LOCK THE GATE ALLIANCE
AUSTRALIANS WORKING TOGETHER TO PROTECT OUR LAND, WATER, AND FUTURE

Submission to the NT Scientific Inquiry into Hydraulic Fracturing and Associated Activities

April 2017

Introduction

Lock the Gate Alliance is a national grassroots organisation made up of thousands of individuals and over 250 local groups who are concerned about unsafe or inappropriate mining. The mission of the Lock the Gate Alliance is to protect Australia's agricultural, environmental, and cultural resources from inappropriate mining and to educate and empower all Australians to demand sustainable solutions to food and energy production. Lock the Gate Alliance is committed to advocating for environmental and community health, and the productivity of local economies.

Lock the Gate Alliance wholeheartedly welcomes this Inquiry. The Alliance appreciates the opportunity to make a submission on the existing and potential impacts of the unconventional shale gas industry in the Northern Territory and the impacts on Territory communities, local environments, land and water resources on which they depend.

This submission is has two sections. The first considers the NT Fracking Inquiry's Background and Issues Paper, provides opening comments, detailed evidence and feedback in relation to risks identified and any recognized gaps. Throughout the first section, we aim to provide insights and examples of the gaps in data and knowledge, to provide clear feedback to questioning by the Panel of Naomi Hogan at the Inquiry Hearing on Friday 10 March 2017. The second section is a copy of the Lock the Gate Alliance's Powerpoint presentation provided to the Fracking Inquiry Panel, with a notes page with full references for all information provided.

Section 1: Response to the Background and Issues Paper

Opening Comments of Relevance to the Paper in General

Following two and a half decades of rapid development that has seen a massive expansion in the unconventional gas (UG) industry across twenty one states of the USA, there is a growing body of scientific literature detailing the many negative impacts of unconventional gas extraction, in particular shale gas extraction, including hydraulic fracturing (fracking) processes.

In the last few years, the state of knowledge about the risks and harms of unconventional gas mining has grown exponentially. When the New York State (NYS) Department of Health released its final Public Health Review[1] of fracking in December 2014, the number of studies in the peer-reviewed scientific literature exceeded 400, up from the 60 studies that existed two years previously in a similar review by the NYS Department of Conservation.

Summarized below is a list from the NYS Public Health Review outlining some of the environmental impacts and health outcomes that have been associated with UG operations:

- Air impacts that could affect respiratory health due to increased levels of particulate matter, diesel exhaust, or volatile organic chemicals.

- Climate change impacts due to methane and other volatile organic chemical releases to the atmosphere.

- Drinking water impacts from underground migration of methane and/or fracking chemicals associated with faulty well construction.

- Surface spills potentially resulting in soil and water contamination.

- Surface-water contamination resulting from inadequate wastewater treatment.

- Earthquakes induced during fracturing.

- A range of health complaints and impaired health outcomes among residents living near HVHF [fracking] activities.

- Community impacts associated with boom-town economic effects such as increased vehicle traffic, road damage, noise, odor complaints, increased demand for housing and medical care, and stress.

Additionally, the NYS Health Department review notes that an evaluation of the available research on fracking impacts reveals critical information gaps. They state: “These need to be filled to more fully understand the connections between risk factors, such as air and water

[1] New York State Department of Health (2014) A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development: http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

pollution, and public health outcomes among populations living in proximity to HVHF [fracking] shale gas operations."[2]

The environmental impacts outlined in the NYS Health Department review and their potential adverse effects on public health led the Department to recommend to the state government that fracking should not proceed in the State of New York. (The NYS legislature subsequently announced plans to impose a ban on fracking in the state).

The New York based health organization, the *Concerned Health Professionals of New York,* have compiled the *Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking*[3] (the *Compendium*) - "a fully-referenced compilation of the evidence for the risks and harms of fracking that brings together findings from the scientific and medical literature, government and industry reports, and journalistic investigation." The Lock the Gate Alliance has worked through that report to pull out some of the summaries of peer-reviewed papers that demonstrate risks and impacts of the shale gas fracturing industry of relevance to this inquiry and the Northern Territory.

