Submission in response to the *Background and Issues Paper* for the Inquiry into Hydraulic Fracturing in the Northern Territory.

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Author background and relevant expertise

I have been working in tropical agriculture and in particular the semiarid tropics which embraces much of the Northern Territory for more than 45 years, employed by Government Research Organisations, Universities, International Agencies including the International Crops Research Institute for the Semiarid Tropics, and consultations for the Consultative Group on International Agricultural Research, World Bank, FAO, UNDP,UNEP. AusAID, USAID, UKODA, GIZ, Rockefeller Foundation. I have been advising the Condamine Irrigators on the Darling Downs in their response to the Arrow Energy Surat Gas Project EIS preparing a background report for a Land Court case and have coordinated 3 public forums on Gas and Mining Projects in Brisbane and Sydney which were attended by more than 1000 participants. My research is in soil science especially soil biology and plant nutrition, farming systems and animal production, and am currently involved in developing a probiotic for cattle production that would be used in the grass fed systems in northern Australia in the Advance Queensland Innovation Partners Project "*Biomanufacturing advanced animal feed supplements*" with UQ, QUT and 3 commercial company partners. I have published more than 160 peer reviewed papers, 14 book chapters and 30 consultancy reports.

Risks associated with mining and fracking for unconventional gas.

1. In this submission I summarise my analysis of the risks associated with the extraction and handling of unconventional oil and gas production (OUG) and would be happy to expand on the issues raised if deemed helpful to the inquiry. The risks involved can have considerable impact on the environment, households, urban and domestic water supplies and agricultural production systems that indicate that the precautionary principle (Randall 2011) should prevail in Government regulation and management of the process (Randall 2012; Chen and Randall 2013). These risk factors need to be addressed in the context of the life cycle of gas production and use. Unconventional gas and oil extraction can result in contamination of aquifers with chemicals such as benzene, toluene, ethylbenzene, xylenes compounds (BTEX) (Gross et al 2013), radioactive nucleides such as uranium and radon (Casey et al 2013; Atkins et al 2016), salts and methane that fracking can exacerbate (EPA 2016). Recent research on US OUG production systems have indicated that these risks can eventuate into events (eg Jackson et al 2014; DiGuillo et al 2016; Patterson et al 2017, EPA 2015). New equipment has enabled the monitoring of methane levels from aeroplanes and moving vehicles over large areas (eg Caulton et al 2014) showing that fugitive methane leaks can account for 2 to 14% of the gas produced which contributes a considerable impact on global warming, with these emissions in the main being due to OUG particularly extraction from shale strata where fracking is a normal component of the operational process.

2. Comprehensive analyses including isotope analysis collated by the US EPA in a major report has shown that aquifers can be contaminated by the production process as a result of fracking (EPA 2016) through water seeping from leaking wells, from faults induced by fracking and depressuring of the gas source associated with the extraction process, or from surface spills of produced water involved in the fracking process or contaminated water from the gas source *per se*. The EPA found that fracking contributes to drinking water contamination during all stages of the process:

- Water withdrawals for hydraulic fracturing in times or areas of low water availability, particularly in areas with limited or declining groundwater resources
- Spills during the management of hydraulic fracturing fluids and chemicals or produced water that result in large volumes or high concentrations of chemicals reaching groundwater resources
- Injection of hydraulic fracturing fluids into wells with inadequate mechanical integrity, allowing gases or liquids to move to groundwater resources
- Injection of hydraulic fracturing fluids directly into groundwater resources
- Discharge of inadequately treated hydraulic fracturing wastewater to surface water resources
- Disposal or storage of hydraulic fracturing wastewater in unlined pits, resulting in contamination of groundwater resources

3. Faults in well casings and cement linings are not uncommon when drilling to depths particularly greater than 1000m as likely (and proposed) for the OUG extraction from the deep Proterozoic shales in the Beetaloo resource area. Such processes continue long after the well has been abandoned for gas extraction. This is likely to be a much greater risk to the aquifers lying above than the fracking process *per se*.

