rehabilitated. The water is typically saline and should the ponds fail (e.g. leak) surrounding soil quality and vegetation could be compromised or in the worst case destroyed. If pond liners fail, it could also contribute to aquifer contamination with chemicals and saline water. If ponds are flooded, their contaminants are released to surface water.

Evaporative ponds will inevitably result in the transfer of chemical pollutants into the atmosphere either in gas or particle phase.

Produced water

Gas companies in Australia are now developing and/or operating plants to treat the 'produced water' (for instance using reverse osmosis) and to on sell it to farmers for irrigation, domestic drinking water supply or cooling of power stations. However, reverse osmosis filtration has significant limitations and may not be successful in removing all contaminants.[40] The Queensland Gas Company (QGC) will open a water treatment facility in the Western Downs region in October 2011. The $350

---

[37] Global, Regional, and National CO2 Emissions. In Trends: A Compendium of Data on Global Change, Marland, G., T.A. Boden, and R. J. Andres, 2005, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

[38] Canadian Public Health Association, Background to 2000 Resolution No. 3 Available at http://www.climatelaw.org/cases/country/nigeria/cases/casedocuments/nigeria/report/section7/doc7.1.pdf

[39] See: http://www.fws.gov/mountain prairie/contaminants/contaminants1f.html Contaminant Issues - Oil Field Waste Pits. US Fish and Wilife serves

[40] See A. Bbdalo-Santoyo, J.L. Gbmez-Carrasco, E. Gbmez-Gbmez, M.F. M&&no-Martin, A.M. Hidalgo-Montesinos Spiral-wound membrane reverse osmosis and the treatment of industrial effluents. *Desalination* 160 (2004) 15 l-l 58: Also see Lianfa Song, J.Y. Hu, S.L. Ong, W.J. Ng, Menachem Elimelech, Mark Wilf Performance limitation of the full-scale reverse osmosis process. *Journal of Membrane Science* 214 (2003) 239–244

million facility will treat 100 megalitres of water used at the Chinchilla gas processing plant. It is unknown what the company will do with the 200 tonnes of salt produced a day, but a company representative has said, "Dumping it will be a last resort".[41]

Waste Water Management Permits

Permits are provided for the release of waste water produced in association with the fracking process. In one authorisation for one CSG company, [42] the release of treated water was authorised for a period of 18 months at a maximum volume of 20 ML per day. The receiving waters were the Condamine River. Over 80 chemical compounds plus radionuclides were permitted to be released and included a range of persistent, bioaccumulative toxic substances (eg 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.

Release limits were included for the listed compounds however, the majority could not based on the ANZECC water guidelines [43] as many were not listed in the guidelines or were marked as having insufficient data to set a water quality guideline. [44]

While follow up monitoring was required by the authorisation, the current National Water Quality Management Strategy (NWQMS)[45] recommends moving away from relying solely on chemical specific guidelines coupled with water quality monitoring to an integrated approach using direct toxicity assessment (toxicity bioassays) and biological monitoring. Neither of these are these required by the authorisation.

An assessment of cumulative loads of a selection of compounds is presented in Table 3.

[41] Farms to get treated coal seam gas water, Sam Burgess and Fidelis Rego ABC News 2911/2010 Available http://www.abc.net.au/news/stories/2010/11/29/3079368.htm

[42] Schedule C, Australian Pacific LNG Pty Ltd Environmental Authority (petroleum activities) No PEN100067807

[43] http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality

[44] The authors note that the Australian Centre for Mining Environmental Research, an industry consultancy has published their own list of TRIGGER VALUES FOR TOXICANTS in the document; Batley, GE, Humphrey CL, Apte SC and Stauber JL (2003). A Guide to the Application of the ANZECC/ARMCANZ Water Quality Guidelines in the Minerals Industry. (Australian Centre for Mining Environmental Research: Brisbane). However, the document is not in the public domain hence the trigger values, the data used or the methodology cannot be assessed.

[45] http://www.environment.gov.au/water/policy-programs/nwqms/

Chemical compound	Release rate/day	Total (release rate x 20ML x 547.5 days / 18 months)
BPA	200g/ML	2,298KG (2.298 tonnes)
Bromide	7,000g/ML	76,650KG (76.65 tonnes)
Total Chlorobenzenes	1,840g/ML	20,148KG (20.148 tonnes)
Monochloramine	3,000g/ML	32,850KG (32.85 tonnes)
Nitrate	50,000g/ML	5,475,000KG (5,475 tonnes)
Uranium	20g/ML	219KG
Toluene	800g/ML	8,760KG (8.76 tonnes)
Xylene	600g/ML	6,570KG (6.57 tonnes)
Ethylbenzine	300g/ML	3,285KG (3.285 tonnes)
Benzene	1g/ML	10.95KG
Cyanide	80g/ML	876KG
Lead	10g/ML	109.5KG

Hazardous waste disposal

Concentrated hazardous wastes from evaporation ponds need to be disposed of to an appropriate licensed facility. This will add significant demands on regional waste management capacity (e.g. landfills).

Radioactive tracers

Radioactive tracers are used with various types of propane that include resin coated sand and man made ceramics (eg polymers, nanomaterials) which can be retained in the produced water.

Risk Assessments and the Effects of Fracking Fluids and Chemical Impacts of Hydraulic Fracturing

The Queensland Environmental Protection Act of 1994 (S310D) calls for companies to provide a complete inventory of chemicals, full toxicity data including mixture toxicity and a risk assessment. Relevant authorities acknowledge however that not all chemicals can be assessed because some are commercial secrets, and even those that are disclosed, have very little data available.

