TOWN AND COUNTRY PLANNING (APPEALS) (SCOTLAND) REGULATIONS 2013

APPEAL UNDER SECTION 47(2) OF THE TOWN AND COUNTRY PLANNING (SCOTLAND) ACT 1997 BY DART ENERGY (FORTH VALLEY) LTD CONCERNING COAL BED METHANE PRODUCTION, INCLUDING DRILLING, WELL SITE ESTABLISHMENT AT 14 LOCATIONS AND ASSOCIATED INFRASTRUCTURE AT LETHAM MOSS, FALKIRK, AND POWDRAKE ROAD, NEAR AIRTH, PLEAN

(REFERENCES PPA-240-2032 AND PPA-390-2029)

PRECOGNITION BY Dr Mariann Lloyd-Smith
ON BEHALF OF
CONCERNED COMMUNITIES OF FALKIRK
(AND SUPPORTERS)

Introduction

1. I am Dr Mariann Lloyd-Smith, Senior Advisor, to the National Toxics Network Inc, the peak chemical public interest non-government organisation (NGO) in Australia and Pacific region. I have a PhD in chemical policy and law and have worked in chemicals policy and waste management for nearly three decades. I have been employed as a consultant to the Australian and the Pacific Island governments and their agencies, to the United Nations Environment Program and to the Secretariats of the three international chemical and waste conventions. I was a coauthor of Australia's National Waste Management Plans for Hazardous Waste and am currently a member of the Technical Advisory Group to the Australian National Industrial Chemical Notification and Assessment Scheme. For six years I was chair of the international chemical NGO, IPEN and and was a member of the UN Expert Group on Climate Change and Chemicals, coauthoring the report 'Climate Change and POPs; Predicting the Impact'. I have published a range of papers in scientific journals and many articles on the impacts and regulations of industrial chemicals. Most recently, I authored NTN's report *Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources*, presenting the findings to communities, governments and industry across Australia, UK and Europe. I am currently Chair of the IPEN Working Group on chemicals used and released by unconventional gas activities, and in this role assisted the OECD in the organisation of their focus session held in Paris, November 2012 on drilling and fracking chemicals.

Summary

2. The current project proposal including the waste management plan (WMP) provides only limited information on the identity of the drilling chemicals, wastewater treatment chemicals and industrial cleaners/solvents to be used on site and does not address natural contaminants sourced from the coal seam. The proposals fail to adequately address the full range of fugitive emissions associated with coal bed methane (CBM) activities and their impacts on human health and the environment. These are serious failures as families and children would be living approximately 50 metres from the proposed infrastructure.

General comments

3. In assessing the proposed coal bed methane (CBM) extraction at Airth in Scotland, it is useful to examine other countries, which have considerable experience of the matter. For example, in Australia, the exploration and production of CBM has expanded rapidly in recent years bringing severe problems of air pollution, unsustainable water consumption and other waste management issues. As a result, in 2013, the New South Wales (NSW) state government introduced a two kilometre buffer zone around urban areas and agricultural infrastructure such as horse breeding and wine growing for CBM activities. This ensures that no CBM developments occur within a 2 kilometre zone around urban areas and certain agricultural

infrastructure. [1] The Australian Federal Government also brought in new rules requiring proposed gas projects that could affect water supplies to first earn Federal approval. In response, some CBM companies including Dart Energy have withdrawn from Australia to pursue activities elsewhere. In April 2013 Dart Energy informed the Australian Stock Exchange it would mothball activities in NSW as a direct result of new laws.[2]

4. In this proposed project, Dart has stated that 'No fracturing is proposed now or in the future,' yet the proposal is based on unrealistic well life of 25-30 years. Dart states they anticipate that gas production will peak approximately 6 months after dewatering commences, for up to 18 months, thereafter declining annually. The International Energy Agency states a well lifespan as 5-15 years.[3] Most recoverable gas is extracted after a few years, when the need to hydraulic fracture the well increases substantially. In Australia, over 40% of all coal bed gas wells are fracked. As the well gas pressure reduces (after the initial depressurisation of the well and the removal of produced water), fracking is often used to ensure as much gas as possible is removed.