The growing evidence of actual harm, and the potential environmental and health risks from shale gas development, has now resulted in decisive action from governments across the globe to halt the expansion of this industry. Internationally, jurisdictions with some form of ban or moratorium in place include Scotland, Wales, Germany, Bulgaria, Romania, the Netherlands, Northern Ireland, Wales, the Czech Republic, Luxembourg and France as well as the US States of New York, Maryland, Florida and Vermont and the Canadian Provinces of New Brunswick, Newfoundland, Nova Scotia and Quebec.

In addition to the science, the Lock the Gate Alliance developed initial concerns with unconventional gas extraction from the lived experience of farmers and rural communities in Queensland. There are over 5000 coal seam gas (CSG) wells producing gas in that state[4], with an additional 20,000 wells already approved. The rush to exploit CSG in Queensland and convert it to LNG, never previously attempted, has done lasting damage to the water resources and communities of the affected areas, and has had drastic negative economic consequences, rapidly driving up the price of gas for domestic consumers and industry, and throwing regional economies into turmoil. In Queensland, the approvals for large scale CSG projects were done in

[2] Ibid.
[3] Concerned Health Professionals of New York & Physicians for Social Responsibility. (2016, November 17). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (4th ed.). http://concernedhealthny.org/wp-content/uploads/2016/12/COMPENDIUM-4.0_FINAL_11_16_16Corrected.pdf
[4] QLD CSG Production, 6 Monthly Statistics: https://data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics/resource/63a8a6cc-7fb6-4040-b4e7-9d453b14d3ed

haste and implemented before communities knew of the potential impacts and without any opportunity for them to object to the industry being imposed upon them.

The expanding scientific literature, coupled with the lived experience of unconventional gas extraction operations in Australia, and concurrent research of the impacts of shale and tight gas extraction from across North America, provides the basis of this submission to the NT Fracking Inquiry.

Specific responses to sections of the Background and Issues Paper:

Section 3.1 – The difference between conventional and unconventional gas

We recommend this further information is included in the comparison:

As unconventional gas is found in less permeable deposits or spread more diffusely throughout rock substrates than conventional (or so-called "natural") gas, rather than in discrete pockets or reservoirs, it is more difficult to extract and therefore requires more specialized (i.e. 'unconventional') extraction techniques and processes. The methods required for the extraction of unconventional gas include hydraulic fracturing (fracking), horizontal drilling and multiple drilling. In addition to these extra processes, unconventional gasfields involve the industrialisation of entire landscapes with hundreds and often thousands of wells and ancillary infrastructure.

Unconventional Oil and Gas Magazine uses the following statement to highlight some of the differences and the need for more wells in unconventional gas extraction: "*High permeability rock equals higher flow rates and lower cost development by virtue of requiring a lesser number of wells (e.g. for sandstone and limestone reservoired gas) and by contrast lower permeability rock (e.g. shale, coal, and tight sandstone reservoired gas) equals lower flow rates and higher cost development as more wells are required to achieve the same flow rate*."[5]

More wells equals more risk. Shale gas fracking equals more water and more chemicals injected under higher pressures, producing more waste to get less gas. Whether shale wells are placed closely together or evenly spread across the landscape at about 1km intervals, the number of high number wells remains an inescapable reality of the industry.

This infrastructure includes vast networks of roads and pipelines, gas compressor stations and processing plants, and wastewater holding dams and treatment facilities. The number of wells required and area of land impacted is exponentially larger than for conventional gasfields. In summary, the technologies of scale and spatial intensity of unconventional gas development,

[5] Unconventional Oil and Gas, (2016). http://www.unconventionaloilandgas.com.au/east-coast-gas-prices-will-stimulate-the-search-for-new-resources/

both at the surface and underground, makes it an entirely different proposition to conventional gas extraction. (For a useful explanation of scale and intensity of shale gas activities in comparison to conventional gas, see Professor Tony Ingraffea's December 2015 testimony to the South Australian Fracking Inquiry, **Attachment A**).

