NATIONAL TOXICS NETWORK

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

www.ntn.org.au Working globally for a toxic free future

WA Parliamentary Standing Committee on Environment and Public Affairs

REPORT 33: INQUIRY INTO THE IMPLICATIONS FOR WESTERN AUSTRALIA OF HYDRAULIC FRACTURING FOR UNCONVENTIONAL GAS

This joint submission has been prepared by:
Dr Mariann Lloyd-Smith and Joanna Immig for the National Toxics Network Inc. and Jane Bremmer for the Alliance for a Clean Environment Inc.

Alliance for a Clean Environment

Promoting Community Right to Know and Environmental Health and Justice in WA

National Toxics Network Inc.
The National Toxics Network (NTN) was established in 1993 and has been granted charity status. It is a community-based network of experts working on a wide range of toxic chemical pollution issues across the Australasian and Pacific region, as well as internationally. NTN representatives sit on a range of national advisory bodies and community consultative committees in relation to international chemical conventions, hazardous waste, contaminated sites, industrial, agricultural and veterinary chemical regulation.

NTN is the Australian focal point for the International Persistent Organic Pollutants Elimination Network (IPEN) and also participates in the work of the International Pesticide Action Network (PAN). NTN is a member group of the Climate and Health Alliance (CAHA) and the Lock the Gate Alliance. NTN representative helped to organise and presented at the OECD *Special Session on Chemicals used and Released in Unconventional Gas Activities* held in Paris in November 2012 for national government regulators.

For further details about the National Toxics Network please visit www.ntn.org.au

Dr Mariann Lloyd-Smith
Dr Mariann Lloyd-Smith, NTN Advisor on UG is a Director of the research group, BioRegion Computer Mapping & Research Pty Ltd (BRCM) and the Senior advisor to the International NGO IPEN, a public interest chemical safety network, representing 800 organisations in over 100 countries.

Mariann gained her PhD from the Faculty of Law at the University of Technology (UTS), Sydney and has worked in the area of chemicals policy and waste management for over two decades. Mariann has published widely on chemical issues and as a member of the National Advisory Body on Scheduled Waste, was a coauthor of Australia's national management plans for POPs waste.
Dr Lloyd-Smith was a member of the UN Expert Group on Climate Change and Chemicals and co-authored NTN's report on the chemical impacts of hydraulic fracturing in the Australian shale and coal seam gas industry. Dr Lloyd-Smith was guest speaker on unconventional gas in both the Scottish and UK Houses of Parliament and at the launch of the Extreme Energy Initiative of London University Human Rights Consortium
For further information contact Dr Mariann Lloyd-Smith: biomap@oztoxics.org

Foreword

The National Toxics Network welcomes the WA Parliamentary Standing Committee on Environment and Public Affairs decision to *… 'inquire into and report on the implications for Western Australia of hydraulic fracturing for unconventional gas'.*

However the stated aim of the inquiry will not be met by the current terms of reference.

This is a major concern as the real world experience of affected communities around the world where such industries are operating are consistently reporting adverse public health, social and environmental impacts. The failure of this inquiry's terms of reference to investigate and report on the potential public health, social and environmental impacts of hydraulic fracturing for unconventional gas, internationally recognised as major "implications" of this industry, renders the inquiry insufficient to meet its aims and is a profound disservice to the public interest and all West Australians.

Therefore we urge the WA parliament to expand the terms of reference so that issues of environmental health and justice related to this industry can be fully examined for the benefit of our environment and civil society in Western Australia.

On 7 August 2013, the Committee resolved to inquire into and report on the implications for Western Australia of hydraulic fracturing for unconventional gas, including:

a) how hydraulic fracturing may impact on current and future uses of land;

b) the regulation of chemicals used in the hydraulic fracturing process;

c) the use of ground water in the hydraulic fracturing process and the potential for recycling of produced water; and

d) the reclamation (rehabilitation) of land that has been hydraulically fractured.

Overview
The National Toxics Network (NTN) welcomes the opportunity to make a submission to the WA Parliamentary Standing Committee on Environment and Public Affairs - REPORT 33: INQUIRY INTO THE IMPLICATIONS FOR WESTERN AUSTRALIA OF HYDRAULIC FRACTURING FOR UNCONVENTIONAL GAS

Our expertise is specifically in the area of chemicals, pollution and community engagement so we will provide detailed information on these issues as they relate to the Terms of Reference.

The social and environmental impacts of hydraulic fracturing for unconventional gas are significant issues of concern to communities around the world, including Australians, and specifically the communities and individuals faced with UG developments in their regions.[1]

NTN representatives have spoken at many public forums on unconventional gas extraction during 2010/2013 including events in Queensland, NSW and Victoria, as well as internationally in Brussels, Geneva, London and Edinburgh where collectively, thousands of citizens well informed about the UCG industry have voiced their concerns about the possible impacts to their individual properties, communities and environment.

NTN produced a technical report (May 2011) titled *Hydraulic Fracturing in Coal Seam Gas Mining:The Risks to Our Health, Communities, Environment and Climate* and recently produced NTN's 2013 updated brief, *Toxic Chemicals In The Exploration And Production Of Gas From Unconventional Sources*.. Both reports are fully referenced and freely available on our website.
Some of the information provided in this submission is taken directly from the report.