5. In Australia, CBM companies have also made public commitments that they would not use hydraulic fracturing ('fracking') in an attempt to win public support only to renege on them at a future date.[4] In December 2012, the Australian company AGL told Fairfax Media 'unconditionally' that it would not use fracking in its planned 66-well drilling program in western Sydney. Its assurances prompted the NSW Premier to defend AGL and downplay any environmental health impacts of the project. In January 2013, AGL reversed its decision stating it would maintain the right to use 'well stimulation', or fracking and admitted fracking 75 per cent of their existing CBM wells outside urban Sydney.

A. Chemical Use

6. **Drilling fluids**
Dart's documents state that the drilling fluids to be used will vary according to the geology to be drilled but claim they will always be non-toxic, biodegradable and harmless. The drilling fluids to be used are listed as containing water, brine, drilling starch or biodegradable viscosifiers and in some instances weighting agents. A short list of commercial names (some unidentified) without active ingredients and some chemicals without commercial names are provided. The following commercial products are listed; PURE-BORE, CLEAR GEL, DRILL-SORB, and PAC (Polyanionic) Polymer Clear Stabiliser. However, Manufacturing Safety Data Sheets (MSDS) for these products were not supplied and could not be sourced. MSDS supply basic health and safety information as well as waste management and regulatory label requirements. It is common practice to provide these to workers handling chemicals and their products in Canada and the US and in Australia, it is required by law. However basic health and safety information for these products was not supplied by Dart.

7. The general class of defoamers and viscosifiers and the following are also mentioned.

- Potassium Chloride (KCl) - skin and eye irritant, high concentrations are genotoxic.
- Soda Ash (sodium carbonate) - eye, skin and respiratory tract irritant. Particulate inhalation can lead to pulmonary fibrosis, chronic bronchitis, emphysema and bronchial asthma.
- Xanthan Gum - hazardous via skin and eye contact, via ingestion and by inhalation.
- Calcium Carbonate
- Citric Acid

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[1] CCoF 191: However, it should be noted that recent studies have shown an association between density and proximity of natural gas wells within a 10-mile radius of maternal residence and the prevalence of birth defects. (McKenzie er al., Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, *Environ Health Perspect*; DOI:10.1289/ehp.1306722 http://ehp.niehs.nih.gov/1306722/)

[2] CCoF 146: http://www.northernstar.com.au/news/csg-exploration-firm-pulls-out-australia-after-bac/1814114/ http://www.theaustralian.com.au/business/mining-energy/dart-energy-withdraws-from-csg-projects-as-state-ruling-bites/story-e6frg9df-1226611207012#mm-premium

[3] CCoF 271: International Energy Agency, Golden Rules for a Golden Age of Gas,World Energy Outlook Special Report on Unconventional Gas
http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf

[4] CCoF 194: Sydney Morning Herald AGL breaks fracking pledge 6/ January 16, 2013 Ben Cubby, Esther Han

Defoamers to reduce mud foaming use ingredients such as eg glycol blends, light aromatic and aliphatic oil and naptha. Glycol blends often contain ethylene glycol, a reproductive toxin. Viscosifiers used to increase viscosity of mud to suspend cuttings are often based on bentonite and polyacrylamide polymers. Polyacrylamide, may be contaminated with small amounts of acrylamide, a neurotoxin.

8. Typically, 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)

• **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)

and in the case of drilling for shale gas:

• **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)

B. Drilling Muds, Cuttings and Wastes

9. Drilling muds consist of drilling fluid, weighting agents, and stabilizing materials. They come in contact with the coal and its contaminants which may mix with the mud fluid, and then be transported to the surface with the drilling muds. While paragraph 3.54 in the WMP acknowledges that a range of impurities can be dissolved in the water associated with coal seams and bought to the surface, this is not addressed in the context of the drilling muds also brought to the surface. Instead all drill fluids, muds and cuttings are defined in the WMP (paragraphs 3.3, 3.24, 3.26) as 'non-hazardous non-inert'. The WMP also claims that although the nature of the drilling fluids will change they will always be considered as non-hazardous waste. With no consideration of the impurities and contaminants adsorbed from the coal seam and no clear identification of the drilling fluid components, these can only be viewed as unsubstantiated claims.