4. Spills of produced water occurred at a rate of 15% of wells each year in the first 3 years of operation in North Dakota, one of four USA states where spills were monitored in detail (Patterson et al 2017). Isotope analysis has been used in Gippsland Victoria to determine the origin of methane in groundwater (Currell et al 2016). Also at a catchment level, spatial and temporal baseline assessment of methane, carbon dioxide and organic carbon in the subtropical Richmond River system in Northern NSW (Atkins et al 2017) was conducted on behalf of the Northern Rivers Regional Council as a prelude to proposed CSG mining in the catchment, now apparently not going ahead because of the local political pressure. The Southern Cross University group had previously shown that in the Condamine River area considerable atmospheric methane levels were associated with the CSG development in the Surat Basin area where fracking had occurred (Maher et al 2014). These were likely related to the dewatering and depressuring process in the gas mining allowing the methane released from the coal bed to seep through the soil along with fugitive emissions from mining equipment. Such releases are dramatically demonstrated in the bubbling of methane in the Condamine River. Once initiated there is no way currently known to stop this fugitive emission process except to stop further well drilling into such permeable and shallow geological formations.

5. Such aquifer and soil contamination risks makes it behoven on the NT Government to develop a robust regulatory, reporting and monitoring system to manage this OUG development including strict regulations around fracking to reduce aquifer contamination and fugitive methane leaks. The information required of the OUG operators and Government monitoring should be publicly available in order to remove or mitigate risk factors and improve environmental performance of the industry. This data needs to be assembled in a centralised electronic data base to enable rigorous analysis by all stakeholders including nongovernment agents. These issues have been addressed by Currell et al (2017) when discussing the "problems with the application of hydrology to regulation of Australian mining projects" using the example of the Carmichael Mine and Doongmabulla Springs

- "*Greater emphasis should be place on identifying and resolving scientific uncertainties relating to groundwater during the upfront environmental impact assessment (EIA)*
- *There needs to be a stronger role for independent scientific opinion in the approvals process*
- *Monitoring criteria and proposed mitigation strategies should be available for public review and scrutiny prior to project approval*"

These matters relate to paragraphs 11, 13 and 14.

6. Baseline data before OUG exploration and extraction begins is critical to monitoring the extent to which identified risks develop into actuality so that ameliorative mitigating action can be initiated as soon as possible and before the risk develops into an event for which make good provisions are just not available or feasible. This involves a requirement for mandated continual monitoring for fugitive emissions and water contamination through produced water spills or pipe or fault line and fracture leaks, the results of which are publicly available.

7. A major risk to the environment and to agriculture is the effect of the gas gathering lines (pipes) and roads on weed invasion from seeds transported by vehicles (see review by Adkins and Morgan 2015;). This has already occurred in Queensland with seismic investigations for mining resulting in invasion with pernicious, notifiable weeds such as Parthenium (Adkins pers comm). The Queensland Government regulations for wash down before entry to a site by company vehicles is inadequate as the recommended facilities do not remove all the weed seeds (Khan et al 2017). Disposal of the wash down products is also not a trivial task and needs to be properly regulated. The construction of roads to the well sites can also affect the surface hydrology leading to major erosion and this is particularly important where there are likely to be intensive rainfall events and these are becoming more likely with climate change. These risks are augmented by the fracking process because of the need for extra vehicle movement to bring in water and chemicals for the fracking and removal of produced water.

8. Fracking chemicals can be toxic and many of those used in the USA are (eg fracking mixtures supplied by Haliburton contain BTEX) and companies do not want to disclose their trade secret mixtures. This should not occur in the NT and a public detailing of all chemicals used and their concentrations should be mandated and any known toxic chemicals banned from use. OUG development companies will argue that it is not the nature of the chemical

per se that is the issue but rather its concentration. When materials come in concentrated form to be then mixed into the fracking mixture, spills can occur and hence no such toxic chemicals should be allowed regardless of the concentration used.

9. Landholders including Government (eg National Parks and leasehold land) and Native Title Land Holders need to be fully informed of the processes that the OUG companies are planning to undertake and to have the option of refusing to allow such operations on the land they are stewards of, as occurs in the USA.