Section 3.5 Chemicals used in hydraulic fracturing

We recommend this section of the Paper would be strengthened with the inclusion of more recent peer reviewed science and analysis of the measured impacts of chemical use in hydraulic fracturing. For example, the 2014 paper *Environmental Public Health Dimensions of Shale and Tight Gas Development* discusses the body of scientific literature relevant to the environmental public health impacts of shale gas production.

Based on the literature available, here is an excerpt regarding chemicals used in hydraulic fracturing[6]:

Hydraulic Fracturing Fluids: Chemical Toxicology and Exposure Pathways

Shale gas development uses fracturing fluids that contain organic and inorganic chemicals known to be health damaging (Aminto and Olson 2012; U.S. House of Representatives, Committee on Energy and Commerce 2011). Fracturing fluids can move through the environment and come into contact with humans in a number of ways, including surface leaks, spills, releases from holding tanks, poor well construction, leaks and accidents during transportation of fluids, flowback and produced water to and from the well pad, and run-off during blowouts, storms, and flooding events (Rozell and Reaven 2012). Further, the mixing of these compounds under conditions of high pressure—and often high heat—may synergistically create additional potentially toxic compounds (Kortenkamp et al. 2007; Teuschler and Hertzberg 1995; Wilkinson et al. 2000). Compounds found in these mixtures may pose risks to the environment and to public health through numerous environmental pathways, including water, air, and soil (Leenheer et al. 1982).

Chemicals are used in drilling and fracturing processes as corrosion inhibitors, biocides, surfactants, friction reducers, gels, and scale inhibitors, among others (Aminto and Olson 2012; New York State Department of Environmental Conservation 2011; Southwest Energy 2012). These chemicals include methanol, ethylene glycol, naphthalene, xylene, toluene, ethylbenzene, formaldehyde, and sulfuric acid, some of which are known to be toxic, carcinogenic, or associated with reproductive harm (Colborn et al. 2011; New York State Department of Environmental Conservation 2011). Many of these compounds are considered

[6] Shonkoff, Hays and Finkel, 2014, Environmental Public Health Dimensions of Shale and Tight Gas Development, *Environ Health Perspect*; DOI:10.1289/ehp.1307866 https://ehp.niehs.nih.gov/1307866/

hazardous water pollutants and are regulated in other industries (Clean Water Act of 1972; Safe Drinking Water Act of 1974; U.S. House of Representatives 2011).

Many of the chemical compounds used in the fracturing process lack scientifically based maximum contaminant levels, making it more difficult to quantify their public health risks (Colborn et al. 2011). Moreover, uncertainty about the chemical makeup of fracturing fluids persists because of the limitations on required chemical disclosure, driven by the Energy Policy Act of 2005. For instance, in many states, companies are not mandated to disclose information about the quantities, concentrations, or identities of chemicals used in the process on the principle that trade secrets might be revealed (Centner 2013; Centner and O'Connell 2014; Maule et al. 2013).

Section 7. The possible risks or issues associated with hydraulic fracturing

The Lock the Gate Alliance notes that submissions are invited to comment on what the acceptable levels of risk might be and how these levels might be achieved.

Firstly, unconventional gas development comes with a large number of known deleterious impacts. These include land use intensification, fragmentation, disruption to agricultural operations and alienation of agricultural land, large water demand, vegetation clearing and the production of polluting waste. These are not risks – they are known impacts. It is also known that the development of unconventional gas will produce substantial greenhouse gases that will contribute to global warming both during the extraction process and when finally used to create electricity or in other industrial processes.