10. Trials undertaken in Australia on a proposal for land spraying of drilling by–products identified environmental hazards associated with drilling by–products include potentially toxic additives, salt compounds, heavy metals, hydrocarbons, pH-control additives, and total suspended solids (TSS).[5] The report notes that concentrations of aluminium, boron, iron, manganese, molybdenum, vanadium and

[5] CCoF 272: Origin's EMP Landspraying While Drilling (LWD) Trial Program OEUP-Q8200-PLN-ENV http://www.aplng.com.au/pdf/Environmental_Management_Plan_Landspraying_While_Drilling_Trial_Program.pdf

mercury exceeded the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000) Guidelines[6] and detectable concentrations of petroleum hydrocarbons were observed in drilling muds. They concluded that the C6–C9 fraction, which include BTEX (benzene, toluene, ethyl benzene and xylenes), may pose a risk from an environmental and human health perspective.

11. Although the WMP states (6.9) that fluid and solid drilling wastes will be sampled at "the first available opportunity" for chemical analysis and any other additional waste acceptance criteria as requested by the off-site waste facility to inform future waste management arrangements and risk control measures, this does not address ongoing pollution risks for human health and the environment.

Other chemicals used

12. Little health and safety information on the waste water treatment chemicals or industrial cleaners/ solvents to be used on site is provided, eg methyl ethyl ketone (MEK), a toxic industrial chemical used in the cleaning, degreasing, descaling pipes and in wellhead maintenance found in ambient air around CBM activities.

C. Impacts on Air

Air pollutants associated with unconventional gas activities

13. While air emissions from the rig, vehicles and venting are acknowledged in the proposal, emissions from flaring, treatment of gas and water or unwanted fugitive emissions are not. Unconventional gas activities have been shown (CCoF 133) to be sources of both (a) air pollution by primary pollutants such as oxides of nitrogen (NOx) and particulate matter (PM) and (b) the precursors of secondary pollutants such as ozone (O3). There is a diverse range of sources and air pollutants associated with the unconventional gas industry.[7]

14. **Carbon monoxide -** CO is emitted during flaring and from machinery used in CBM. CO is poisonous if inhaled, inhibiting blood's ability to carry oxygen and can cause dizziness, unconsciousness, and even death.

15. **Sulfur dioxide** - CBM may contain traces of sulfur, which can be emitted during flaring or from equipment onsite. SO2 reacts with other chemicals to form acid rain and particulate pollution, which can damage lungs and cause respiratory illness, heart conditions, and premature death.

16. **Hydrogen sulfide** – H2S occurs naturally in some gas formations and is released when gas is vented or flared, or via fugitive emissions. It is a toxic gas, which is lethal if inhaled at high concentrations.

17. **Nitrogen Oxides -** NOx are emitted from machinery and compressors as well as during flaring. NOx may react with volatile organic compounds to form ground-level ozone. Nitrogen dioxide can cause respiratory problems, heart conditions and lung damage,

18. **Particulate Matter -** Particulate matter can be emitted during construction, venting, flaring and transport operations. Chronic inhalation of PM10 and is PM 2.5 may lead to respiratory problems, cancer or premature death.

19. **Volatile organic compounds -** VOCs can be emitted during drilling, flaring, from machinery and from produce water. Some are known to cause cancer in animals and humans eg methylene chloride, formaldehyde, chloroform, bromodichloromethane. VOCs are key ingredients in smog linked to asthma,

[6] CCoF 273: http://www.environment.gov.au/resource/australian-and-new-zealand-guidelines-fresh-and-marine-water-quality-volume-1-guidelines

[7] CCoF 133: A Kibble, T Cabianca, Z Daraktchieva, T Gooding, J Smithard, G Kowalczyk, N P McColl, M Singh, S Vardoulakis and R Kamanyire Review of the Potential Public Health Impacts of Exposures to Chemical and Radioactive Pollutants as a Result of Shale Gas Extraction: Draft for Comment, PHE-CRCE-002 http://www.hpa.org.uk/Publications/Environment/PHECRCEReportSeries/PHECRCE002/

eye, nose, and throat irritation; headaches, visual disorders, memory impairment, loss of coordination, nausea, damage to liver, kidney and central nervous system.[8]