Risk assessments of Hydraulic Fracturing have generally failed to include adequate assessment of:

- Air emissions produced by fracturing chemicals in their use phase;
- air emissions from evaporative ponds;
- emissions and releases from gas flares/pits

- the impact of the release of BTEX from the coal seam;
- the impact of potential break down products fracking chemicals intermediates;
- endocrine disrupting potential (of concern as impacts occur at very low levels);
- combined effect of the complex mixture of chemicals on the environment, especially water contamination; and
- the lack of life cycle assessment of fracking fluids.

APPENDIX 1.

Some of the companies actively exploring and/or extracting CSG in Australia include:

Note: this is an indicative list of companies at the time of writing. Companies may cease exploration or expand exploration as required. [46,47]

- Santos Ltd - Surat and Bowen Basins
- Origin Energy - Surat and Bowen Basins
- Westside corporation (http://www.westsidecorporation.com/) - Bowen Basin.
- Queensland Gas Company - Surat Basin
- Sunshine Gas Ltd - Surat and Bowen Basins
- Arrow Energy NL - Surat and Bowen Basins, Clarence-Moreton Basins
- Molopo Australia Ltd - Gloucester, Bowen and Clarence-Moreton Basins
- Blue Energy Pty Ltd - Bowen, Surat and Maryborough Basins
- Magellan Petroleum Australia - Maryborough Basin
- Red Sky Energy - Clarence-Moreton Basins
- Metgasco Ltd - Clarence-Moreton Basin
- AGL(agl.com.au): Glouchester Basin
- Sydney Gas Ltd - Sydney Basin
- Eneabba Gas Ltd - Perth Basin
- Pure Energy Resources Ltd - Bowen, Duaringa, Surat and Tasmania Basins
- Comet Ridge Ltd - Bowen, Galilee and Gunnedah Basins
- Planet Gas Ltd - Gippsland, Eromanga, Wilochra, Gunnedah and Otway Basins
- Eastern Star Gas – Otway Basin, Gunnedah Basins (Narabi Coal Seam project)
- Westralian Gas and Power Ltd - Perth, Collie and Wilga Basins
- Central Petroleum Ltd - Pedirka Basin
- Rey Resources Ltd - Canning Basin
- Red Sky Energy – numerous basins In NSW, Northern Territory and Queensland are being explored

[46] Coal bed methane- factsheet, Australian Mining Atlas Available at http://www.australianminesatlas.gov.au/education/fact_sheets/coal_bed_methane.jsp
[47] Coal Seam Gas Factsheet. Australian Mining Atlas Available at http://www.australianminesatlas.gov.au/education/fact_sheets/coal_seam_gas.jsp

APPENDIX 2: MSDS Supplementary Information

To download *The National Code of Practice for the Preparation of Material Safety Data Sheets* go to: www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Pages/CP2003MaterialSafetyDataSheets2ndEdition.aspx

Material Safety Data Sheets (MSDS)

The MSDS National Code

The National Occupational Health and Safety Commission (NOHSC) has produced *The National Code of Practice for the Preparation of Material Safety Data Sheets*, 2nd Edition 2003, which has been adopted as a Code of Practice under some state legislation. The application of the code is the prerogative of that State or Territory. MSDS are controlled by the hazardous substances and dangerous goods Acts in each state and territory.

(*The Workplace Health and Safety Regulation 2008* and the *Workplace Health and Safety Act 1995* provide a framework for managing health and safety risks in Queensland workplaces. The regulation sets out the legal requirements to prevent or control certain hazards, which might cause injury or death in the workplace.)

While an MSDS is not required for substances not classified as hazardous, there is often a legislative requirement to provide hazard information.

Hazardous Substances

The Code applies to hazardous substances and dangerous goods.

"A material is classified as hazardous and/or dangerous if it is:

(a) classified as hazardous according to the latest edition of the NOHSC *Approved Criteria for Classifying Hazardous Substances* [NOHSC:1008] and is above the cut-off concentration criteria for being classified as a hazardous substance;

(b) specified in the NOHSC *List of Designated Hazardous Substances* [NOHSC:10005];

(c) classified for physicochemical hazards according to the ADG Code (including class(es), subsidiary risk(s), Packing Group, Proper Shipping Name and UN Number); and/or

(d) specified as dangerous in the ADG Code or determined by the Competent Authorities. "

Under the code, Australia MSDS are based on 16 part data sheet, all sections of an MSDS need to be completed. Where information relevant to a particular section is not available, the MSDS should state 'Not available'.

Acceptability of Overseas MSDS

Currently, MSDS prepared overseas are accepted by Commonwealth, State and Territory legislation if they meet the following requirements:

The MSDS is prepared in accordance with this code including the provision of the following information:

(i) Australian contact details – name of supplier, address and telephone number, including emergency contact details (see section 6.1);

(ii) classification in accordance with the Australian hazardous substance and Dangerous Goods regulatory framework

(iii) ingredient disclosure as required by Commonwealth, State and Territory legislation (see section 6.3);

(iv) national exposure standard value if available (see section 6.8); and

(v) relevant additional Australian regulatory information (see section 6.15).

New Zealand is in the process of harmonizing their MSDS with Australia. Their MSDSs also adhere to the 16 sections and are based on the UN GHS classification. Overall, they are a much more detailed and useful documents.

MSDS must be updated or reviewed:

- whenever there is new information on changes to hazardous properties of the product;
- whenever there is a formulation change;
- often enough to keep it up to date; and
- at least every five years.