The social and environmental impacts of unconventional gas mining cuts across many challenging areas including: climate change and greenhouse gas emissions; sustainable/renewable energy; chemical use; hazardous waste disposal; air, soil and water pollution; land and water use.

After careful consideration of the chemical pollution issues associated with UG, NTN recommends that a WA moratorium be placed on the use of all chemicals involved in the exploration and production of unconventional gas until all of the chemicals used (or proposed for use) have been fully assessed for their health and environmental hazards and their specific cumulative risks as used in coal seam gas mining.

Key findings

1. The approach to risk assessment in UG operations on a project-by-project basis does not take into account the *cumulative impacts* on water and air quality.

2. The disposal of salt and treatment of contaminated produce water is a significant challenge in UG operations. Limited assessment has been made of the options for treatment and capacity of wastewater facilities and landfills to manage this hazardous waste.

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[1] Stop Coal Seam Gas Now http://www.youtube.com/watch?v=93hRPRxXFg4&feature=related

3. Treatment of contaminated produce water using membrane filtration has significant limitations, as it cannot remove all contaminants, particularly organic compounds with low molecular weight.

4. There is no requirement for the assessment and monitoring of the *cumulative load* of chemicals used in UCG operations, or their potential to contaminate sediment, plants, aquatic species and /or animals prior to release of contaminated produce water. A chemical-by-chemical approach to risk assessment is also in contradiction with the current *National Water Quality Management Strategy* which recommends moving away from relying solely on chemical specific water monitoring to a more integrated approach using direct toxicity assessments (toxicity bioassays which assess overall toxicity of the water) and biological monitoring to fully assess the cumulative (additive and synergistic) impacts of complex mixtures of chemicals.

5. NTN's scientific literature review of chemicals used by the UCG industry has found that only 2 out of the 23 most commonly used fracking chemicals in Australia (that we could ascertain) have been assessed by NICNAS, the federal regulator of industrial chemicals. Of the 2 assessed chemicals, neither has been specifically assessed for its use in UCG mining activities.

6. BTEX chemicals are commonly found in the products used in the drilling stage of hydraulic fracturing and BTEX chemicals are also components of the volatile compounds found naturally in the coal gas seams. The fracking process itself can release BTEX from the natural-gas reservoirs, which may allow them to disperse into the groundwater aquifers or to volatilise into air. People may be exposed to BTEX chemicals by drinking contaminated water, breathing contaminated air or from spills on their skin.

7. After hydraulic fracturing is completed, a mixture of hazardous chemical compounds remains underground. These chemicals are distributed over time and space making them difficult and unpredictable to manage into the future, and potentially causing impacts to landscapes and future uses of the land and water.

8. The lack of disclosure on Material Safety Data Sheets of the full chemical identity of chemical ingredients used in products for UCG mining makes it impossible to realistically assess their risks and their possible impacts to the environment and human health.

9. There is an assumption that natural gas derived from UCG can act as a transition fuel because it is a 'cleaner' fossil fuel than coal however, there appears to be limited independent data on which to base this assumption. The total greenhouse gas emissions associated with UCG need to be accounted for in a thorough life cycle analysis. However, current studies indicate UG produces significant amounts of green house gases.

10. Air pollution associated with UCG sites including emissions from well pads, compressors, gas plants, and waste sites must undergo continuous monitoring for volatile organic compounds and hydrogen sulfide. The data should be provided to regulators and be made publically available. Facilities unable to eliminate toxic emissions should be required to cease operations. All new applications should require a full assessment of the risks and hazards to air quality.

11. UCG exploration and extraction as an industrial activity with a potentially significant impact on the environment and community should require public consultation as part of the authorisation procedure.

12. A cost/benefit analysis should be undertaken for each UCG development and include a full life cycle assessment (including greenhouse gas emission, resource consumption and cumulative impacts) to demonstrate the overall costs/benefits for the society.

Further comments on the specific terms of reference are provided here.

1. How hydraulic fracturing may impact on current and future uses of land.

Impacts on landscape

Extractive industry's by nature come with considerable impacts on the environment including legacy impacts. Efforts to rehabilitate former mine sites illustrate the difficulties for environmental rehabilitation and provide a good example of the expected long term impacts of such land uses. Where the land is used for agriculture and farming these legacy impacts may be irreversible and thus undermine any future intended land use such as food production. The contaminant profile in the groundwater and soil which may include dioixns, PAH's and BTEX chemical residues which are difficult if not impossible to remediate to a level that food can be safely grown or livestock raised.