20. **Benzene, toluene, ethylbenzene, xylene** - BTEX chemicals are naturally occurring in coal and gas deposits and found in associated groundwater.[9] Their short term health effects including skin, eye and nose irritation, dizziness, headache, loss of coordination and impacts to respiratory system. Chronic exposure can result in damage to kidneys, liver and blood system. Benzene linked is with cancer and leukemia.[10]

21. **Natural Gas** - while the primary component of natural gas is methane, it typically contains other hydrocarbons such as ethane, propane, butane, and pentanes and in some cases, may also contain hazardous air pollutants such as BTEX, hexanes, hydrogen sulphide (H2S), and carbon dioxide. Fugitive emissions associated with leaks from pumps, flanges, valves, pipe connectors etc. can include methane and these other gases.

Sources of air pollutants not addressed

22. **TEG dehydration units**
The proposed triethylene glycol (TEG) dehydration unit is a likely source of BTEX emissions which are not addressed in the WMP. TEG dehydration units are the most polluting of the three forms of glycol dehydration types (eg triethylene glycol (TEG), diethylene glycol (DEG) ethylene glycol (EG).)[11]

23. **Flare stack**
The USEPA has effectively banned gas flaring after January 2015 due to growing concerns over air pollution.[12] The practice of flaring means that air contaminants including hydrogen sulphide, methane, BTEX [13] and other contaminants associated with methane are released. Gas flaring is recognised as a significant source of soot, or black carbon, pollution in the Arctic, with new research indicating that flaring from oil and gas developments is the largest source of this pollutant, responsible for 42% of black carbon pollution in the Arctic.[14]

24. **Gas venting**
Gas venting through a Cold Gas Vent (0.4 m diameter x 20 m high) will take place until the gas can be exported to the GDWTF yet there is no discussion of (a) the contaminants (b) their concentrations and (c) total amounts that will be released through this form of venting. Exhaust from the energy generation equipment is also to be vented to atmosphere.

25. **Fugitive non-methane emissions**
The WMP does not address non-methane fugitive emissions. Australian research[15] (CCoF 76) measured atmospheric radon (Rn-222 and Rn-220) and carbon dioxide (CO2) concentrations as a measure of fugitive emissions in the CBM gas fields. The researchers suggest the presence of radon and CO2 indicates the possible release of other gases, such as VOCs. They also suggests that CBM activities such as the depressurisation by groundwater extraction of coal bed strata change the geological structure and

[8] CCoF 274: http://www.epa.gov/iaq/voc.html
[9] CCoF 275: https://www.ehp.qld.gov.au/management/coal-seam-gas/pdf/btex-report.pdf
[10] CCoF 157: Rinsky, R.A Benzene and leukemia: an epidemiologic risk assessment. *Environ Health Perspect*.1989 July 82:
[11] CCoF 149: Reduce Emissions and Operating Costs with Appropriate Glycol Selection HAROLD O. EBELING, Latoka Engineering, L.L.C., Tulsa, OK LILI G. LYDDON, KIMBERLY K. COVINGTON, Bryan Research & Engineering, Inc., Bryan, Texas
http://www.bre.com/portals/0/technicalarticles/Reduce%20Emissions%20and%20Operating%20Costs%20with%20Appropriate%20Glycol%20Selection.pdf
[12] CCoF 148: http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf
[13] CCoF 150: http://www.med.upenn.edu/ceet/documents_user/MarcellusShale_Penning3.pdf
[14] CCoF 276: Stohl, A., Klimont, Z., Eckhardt, S. et al. (2013). Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions. *Atmospheric Chemistry and Physics*. 13: 8833–8855. Also see http://ec.europa.eu/environment/integration/research/newsalert/pdf/349na5.pdf
[15] CCoF 76: Douglas R. Tait, Isaac Santos, Damien Troy Maher, Tyler Jarrod Cyronak, & Rachael Jane Davis, Enrichment of radon and carbon dioxide in the open atmosphere of an Australian coal seam gas field *Environ. Sci. Technol.* http://pubs.acs.org/doi/abs/10.1021/es304538g

pressures, helping gases to seep through the soil and be released to the atmosphere. They reported a 3-fold increase in maximum radon concentration inside the gas field compared to outside with a significant relationship with the number of wells. In their submission (CCoF 151) to the Australian government, they reported hotspots with concentrations of methane (CH4) as high as 6.89 ppm and CO2 as high as 541 ppm near Tara. For comparison, background atmospheric CH4 outside the gas fields were lower than 2 ppm.[16]