On top of those known and accepted impacts, there are many very serious risks, which are frequently more difficult to quantify or assess. These include risks to groundwater and surface water resources, risks to public health and risks of induced seismicity, damage to existing industries, as well as far-reaching risks to social cohesion and wellbeing.

For example, across the vast majority of the Northern Territory, regional drinking water supplies, stock water, industry, tourism places, cultural sites and regional economies are entirely dependent on groundwater. Any level of risk to the Northern Territory's groundwater poses a direct risk to regional communities and the Territory economy.

There are other proven and long term options for providing energy to the Northern Territory that do not carry risks to groundwater, or the other risks and known impacts that are associated with unconventional gas. There are also numerous other ways to stimulate growth in the Territory economy and population that do not put entire communities and their water supplies at risk of pollution from the shale gas fracking industry. Therefore, we invite the Panel to consider why Territorians should accept any level of risk to their water supply at all, if there is no need?

Overall, the scale of the risks is perhaps best quantified by reference to recent US research which involved a literature review of all 685 peer reviewed papers on unconventional gas in the US as of the end of 2015[7]. The review found that:

- 84% of public health studies contain findings that indicate public health hazards, elevated risks, or adverse health outcomes;
- 69% of water quality studies contain findings that indicate potential, positive association, or actual incidence of water contamination; and
- 87% of air quality studies contain findings that indicate elevated air pollutant emissions and/or atmospheric concentrations.

We believe that summary of the peer reviewed literature on risks combined with the known serious impacts caused by this industry, is sufficient to confirm that the risks are far, far too high.

This submission offers an overview of recent scientific evidence to demonstrate the risks and measured negative impacts of the unconventional gas industry, both in Australian and internationally. We encourage the Panel to consider for the Northern Territory: Who bears the brunt of these negative impacts risks and for how long into the future will these risks carry? What impacts have been measured across all projects to date and what risks are entrenched through geological reality or the shale gas extraction process itself, and therefore cannot be regulated away?

A further consideration in risk assessment is the environment in which the shale gas industry is proposed to operate. For example, have risk assessors measured what will be put at risk? Assessments to determine the baseline water quality and quantity available, the pre-existing health of communities to be impacted, the cultural significance of a landscape or the agricultural output and viability of an area – these are all required to help judge whether risks are acceptable. Risk mitigation would also be aided by knowledge of fault lines and other geological or landscape attributes that are known migration pathways for methane[8].

It is apparent that the scale, nature and diversity of risks and impacts that unconventional gas poses means that it is entirely inappropriate to manage it through an adaptive management regime. Too many of the risks are irreversible and too much is at stake for communities and industries forced to deal with the industry, to leave it to a 'suck it and see' approach. In the NT, we have the benefit of being able to see the impacts that have occurred in the US and to take

[7] Hays J, Shonkoff SBC (2016) Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed Scientific Literature, 2009-2015. PLoS ONE 11(4): e0154164. doi:10.1371/journal. pone.0154164

[8] http://energy.unimelb.edu.au/__data/assets/pdf_file/0019/2331604/Migratory_emissions_20160913.pdf

action to avoid them. We should not be subjecting our population here to an uncontrolled experiment in large-scale gasfield developments in a world class natural environment.

7.1. Water

Unconventional gas development has the potential to negatively impact on the Northern Territory's water resources, which in many instances are considered already fully allocated and/or gradually diminishing as a finite resource.

Water resources can be impacted by both contamination and depletion as a result of UG development, as outlined by the following evidence.

Water Quality

Groundwater

During fracking processes, contamination of underground water resources with flowback fluids can occur via a number of pathways. These include: migration of fluids via natural pathways in underground geologies; via pathways created by the fracking process; or as a result of well blow outs and well casing failure[9]. Flowback fluids contain hazardous fracking chemicals as well as naturally occurring toxic substances released from target geological zones such as methane, BTEX (benzene, toluene, ethylbenzene, xylene), polycyclic aromatic hydrocarbons (PAHs), naturally occurring radioactive materials (NORMs), heavy metals and other volatile organic compounds (VOCs)[10].