A recent European Parliamentary report on the impacts of shale gas extraction and experiences in North America[2] reports that:

"*The development of gas shales requires well pads allowing for the storage of technical equipment, the trucks with compressors, chemicals, proppant, water and containers for waste water if these are not delivered from local water wells and collected in ponds. A typical multi-well pad size in Pennsylvania during the drilling and fracturing is about 4-5 acres (16,200-20,250 m2). After partial restoration the production pad size might average between 1 – 3 acres (4,050-12,150 m2).*
For comparison, if such an area (~10,000 m2) would be occupied by a solar power plant, about 400,000 kWh of electricity could be generated per year, corresponding to about 70,000 m3 of natural gas per year if this would be converted to electricity at 58% efficiency. The typical gas production of wells in the Barnett shale (Texas, USA) amounts to about 11 Mio. m3 per well in the first year, but only about 80,000 m3 in the 9th year and about 40,000 m3 in the 10th year [Quicksilver 2005].

In contrast to fossil fuel energy extraction, the solar power plant generates electricity for more than 20 years. At the end of its life time the solar plant can be substituted by a new one without additional land consumption".

[2] Impacts of shale gas and shale oil extraction on the environment and human health (2011), Directorate-General for Internal Policies, Policy Department A, Economic and Scientific Policy, European Parliament

Legal rights of property owners and property values

Anecdotal information told to NTN by individuals and communities living in regions such as SE QLD where UC gas fields are well established indicate they are no longer able to peacefully enjoy the amenity of their own properties due to the levels of noise (trucks and compressors), vibrations, air and water pollution and intrusion into their privacy as a result of the establishment of UCG wells. They also indicate the value of their properties has declined and they are unable to sell their properties.

2. The regulation of chemicals used in the hydraulic fracturing process

NTN's scientific literature review of chemicals used by the UCG industry has found that only 2 out of the 23 most commonly used fracking chemicals in Australia (that we could ascertain) have been assessed by NICNAS, the federal regulator of industrial chemicals. Of the 2 assessed chemicals, neither has been specifically assessed for its use in CSG mining activities.

BTEX chemicals

BTEX is shorthand for a group of compounds: benzene, toluene, ethylbenzene and xylene. 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 (BTEX) had been found in well water associated with its unconventional gas operation at Moranbah, west of Mackay.[3]

On 27th August 2011, Arrow Energy released monitoring results[4] of samples taken over three days from monitoring bores constructed around unconventional gas (UCG) dams.

BTEX chemicals were found in 5 of 14 shallow bores at Arrow's Tipton West and Daandine gas fields, approx 25 kilometres from Dalby. Some bores detected benzene at levels between 6 to 15 times the Australian drinking water standard. The drinking water standard is set at 0.001milligram per litre or, approximately 1 part per billion (ppb). Australian water regulators acknowledge that *'No safe concentration for benzene in drinking water can be confidently set. However, for practical purposes the concentration should be less than 0.001 mg/L (approximately 1ppb), which is the limit of determination.'*

An underground coal gasification (UCG) project run by a Cougar Energy, near Kingaroy Queensland, was also temporarily shut down when benzene and toluene were detected.[5] The QLD Department of Environment and Resource Management has laid charges on three counts of breaching conditions of environmental authority.[6] Queensland has since

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

[4] 26/08/2011 - Arrow Energy advises of monitoring results, http://www.arrowenergy.com.au/page/Media_Centre/Latest_News/

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

[6] Cougar Energy charged with three counts of breaching conditions of environmental authority, The

banned the use of BTEX chemicals in fracking fluids. The NSW Government announced it would examine banning the use of BTEX chemicals in ‘situations, which may pose risk to groundwater’.[7]

BTEX chemicals are commonly found in the products used in the drilling stage of hydraulic fracturing. However BTEX chemicals are also components of the volatile compounds found naturally in the coal gas seams. The fracking process itself can release BTEX from the natural-gas reservoirs, which may allow them to disperse into the groundwater aquifers or to 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.[8]

BTEX compounds can contaminate both soil and groundwater. 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.[9]

Fracking Fluids

“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.”[10]

Fracturing fluids or ‘fracking fluids’ consist of water, sand and chemicals that are combined and injected into the coal seam at high pressure. The fracking fluids include 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.

The *US Ground Water Protection Council and Interstate Oil and Gas Compact Commission* describes the contents of fracking fluids;

“The addition of friction reducers allows fracturing fluids and sand, or other solid materials called proppants, to be pumped to the target zone at a higher rate and reduced pressure

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Courier-Mail July 02, 2011 http://www.couriermail.com.au/news/queensland/cougar-energy-chargedwith-three-counts-of-breaching-conditions-of-environmental-authority/story-e6freoof-1226085900407

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

[8] 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.

[9] 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.

[10] 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

than if water alone were used. In addition to friction reducers, other additives include: biocides to prevent microorganism growth and to reduce biofouling of the fractures; oxygen scavengers and other stabilizers to prevent corrosion of metal pipes; and acids that are used to remove drilling mud damage within the near wellbore area. These fluids are used to create the fractures in the formation and to carry a propping agent (typically silica sand) which is deposited in the induced fractures to keep them from closing up." [11]

While UCG mining 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, the identity of the types of chemicals used in fracking fluids is publicly available.[12]

(*See* ***Appendix 1*** *for a list of chemicals used in fracking fluid products identified by the US Ground Water Protection Council and the Interstate Oil and Gas Compact Commission).*

A recent review on the use of chemicals in fracking[13] lists nearly a thousand products involved in natural gas operations (including UCG and shale gas) in the USA. Only a small percentage of these chemicals have CAS Registry Numbers [14] listed on their Material Safety Data Sheets (MSDS). Without a CAS number it is very difficult to search for specific health and environmental data about a chemical.