26. **Air Monitoring**

The USEPA states that air toxics associated with oil and gas extraction activities can cause cancer and other serious, irreversible health effects, such as neurological problems and birth defects.[17] In a 2012 US study (CCoF 162),[18] 44 hazardous air pollutants were detected at gas drilling sites over a 12 month period, with the highest percentage of detections occurring during the initial drilling phase. In Australia, a similar range of hazardous air pollutants were detected in ambient air around homes near CBM activities. These included many toxic VOCs, eg ethanol, acetone, benzene, toluene, xylene, ethylbenzene, dichlorodifluoromethane, 1,2,4-trimethylbenzene, naphthalene, phenylmaleic anhydride, methyl ethyl ketone, phenol, butane, pentane, hexane.[19] Toluene, a neurotoxin was detected in air around homes and above resident's water bore. [20] In the latter, the level was above the 'Chronic Reference Exposure Limits' used for long-term exposure by the US states of California, Massachusetts, Michigan. Sampling around gas activities with 8-hour canister detected ethanol and chlorofluorocarbons (CFCs).[21] Dichlorodifluoromethane, a potent CFCs was detected in all samples.

Preliminary health investigation by Queensland Health Department have concluded that there was some evidence that might associate some of the residents' health symptoms to exposures to airborne contaminants arising from CSG activities. [22]

27. **CSG Industry National Pollutant Inventory Reports**

In Australia, CBM companies must report their emissions to the government's National Pollutant Inventory (NPI) annually. The following table compares NPI reports from three Queensland based CBM activities.

[16] CCoF 151: Submission on National Greenhouse and Energy Reporting (Measurement) Determination 2012 - Fugitive Emissions from Coal Seam Gas. Submitted 19 October 2012 to Department of Climate Change and Energy Efficiency by Dr. Isaac Santos Southern Cross University, NSW Australia

[17] CCoF 148: http://www.epa.gov/airquality/oilandgas/pdfs/20120417presentation.pdf

[18] CCoF 161: Colborn T, Schultz K, Herrick L, and Kwiatkowski C. 2012 (in press). An exploratory study of air quality near natural gas operations. *Hum Ecol Risk Assess*

[19] CCoF 96: Symptomatology of a gas field [An independent health survey in the Tara rural residential estates and environs, April 2013

[20] CCoF 110: Queensland Department of Health Report 'Coal seam gas in the Tara region: Summary risk assessment of health complaints and environmental monitoring data', March 2013

[21] CCoF 154: Australian Government National Measurement Institute, Report of Analysis of Air Canisters Low Level, Report No. RN900555 (2 Feb 2012), Report No. RN893233 (16 Dec 2011), Report No. RN893232 (16 Dec 2011) as reported in Lloyd-Smith & M, Senjen, R Halogenated Contaminants From Coal Seam Gas Activities, Proceedings of Dioxin 2012 Conference, Cairns, Australia.

[22] CCoF 110: Queensland Department of Health Report 'Coal seam gas in the Tara region: Summary risk assessment of health complaints and environmental monitoring data', March 2013

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

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

Note: Air Total = Air Point + Air Fugitive

28. **Methane Leaks**
Fugitive emissions were evident in bubbling methane gas reported along 5 kilometre stretch of the Condamine River in Queensland, Australia. The Queensland government's initial investigation [23] notes that four CBM wells were within 5 kilometre radius of the gas seep but there was no evidence of fracking within 40 kilometres. Methane was measured at 80% of the lower explosive limit (LEL) (at river surface) equating to 4% gas in air.