10. Landholders on which OUG operations occur need to be adequately compensated for allowing the OUG companies to work on "their" land. This includes taking into account the long term consequences of movement of contaminants through aquifers and time taken to recharge aquifers that are used for water for the fracking process. Volumes of such waters used need to be subject to the same strict rules for access to Great Artesian Basin and other aquifer waters and for amounts used, as for other users such as landholders, households and urban settlements and need to be carefully calculated based on recharge rates to avoid major aquifer draw down such as has occurred from CSG extraction in parts of the Walloon aquifer in the Surat Basin, Queensland.

11. Strict Government Regulations are required to minimise fugitive emissions including base line measures before the OUG operations commence and regularly thereafter and include specific requirements to minimise the methane lost through pipes and the venting of accumulated water from pipes. Continuing monitoring of atmospheric methane levels around OUG operations is required to detect and prevent atmospheric contamination and to enable the NT Government to adhere to its greenhouse gas (GHG) release targets

12. Storage of produced water eg in evaporation dams, needs to be strictly regulated and monitored to prevent contaminant movement into the soil and eventually groundwater and aquifers. Such regulations have eventually been introduced in Queensland ruling out the use of evaporation dams and with strict requirements for the quality of temporary storage dam liner material and its joining, the monitoring of leaks and height of containing wall to reduce the risk of overflow in a rare major rainfall event. Such dams require continual monitoring for leaks and dam liner integrity by the Government monitors. The treatment of the stored produced water needs to be regulated. Evaporation is not a preferred option and has been banned in Queensland. As the produced water is likely to be contaminated it should not be injected into aquifers as a disposal mechanism or onto land surface without treatment to remove the contaminants. Otherwise environmental damage, most likely irreparable, can occur. It is costly to decontaminate such water and in the case of CSG co-produced water in Queensland the very costly option of reverse osmosis has been adopted (IESC 2014) with two large plants operating.

13. Mitigation of the risks involved in OUG require appropriately detailed and comprehensive Regulations that instigate processes and data gathering that are required for an integrated land use and maintenance of environmental integrity planning process by Government. Such planning processes need to be transparent with opportunities for input by community as well as developer stakeholders at each stage of consultation regarding the development or land use change. Such an appropriately devised planning process would then lead to a consensus indicating when a particular development such as OUG can occur and under what conditions. This would reduce the requirements to be addressed in an EIA

and avoid the use by developers of volume of words produced in an EIA as a process to perplex/confuse assessors both in Government and the general public stakeholders.

14. The cost to Government of managing an OUG development in order to fulfil its fiduciary obligations towards the environment and its citizens is considerable. Such costs need to be underwritten by the companies undergoing such development either as a direct payment for the cost of undertaking required activities, undertaking the activities themselves in a regulated manner, or through an appropriate royalty level to cover Government monitoring costs (including the devising of appropriate rules and regulations, and auditing of OUG company and Government monitoring reports).

15. A major support for the NT Government in managing any OUG development and especially with fracking involved would be to commission a Technical Advisory Panel who are not connected to the OUG industry but have appropriate, comprehensive expertise in dealing with the issues raised in this paper as argued in Currell et al (2017). Dr Matthew Currell from RMIT who has reported to the Victorian Government on fracking, and Professor Adrian Werner, Flinders University who is a hydrologist working on these issues and who consults internationally and who has recently been a hydrology expert witness to the Land Court cases in Queensland for Acland 3 and Carmichael Mine Adani development, and Professor John Quiggan, an Australian Laureate economist at the University of Queensland who has been on Federal Government committees on matters related to this enquiry as well as being an expert witness in Land Court cases dealing with mining issues.