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

A review of 980 chemical products used in the gas industry in the USA found that [15]:

- 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.
- The issue of the lack of disclosure of the full chemical identity on product MSDS is similar in Australia. In 2010, it was reported that a unconventional gas-drilling site

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[11] http://fracfocus.org/chemical-use/what-chemicals-are-used Fracfocus is joint project of the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission

[12] http://fracfocus.org/chemical-use/what-chemicals-are-used

[13] 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

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

[15] 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

near Lismore NSW, run by Metgasco, was permitted to use fracking after supplying only a generic list of hazardous materials safety guidelines.[16]

- A review of MSDS provided by the UG companies and verified by industry sources[17], provides a general list of the type of chemicals used in fracking fluids in Australia. *(See Table 1)*

Table 1. Types of Chemicals Commonly Used in Fracking Fluids in Australia
(NB This summary of chemicals and their uses was consolidated from the MSDS provided by the UG companies and verified by industry sources in Australia)

Additive Type	Main Compound(s)	Purpose
Diluted Acid	Hydrochloric Acid, muriatic acid	Diluted Acid Dissolves minerals
Biocides	Glutaraldehyde, Tetrakis hydoxymethyl phosphonium sulfate	Eliminates bacteria in water that produce corrosive products
Breaker	Ammonium persulfate/ sodium persulfate	Delayed break gel polymer
Corrosion Inhibitor	n,n-dimenthyl formamide, methanol, naphthalene, naptha, nonyl phenol, acetaldhyde	Prevents corrosion of pipes
Friction Reducer Mineral oil	polyacrylamide	Reduces friction of fluid
Gel	Guar gum	Thickens water
Iron Control	Citric acid, thioglycolic 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

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

[17] Australian Petroleum Production & Exploration Association Ltd (APPEA), Chemicals that may be used in Australian fracking fluid Available at http://www.appea.com.au

Surfactants	Isopropanol, 2-Butoxyethanol	Affects viscosity of fluid
Crosslinker	Ethylene glycol	Affects viscosity of fracking fluid

Effects related to 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’ and each gas field incorporates many wells.

UCG industry representatives in Australia repeatedly claim in their literature, media and at public forums that fracking chemicals are ‘safe’ because they are similar to ‘food additives’ and are used in ‘household products’.

NTN believes these claims are false and misleading for several reasons.

A number of the chemicals used in fracking fluids would never be permitted as food additives or household products due to their toxicity. Most importantly, there has been no comprehensive hazard assessment of the chemical mixtures used in fracking fluids or their impacts on the environment or human health.

In Australia, a review of a selection of UG companies’ environmental authorisations identified 23 compounds commonly used in fracking fluids. (*See Table 2*).

Australia’s industrial chemical regulator, the National Industrial Chemical Notification and Assessment Scheme (NICNAS) has assessed only 2 out of the 23. Yet, hydraulic fracturing in Australia does involve the use of large quantities of fracking fluids.

For example, environmental authorisations by Queensland regulators identified that in one UG operation, approximately 18,500kg of additives were to be injected during the hydraulic fracturing process in each well, with only 60% of these recovered and up to 40% of the hydraulic fracturing fluid volume remaining in the formation, corresponding to 7,400kg of chemicals per injection well.[18]

The fluids that return to the surface within a specified length of time are referred to as *‘flowback’*. As well as the original fluid used for fracturing, flowback may also contain other fluids, chemicals and minerals that were present in the fractured formation such as heavy metals and hydrocarbons.[19] Toxic substances like lead, arsenic, barium, chromium, uranium, radium, radon and benzene can be mobilized by drilling and fracking activities, rendering flowback fluids hazardous.

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[18] 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

[19] http://fracfocus.org/chemical-use/what-chemicals-are-used

Drilling Chemicals

UCG activities also require the use of drilling chemicals. Chemicals commonly used at Australian drill sites include calcium sulfate, anionic surfactants, ethylene glycol monobutyl ether, polyacrylamide polymers and petroleum distillate flocculants. Drilling fluid additives are generally claimed as trade secrets and their contents are typically described as carrier fluids, anionic water-soluble polymers, activators, emulsifiers and neutralizers.