29. A Queensland government study found 26 of 58 gas wells tested leaked methane; one above the lower explosive limit (LEL), 4 at or above 10% of the LEL and 21 with levels between 10-3000ppm. Similar figures were found in surrounding gas fields. [24]

C. Impacts on Water

30. **Unsustainable water use - water table drawdown**
Coal bed methane activities also use very large quantities of water, which compete with human and agricultural needs for water, raising important equity issues. This is clearly acknowledged by the CBM companies. CBM company, Santos notes '*The drawdown of ground water heads within coal seam gas aquifers is a necessary process and an unavoidable impact associated with the depressurisation of the coal seam.'* [25] There can be significant losses in pressure both within the aquifer, and/or in the overlying

[23] CCoF 152: Summary Technical Report - Part 1 Condamine River Gas Seep Investigation, December 2012 Version 1 State of Queensland, Department of Natural Resources and Mines, 2012. http://www.dnrm.qld.gov.au/mining/coal-seam-gas
[24] CCoF 195: Investigation report, Leakage testing of coal seam gas wells in the Tara 'rural residential estates' vicinity, The State of Queensland, Department of Employment, Economic Development and Innovation, 2010. http://www.dnrm.qld.gov.au/__data/assets/pdf_file/0011/119675/tara-leakage-csg-wells.pdf
[25] CCoF 277: Groundwater (Deep Aquifer Modelling) for Santos GLNG Project – Environmental Impact Statement 31/3/2009 http://www.santosglng.com/media/pdf41108/P2_Groundwater%20(Deep)%20FINAL%20PUBLIC.pdf

and underlying aquifers. Santos predicts groundwater drawdown for their CSG fields within the Bowen Basin, Queensland of up to 15 metres by 2013 and 65 metres by 2028. For the four bore wells situated in and around the fields, it was estimated they would experience 7 to 25 metres drawdown in the groundwater level by 2028. Significant drawdown of farm bores has already been experienced in the region.

31. **Contamination of groundwater**
CSG company, Shenhua Watermark Coal acknowledge that drill holes may intersect with one or multiple aquifers potentially mixing groundwater from different strata or altering the groundwater chemistry through exposure to air, gas, drilling fluids or release of natural compounds.[26] They also note interconnection of aquifers within the borehole may impact on aquifer levels.

32. BTEX chemicals were found in 5/14 monitoring wells in Queensland gas fields; benzene at levels 6 and 15 times Australian drinking water standard.[27] Toluene and methane were found in private drinking water bore adjacent to gasfields.[28]

33**. Produced Water**
Estimates of 0.3 megalitres of produced water per day are consistent with Australian industry estimations of 0.1 - 0.8 ML/day. [29] Produced water may be contaminated with heavy metals, naturally occurring radioactive materials (NORMs), salts, BTEX, semivolatile organic compounds and drilling chemicals etc. Large quantities of salts are a CBM byproduct.[30]

34. High levels of lead, mercury, chromium, hydrocarbons and phenols were detected in produce water, seven months after a spill in the Pilliga Forest Australian CSG gas field.[31] In 2011, bromine was detected in treated produced water released by Eastern Star Gas at six times background levels. Methane was also detected at 68 micrograms per litre (ug/l), whereas it was not detected in the upstream control sample.[32] Water samples taken from the top of the well-head found bromodichloromethane, dibromochloromethane, bromoform, chloroform, benzene, chromium, copper, nickel and zinc. [33]

35. While the WMP (paragraph 3.54) acknowledges that a range of impurities can be dissolved in the water associated with coal seams and bought back to the surface, the treatment of these impurities is not addressed only the requirement to remove iron and buffer pH is mentioned in the WMP. The WMP (paragraph 3.44) also states that prior to discharge the water will be sampled but there are no details provided as to the scope, type or frequency of the sampling.

36. **Water Treatment - Gas distribution and water treatment facility (GDWTF)**
The proposed treatment for the produced water may not be adequate to ensure all contaminants are removed. It relies on a simple process of polyelectrolyte dosing and mixing to enhance coagulation, followed by flocculation using a polymer flocculant for sludge settlement. The polymer is not identified and there is no discussion of the polymer toxicity, residual polymer in the final effluent or polymer degradation, all relevant for disposal into aquatic environments. This information must be supplied before any permission is granted.