References

Adkins SW, Morgan D. 2015. APGA and EPCRC weed scoping study and weed seed spread by vehicles: a case study from south east Queensland. Review prepared for the Australian Pipelines and Gas Association (APGA) 14pp

Atkins ML, Santos IR, Maher DE. 2015. Groundwater methane in a potential coal seam gas extraction region. Journal of Hydrology Regional Studies. 4, 452-471

Atkins ML, Santos IR, Perkins A, Maher DT. 2016. Dissolved radon and uranium in groundwater in a potential coal seam gas development region (Richmond River Catchment, Australia). Journal of Environmental Radioactivity 154, 83-92

Atkins ML, Santos, IR, Maher, DT. 2017. Seasonal exports and drivers of dissolved inorganic and organic carbon, carbon dioxide, methane and $\delta^{13}C$ signatures in a subtropical river network Science of the Total Environment 575 (2017)545–563 https://doi.org/10.1016/j.scitotenv.2016.09.020

Casey JA, Ogburn EI, Rasmussen SG, Irving JK, Pollak J, Locke PA, Schwarzts BS. 2015. Predictions of indoor radon concentrations in Pennsylvania 1089-2013. Environmental Health Perspectives. DOI: 10.1289/CHP.1409014

Caulton, R. et al. 2014. Toward a better understanding and quantification of methane emissions from shale gas development. Proceedings of the National Academy of Sciences USA. 111(17) 6237-6242

Chen, C. and A. Randall. 2013. "The economic contest between coal seam gas mining and agriculture on prime farmland: it may be closer than we thought", Journal of Econom ic and Social Policy 15(3), Article 5.

Currell MJ. 2016 Geochemical indicators fo the origins and evolution of methane in groundwater : Gippsland Basin, Australia. Environmental Science and Pollution Research. DOI 10.1007/S11356-7290-0

Currell MJ, Werner AD, McGrath C, Webb JA, Berkman M. 2017. Problems with the application of hydrogeological science to regulation fo Australian mining projects: Carmichael Mine and Doongmabulla Springs. Journal of Hydrology 548, 674-682 https://doi.org/10.1016/j.jhydrol.2017.03.031

DiGiulio, D. C.; Jackson, R. B. 2016. Impact to Underground Sources of Drinking Water and Domestic Wells from Production Well Stimulation and Completion Practices in the Pavillion, Wyoming, Field. Environmental Science and Technology. 50 (8), 4524−4536.

EPA. Environmental Protection Agency. 2015. Review of State and Industry Spill Data: Characterization of Hydraulic Fracturing Related Spills. Office of Research and Development, Washington, DC. EPA/601/R-14/001.

EPA. Environmental Protection Agency. 2016. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. EPA-600-R-16-236ES. December 2016. Executive summary https://www.epa.gov/sites/production/files/2016-12/documents/hfdwa_executive_summary.pdf

Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States, Executive Summary (EPA/600/R-16/236es) (PDF) (50 pp, 8 MB, about PDF)

Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States, Main Report (EPA/600/R-16/236fa) (PDF) (666 pp, 48 MB, about PDF)

Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States, Appendices (EPA/600/R-16/236fb) (PDF) (572 pp, 10 MB, about PDF)

Gross SA, Avens HJ, Banducci AM, Sahmel J, Panko JM, Tvermoes BE. 2013. Analysis of BTEX groundwater concentrations from surface spills associated with hydraulic fracturing operations.. J. Air Waste Manage. Assoc. 63 (4), 424−432.

IESC. 2014. Fact sheet Coal seam gas extraction and co-produced water. Independent Expert Scientific Committee. 5pp file:///C:/Users/agpdart/Documents/Assoc/NT%20Fracc/fact-sheet-coal-seam-gas-extraction-co-produced-water.pdf

Jackson R B, Vengosh A, Carey JW, Davies RJ, Darrah TH, O'Sullivan F, Pétron G. 2014. The Environmental Costs and Benefits of Fracking. Annual Review of Environment and Resources. 39, 237−362.

Khan I, Navie S, George D, O' Donnell C, Adkins SW. 2017. Alien and native plant seed dispersal by small vehicles. Australian Ecology in press

Maher DT, Santos IR, Tait DR. 2014. Mapping methane and carbon dioxide concentrations and ∂^{13}C values in the atmosphere of two Australian coal seam gas fields. Water, air, soil Pollution 225, 2216

Randall, A. 2011. Risk and Precaution. Cambridge University Press, UK and US.
Randall, A. 2012. Coal seam gas – toward a risk management framework for a novel intervention. Environmental and Planning Law Journal EPLJ 29,152-162.