Hydrocarbons are also used at the drill sites and surrounding areas and include lubricants, rod grease, petrol and diesel for small plant equipment.[20]

Table 2. NICNAS Status of Chemicals Used in Fracking Fluids

(NB The following list of chemicals and CAS numbers was compiled from MSDS provided by three UG companies based 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 N/A
Ethylene glycol	107-21-1	Pub N/A
Sodium hydroxide	1310-73-2	Pub/NA
Diethylene glycol	111-46-6	Pub N/A
2-Bromo-2-nitro-1,3-propanediol	52-51-7	Pub N/A
Alcohols, C12-14	80206-82-2	Pub N/A
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 N/A

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

[20] For more information see http://www.amcmud.com/amc-drilling-fluids-and-products.html

Other chemicals commonly listed in fracking chemical products but without CAS numbers include the following. Without CAS numbers the identity of the chemical cannot be assured:

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

Health and Environmental Risks of Some Fracking Chemicals

(NB The following information was compiled from publically available sources including the 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

2-Butoxyethanol

2-butoxyethanol was declared a Priority Existing Chemical under NICNAS.[21] The assessment of 2-butoxyethanol shows that 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. High doses of 2-butoxyethanol can cause reproductive problems and birth defects in animals. 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 disrupting chemical (EDC), which has been detected widely in wastewater and surface waters across the globe. NPE disrupt normal hormonal functioning in the body. It can mimic the natural hormone estradiol and binds to the estrogen receptor in living organisms. Exposure to NPE changes the reproductive organs of aquatic organisms.[22] Sexual deformities were found in oyster larvae exposed to levels of nonylphenol (NP) that are often present in the aquatic environment.[23] A 2005 study found that exposure to NP increases the incidence of breast cancer in lab mice.[24] Canada classified NPE

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

[22] 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,

[23] Nice et al. 2003. Long-term & Transgenerational Effects of Nonylphenol Exposure. Possible Endocrine Disruption? *Marine Ecology Progress Series,*Vol. 256, p. 293.

[24] Acevedo et al 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* Vol. 25, issue 5.

metabolites as toxic.[25] The European Union classifies nonylphenol as very toxic to aquatic organisms, which may cause long-term adverse effects in the aquatic environment.[26] The intermediary chemicals formed from the initial degradation of NPE are much more persistent than the original compound.

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.[27] Ethylene glycol is a teratogen (i.e., an agent 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).

Formamide

Formamide is a teratogen with the potential to affect the unborn child. It 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.

Glutaraldehyde

Glutaraldehyde is highly irritating to the eyes, skin [28] and the respiratory tract of humans and laboratory animals. It has induced skin sensitization in humans and laboratory animals, and caused asthma in occupationally exposed people.[29] In animal tests, glutaraldehyde by inhalation caused lung damage in rats and mice. DNA damage, mutations and some evidence of chromosome damage were found in mammalian cells in culture following treatment with glutaraldehyde. Data indicates that both algae and fish embryos may be particularly sensitive to long-term glutaraldehyde exposure.[30]

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.[31]

Methanol

Methanol is a volatile organic compound, which is highly toxic to humans. Methanol causes central nervous system depression in humans and animals as well as degenerative changes in the brain and visual system. Chronic exposure to methanol, either orally or by inhalation, causes headache, insomnia, gastrointestinal problems, and blindness in humans and hepatic and brain alterations in animals. Methanol is highly mobile in soil. In water, the degradation products of methanol are methane and carbon dioxide. Methanol also volatilizes from water and once in air, exists in the vapor phase with a half-life of over 2 weeks. The chemical reacts with photochemically produced smog to produce formaldehyde and can also react with nitrogen dioxide in polluted air to form

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25 Environment Canada 2001 Nonylphenol and its Ethoxylates: Priority Substance Lists Assessment Report.

26 European Union 4-Nonylphenol (branched) and Nonylphenol Risk Assessment Report. European Chemicals Bureau Volume 10,

27 Adotfo Correa et al, Ethylene Glycol Ethers and Risks of Spontaneous Abortion and Subfertility, *American Journal of Epidemiology* Vol. 143, Issue 7

28 http://www.epa.gov/oppsrrd1/REDs/glutaraldehyde-red.pdf

29 http://www.bibra-information.co.uk/profile-45.html

30 Larissa et al. Chronic toxicity of glutaraldehyde: differential sensitivity of three freshwater organisms, *Aquatic Toxicology* 71 (2005) 283–296

31 International Agency for Research on Cancer (IARC) - Summaries & Evaluations ISOPROPANOL

methyl nitrite.[32] Methanol is listed as the most commonly used HF chemical by the United States House of Representatives Committee on Energy and Commerce.[33]

Naphthalene

Chronic exposure of workers and rodents to naphthalene has been reported to cause cataracts and damage to the retina. Based on the results from animal studies, which demonstrated nasal and lung tumours in lab animals, US EPA and the International Agency for Research on Cancer (IARC) has classified naphthalene as a Group C, possible human carcinogen.[34] 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.

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 at very low levels of that substance. Exposure can also cause skin rashes and eczema. Sodium persulfate 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.)

Tetrakis (hydroxymethyl)phosphonium sulfate (THPS)

THPS is toxic to microorganisms Repeated skin exposure to THPS resulted in severe skin reaction and caused skin sensitization in guinea pigs. THPS was also identified as a severe eye irritant in rabbits.[35] It has shown mutagenic potential (in vitro) and cancer potential in rats. The reported acute toxicity values for algae are less than 1 milligram per litre (No Observable Effect Concentration (NOEC) of 0.06mg/litre). No exposure information is available for either humans or organisms in the environment; hence no quantitative risk assessment has been made.[36] Little is known about the effects of the break down products of THPS.