37. **Evidence of Water Contamination in the US**
In 2011, US EPA investigation of water contamination in 23 drinking water wells near natural gas

[26] CCoF 160: Shenhua Watermark Coal Pty Ltd, Review of Environmental Factors Exploration Drilling and Associated Activities -EL 7223 February 2011 GHD-RPT-EXP-DRL-007 [1] Revision 1
[27] CCoF 278: Media Release 'Arrow advises of monitoring results' 26 August 2011
[28] CCoF 282: Simtars Investigation of Kogen Water Bore (RN147705) -16 October 2012
[29] CCoF 155: CSG and water: quenching the industry's thirst, Gas Today Australia — May 2009
[30] CCoF 159: Tim A. Moore, Coalbed methane: A review, *International Journal of Coal Geology* 101 (2012) 36–81
[31] CCoF 158: Flint, C & Hogan, N, THE TRUTH SPILLS OUT: A Case Study of Coal Seam Gas Exploration in the Pilliga, May 2012 Report for Northern Inland Council for the Environment The Wilderness Society Newcastle
[32] Analytical Results ES1118565, 25-AUG-2011 East West Enviroag Project No. EW110647 as cited in CCoF158 The Truth Spills Out.
[33] CCoF 154: Labmark Environmental Laboratories, Certificate of Analysis, Report 331850-W Composite: Roma Water Analysis, Mar 26, 2012 as reported in Lloyd-Smith & M, Senjen, R Halogenated Contaminants From Coal Seam Gas Activities, Proceedings of Dioxin 2012 Conference, Cairns, Australia.

extraction sites detected high concentrations of benzene, xylenes, gasoline range organics, diesel range organics, and other hydrocarbons in groundwater samples from shallow monitoring wells near pits indicated that they were a source of shallow ground water contamination. They concluded that compounds associated with hydraulic fracturing had contaminated the aquifer at or below the depths used for domestic water supply.[34] Elevated levels of dissolved methane in domestic wells generally increased with proximity to gas wells. A review of complaints in four US states, showed more than 100 cases of pollution being confirmed in Pennsylvania alone.

38. **Methane in Drinking Water**
Methane contamination of water was evident in 60 water wells near active gas wells in the US.[35] Contamination at 19 to 64 parts per million was above US federal government safety guidelines. The majority were situated one kilometre or less from a gas well. Wells more than a kilometre from active gas wells had only a few parts per million. In a follow up 2013 study, distance to gas wells was found to be the most significant factor. Water wells close to gas-drilling sites had methane levels more than six times higher than more distant wells.[36] As stated earlier, methane was found in private drinking water bores adjacent to Australian gasfields.[37]

39. **Endocrine disrupting chemicals**
In a 2013 study[38] surface and groundwater near sites experiencing high levels of unconventional gas activity in Colorado contained endocrine-disrupting chemicals and showed moderate to high levels of endocrine-disrupting chemical (EDC) activity, while samples taken from sites with little drilling showed little EDC activity. Exposure to EDCs can increase the risk of reproductive, metabolic, neurological, and other diseases, especially in children and young organisms.

D. Conclusions
40. UNEP has acknowledged in its environmental global alert on unconventional gas (UG), "UG exploitation and production may have unavoidable environmental impacts" some risks occurring if the technology is not used adequately, but others occurring despite proper use of technology, including GHG emissions, water contamination, air and soil contaminants; and impacts on biodiversity, food supply and on soil.[39] Although the CBM industry is still in its infancy in Australia, evidence of negative impacts e.g. air pollution, water contamination, lowering of the water table and waste management challenges, are already apparent. These risks have not been adequately assessed and the mitigation of possible impacts has not been examined in Dart Energy's proposal for CBM production at Airth, Scotland.

[34] CCoF 279: http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-2011.pdf
[35] CCoF 280: Osborn, SG, A Vengosh, NR Warner, RB Jackson. 2011. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. http://www.nicholas.duke.edu/cgc/pnas2011.pdf
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