US Analysis of Fracking Chemicals

A US analysis of chemicals used in fracking based on health data obtained from the MSDS as well as government toxicological reports, and the medical literature for the 362 chemicals with CAS numbers found [37]:

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32 EPA 749-F-94-013a CHEMICAL SUMMARY FOR METHANOL prepared by OFFICE OF POLLUTION PREVENTION AND TOXICS U.S. ENVIRONMENTAL PROTECTION AGENCY, August 1994

33 Methanol was used in 342 of the 750 hydraulic fracturing products used in the US. It is a hazardous air pollutant and on the candidate list for potential regulation under the US *Safe Drinking Water Act* due to its risks to human health. See United States House of Representatives Committee on Energy and Commerce, Minority Staff, April 2011 Chemicals Used In Hydraulic Fracturing http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf.

34 http://www.epa.gov/ttnatw01/hlthef/naphthal.html

35 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

36 Environmental Health Criteria 218 Flame Retardants: TRIS(2-BUTOXYETHYL) PHOSPHATE, TRIS(2- ETHYLHEXYL) PHOSPHATE and TETRAKIS(HYDROXYMETHYL) PHOSPHONIUM SALTS World Health Organization Geneva, 2000

37 *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.*

- 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 brainand nervous system, 72% can harm the cardiovascular system and blood, and 66% can harm the kidneys.

In May 2011, the *US House of Representatives Committee on Energy and Commerce* released their report identifying 750 chemicals that were used in fracking fluids between 2005 and 2009.[38]

They stated:

'Some of the components used in the hydraulic fracturing products were common and generally harmless, such as salt and citric acid. Some were unexpected, such as instant coffee and walnut hulls. And some were extremely toxic, such as benzene and lead.'

They noted that the most widely used chemical in hydraulic fracturing as measured by the number of compounds containing the chemical was methanol. Methanol was used in 342 hydraulic fracturing products, and is a hazardous air pollutant and on the candidate list for potential regulation under the US *Safe Drinking Water Act* due to its risks to human health.

Other widely used chemicals were isopropyl alcohol (used in 274 products), 2 butoxyethanol (used in 126 products), and ethylene glycol (used in 119 products).

Between 2005 and 2009, hydraulic fracturing products contained [39] chemicals that were either known or possible human carcinogens, regulated under the US *Safe Drinking Water Act* for their risks to human health, or listed as hazardous air pollutants under the *Clean Air Act*. These 29 chemicals were components of more than 650 different products used in hydraulic fracturing. [40]

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[38] United States House of Representatives Committee On Energy And Commerce, Minority Staff, April 2011 Chemicals Used In Hydraulic Fracturing. http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

[39] 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

[40] United States House of Representatives Committee On Energy And Commerce, Minority Staff, April

A chemical and biological risk assessment for natural gas extraction by the Chemistry and Biochemistry Department from the State University of New York in March 2011videntified chemical products in widespread use, including in exploratory wells, thatvpose significant hazards to humans or other organisms, *"…Because they remain dangerous even at concentrations near or below their chemical detection limits. These include the biocides glutaraldehyde, 2,2-dibromo-3- nitrilopropionamidev (DBNPA) and 2,2 dibromoacetonitrile (DBAN), the corrosion inhibitor propargylvalcohol, the surfactant 2-butoxyethanol (2-BE), and lubricants containing heavy naphtha."*[41]

*(See **Appendix 2** for health and environmental effects)*

3. The use of ground water in the hydraulic fracturing process and the potential for recycling of produced water;

Produced water is the term used by the industry to describe the waste water produced along with the gas. Produced water from both CSG and shale gas is contaminated with heavy metals, ORMs, fracking or drilling chemicals, volatile and semi volatile organic compounds and high concentrations of salts. For a typical shale gas well, daily produced water volumes range from 300 – 4,500 litres (80 to 1,200 gallons).[42] The amount of produced water from a CSG well varies between 0.1 - 0.8 megalitres (ML) per day.[43] Produced water is either reinjected into aquifer formations, used for dust suppression on roads, reused for brick making, sent to holding ponds or partially 'treated' and released into waterways. The treatments to remove contaminants from produced water are limited by the chemicals they can remove, the energy needed and their economic costs. Reverse osmosis filtration has significant limitations and cannot remove many of the organic chemicals used in UG activities. Low molecular weight, non polar, water-soluble solutes such as the methanol and ethylene glycol are poorly rejected.[44]

Contamination risks to ground and surface water include leakage of drilling fluids from the well bore into near surface aquifers; poor cement jobs on well bore casing, fracking pressure resulting in cracks in the well casing allowing leakage of fluids; contamination from flow back fluid; accidental spills of fluids or solids at the surface; surface and subsurface blow outs; chemicals remaining underground from repeated fracking or naturally occurring contaminants finding their way from the producing zone to shallow or

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2011 Chemicals Used In Hydraulic Fracturing http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Report%204.18.11.pdf

[41] Chemical and Biological Risk Assessment for Natural Gas Extraction in New York. Ronald E. Bishop, Ph.D., CHO, Chemistry & Biochemistry Department, State University of New York, College at Oneonta, Sustainable Otsego March 28, 2011. http://www.sustainableotsego.org/Risk%20Assessment%20Natural%20Gas%20Extraction-1.htm

[42] Bill Chameides, "Natural Gas, Hydrofracking and Safety: The Three Faces of Fracking Water," *National Geographic,* September 20, 2011.

[43] CSG and water: quenching the industry's thirst, Gas Today Australia, May 2009

[44] Chemicals unable to be treated successfully include bromoform, chloroform, naphthalene, nonylphenol, octylphenol, dichloroacetic acid, trichloroethylene. See www.industry.qld.gov.au/documents/LNG/csg-water-beneficial-use-approval.pdf; http://www.aquatechnology.net/reverse_osmosis.html ;Stuart J. Khan Quantitative chemical exposure assessment for water recycling schemes, Waterlines Report Series No 27, March 2010 Commissioned by the National Water Commission

drinking water aquifers through fractures in the rock; and/or discharge of insufficiently treated waste water into surface water or underground aquifers.[45]

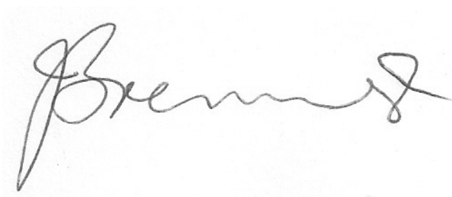
4. Issues not defined in the terms of reference.

NTN wishes to highlight the absence of some major implications emanating from unconventional gas operations in the terms of reference for this inquiry which include air quality and public health impacts. It is noted that the WA EPA has not included air quality impacts in the criteria[46] considered for the assessment and regulation of this industry. This is clearly a major oversight and represents a fundamental flaw of this inquiry.

Therefore NTN recommends that committee members refer to the attached NTN report - ***Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources*** for information on the expected air quality impacts and public health impacts associated with the unconventional gas industry.

The outcomes from this inquiry will be deficient to meet stakeholder and community expectations for the safe operation and regulation of this industry in WA without these critical air quality and public health impact considerations.

Yours sincerely,



Jane Bremmer
Secretary
National Toxics Network Inc.
Chair
Alliance for a Clean Environment Inc.

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[45] Potential Risks for the Environment and Human Health Arising from Hydrocarbons Operations Involving Hydraulic Fracturing in Europe. http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf

[46] http://www.epa.wa.gov.au/EPADocLib/EPB%2015%20Fracking%20050911.pdf

APPENDIX 1

Hydraulic fracturing fluids usually include:

• **Gelling agents** to hold the proppant in suspension (eg mixtures of industrial guar gum, diesel, alkanes/alkenes);

• **Gel stabilisers** (eg sodium thiosulphate) and **gel breakers** (eg Ammonium persulfate, sodium persulfate);

• **Friction reducers** to ease pumping and evacuation of fluid (eg polyacrylamide, mixtures of methanol, ethylene glycol, surfactants /fluorocarbon surfactants);

• **Surfactants** to affect fluid viscosity (eg isopropanol, 2-Butoxyethanol /2-BE)

• **Biocides** to prevent bacterial action underground (eg glutaraldehyde, Tetrakis hydoxymethyl phosphonium sulfate / THPS, 2-Bromo-2-nitro-1,3-propanediol (Bronopol), 2,2-Dibromo-3-nitrilopropionamide (DBNPA);

• **Clay stabilisers** to prevent clay expanding on contact with water and plugging the reservoir (eg tetramethyl ammonium chloride); and

• **Buffer fluids** and **crosslinking agents.**

They may also use:

• **Corrosion inhibitors (**eg formamide, methanol, naphthalene, naptha, nonyl phenols, acetaldhyde);

• **Scale inhibitors** (eg ethylene glycols);

• I**ron control** (eg citric acid, thioglycolic acid);

• **pH adjusting agents** (sodium or potassium carbonate); and

• **Diluted acid** to dissolve minerals (eg hydrochloric acid, muriatic acid);

Drilling fluid components include:

• **Viscosifiers** to increase viscosity of mud to suspend cuttings (eg bentonite, polyacrylamide)

• **Weighting agent** (eg barium sulphate)

• **Bactericides/biocides** to prevent biodegradation of organic additives (eg glutaraldehyde)

• **Corrosion inhibitors** to prevent corrosion of drill string by acids and acid gases (eg zinc carbonate, sodium polyacrylate, ammonium bisulphate)

• **Defoamers** to reduce mud foaming (eg glycol blends, light aromatic and aliphatic oil, naptha)

• **Emulsifiers and deemulsifiers** to help the formation of stable dispersion of insoluble liquids in water phase of mud.

• **Lubricants** to reduce torque and drag on the drill string (eg chlorinated paraffins)

• **Shale control inhibitors** to control hydration of shales that causes swelling and dispersion of shale, collapsing the wellbore wall (eg anionic polyacrylamide, acrylamide copolymer, petroleum distillates)

• **Polymer stabilisers** to prevent degradation of polymers to maintain fluid properties (eg Sodium sulfite).

• **Breakers** to reduce the viscosity of the drilling mud by breaking down long chain emulsifier molecules into shorter molecules (eg diammonium peroxydisulphate, hemicellulase enzyme)

• **Salts** (eg potassium chloride, sodium chloride, calcium chloride)

Persistent Organic Pollutant (POPs); perfluorooctane sulfonic acid (PFOS) is permitted in hydraulic fracturing fluids under an exemption to the *Stockholm Convention on POPs* 2001[47]. Chlorinated paraffins are used in drilling fluids, with the POPs chemicals, short chain chlorinated paraffins (SCCPs) listed in drilling fluid patents. POPs are recognised as the most dangerous of all man made chemicals.

[47] http://www.pops.int

APPENDIX 2: Chemical products in widespread use and dangerous at concentrations near or below their chemical detection limits.

Taken from Chemical and Biological Risk Assessment for Natural Gas Extraction in New York. Ronald E. Bishop, Ph.D., CHO, Chemistry & Biochemistry Department, State University of New York, College at Oneonta, Sustainable Otsego March 28, 2011.
(http://www.sustainableotsego.org/Risk%20Assessment%20Natural%20Gas%20Extraction-1.htm)

Glutaraldehyde:
Glutaraldehyde (CAS No. 111-30-8) is a biocide used widely in drilling and fracturing fluids. Along with its antimicrobial effects, it is a potent respiratory toxin effective at parts-per-billion (ppb) concentrations (70); a sensitizer in susceptible people, it has induced occupational asthma and/or contact dermatitis in workers exposed to it, and is a known mutagen (i.e., a substance that may induce or increase the frequency of genetic mutations) (70, 71). It is readily inhaled or absorbed through the skin. In the environment, algae, zooplankton and steelhead trout were found to be dramatically harmed by glutaraldehyde at very low (1 – 5 ppb) concentrations (72).

DBNPA:
2,2-Dibromo-3-nitrilopropionamide (DBNPA) (CAS No. 10222-01-2) is a biocide finding increasing use in drilling and fracturing fluids. It is a sensitizer, respiratory and skin toxin, and is especially corrosive to the eyes (73). In the environment, it is very toxic to a wide variety of freshwater, estuarine and marine organisms, where it induces developmental defects throughout the life cycle. In particular, it is lethal to "water fleas" (Daphnia magna), rainbow trout and mysid shrimp at low (40 to 50 ppb) concentrations, and is especially dangerous to Eastern oysters (74). Chesapeake Bay oysters are killed by extremely low (parts-per-trillion, ppt) concentrations of DBNPA, well below the limit at which this chemical can be detected.

DBAN:
Dibromoacetonitrile (DBAN) (CAS No. 3252-43-5) is a biocide often used in combination with DBNPA, from which it is a metabolic product (with the release of cyanide). Its human and environmental toxicity profiles are similar to that of DBNPA, except that DBAN is also carcinogenic (75). DBNPA and DBAN appear to work synergistically. In combination, the doses at which these biocides become toxic are significantly lower than when they are used separately. In other words, it takes much less of these chemicals to exert toxic effects when they are used together, although the specific degree of potentiation has not been publicly reported.

Propargyl Alcohol:
Propargyl alcohol (CAS No. 107-19-7) is a corrosion inhibitor that is very commonly used in gas well construction and completion. This chemical causes burns to tissues in skin, eyes, nose, mouth, esophagus and stomach; in humans it is selectively toxic to the liver and kidneys (76). Propargyl alcohol is a sensitizer in susceptible individuals, who may experience chronic effects months to years after exposure, including rare multi-organ failure (77). It is harmful to a variety of aquatic organisms, especially

fathead minnows, which are killed by doses near 1 ppm (78).

2-BE:
2-Butoxyethanol (2-BE), also known as ethylene glycol monobutyl ether (EGBE) (CAS No. 111-76-2), is a surfactant used in many phases of gas exploration and extraction. It comprises a considerable percentage of Airfoam HD, commonly used for air-lubricated drilling (79). Easily absorbed through the skin, this chemical has long been known to be selectively toxic to red blood cells; it causes them to rupture, leading to hemorrhaging (80). More recently, the ability of EGBE at extremely low levels (ppt) to cause endocrine disruption, with effects on ovaries and adrenal glands, is emerging in the medical literature (81). This chemical is only moderately toxic to aquatic organisms, with harm to algae and test fish observed with doses over 500 ppm (80).

Heavy Naphtha:
Heavy naphtha (CAS No. 64741-68-0) refers to a mixture of petroleum products composed of, among other compounds, the aromatic molecules benzene, toluene, xylene, 1,2,4-trimethylbenzene and polycyclic aromatic hydrocarbons including naphthalene. It is used by the gas industry as a lubricant, especially in drilling muds. This material is hazardous to a host of microbes, plants and animals (82). Several of the mixture’s components are known to cause or promote cancer. If released to soil or groundwater, several components are toxic to terrestrial and aquatic organisms, especially amphibians, in which it impedes air transport through the skin.