Researchers have shown that liquid waste from shale gas fracking operations is chemically different than waste flowing out of conventional wells and hypothesize that the hydraulic fracturing process itself liberates elements from clay minerals in the shale formations, including boron and lithium, which then enter the liquid waste.[11]

International science now clearly confirm the fact that drilling, fracking and other aspects of unconventional gas development inherently threaten groundwater and have contaminated drinking water sources in the United States.

---

[9] National Toxics Network, 2013, Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources http://www.ntn.org.au/wp/wp-content/uploads/2013/04/UCgas_report-April-2013.pdf

[10] Ibid.

[11] Warner, N. R., Darrah, T. H., Jackson, R. B., Millot, R., Kloppmann, W., & Vengosh, A. (2014). New tracers identify hydraulic fracturing fluids and accidental releases from oil and gas operations. Environ. Sci. Technol., 48(21), 12552–12560. doi: 10.1021/es5032135

For example:

- Widespread drinking water contamination throughout the heavily drilled Barnett Shale region in northern Texas, where 550 water samples from public and private water wells, found elevated levels of 19 different hydrocarbon compounds associated with fracking (including the carcinogen benzene and the reproductive toxicant, toluene), detections of methanol and ethanol, and strikingly high levels of 10 different metals.[12]
- In the first fully documented case of a commonly used fracking chemical entering a drinking water source, researchers found the presence of a fracking-related solvent in private drinking water wells near drilling and fracking operations. Study authors propose that "the most likely explanation of the incident is that stray natural gas and drilling or [hydrofracking] compounds were driven ~1-3 km along shallow to intermediate depth fractures to the aquifer used as a potable water source."[13]
- Elevated levels of methane in groundwater discharging into a stream near drilling and fracking operations in Pennsylvania along with high levels of methane in nearby private water wells as a result of gas migration near a gas well with a defective casing. The monitoring technique used in this study allowed researchers to demonstrate that the source of the methane was shale gas from the Middle Devonian period, which is the kind of gas found in the Marcellus Shale.[14]
- Comparison of pre-drill and post-drill data on water quality found changes in water chemistry that coincided with the advent of drilling and fracking activities. Elevated levels of chloride, iron, barium, strontium, and manganese were found with concentrations exceeding health-based maximum contaminant levels in some cases. Methane was also detected in most houses tested in this study.[15]

A 2016 study by Stanford University scientists determined that fracking and related oil and gas operations have contaminated drinking water in the town of Pavillion, Wyoming where residents have long complained about foul-tasting water. The researchers found substances in the water that match those used in local fracking operations or found in nearby pits used for

[12] Hildenbrand, Z. L., Carlton, D. D., Fontenot, B. E., Meik, J. M., Walton, J.L., Taylor, J. T., . . .Schug, K.A. (2015) A comprehensive analysis of groundwater quality in the Barnett Shale region. *Environmental Science & Technology, 49*(13), 8254-62. doi: 10.1021/acs.est.5b01526

[13] Llewellyn G. T., Dorman, F, Westland, J. L., Yoxtheimer, D., Grieve, P. Sowers, T., Brantley, S. L. (2015). Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development. *Proceedings of the National Academies of Science, 112,* 6325-30. doi: 10.1073/pnas.1420279112/-/DCSupplemental

[14] U.S. Geological Survey. (2015, April 1). New stream monitoring method locates elevated groundwater methane in shale-gas development area. Retrieved from http://www.usgs.gov/newsroom/article.asp?ID=4176&from=rss&utm_source=dlvr.it&utm_medium=facebookhttp://www.readcube.com/articles/10.1002%2F2014WR016382?r3_referer=wol&tracking_action=preview_click&show_checkout=1&purchase_site_license=LICENSE_DENIED_NO_CUSTOMER#.VaPKNYsqdyA

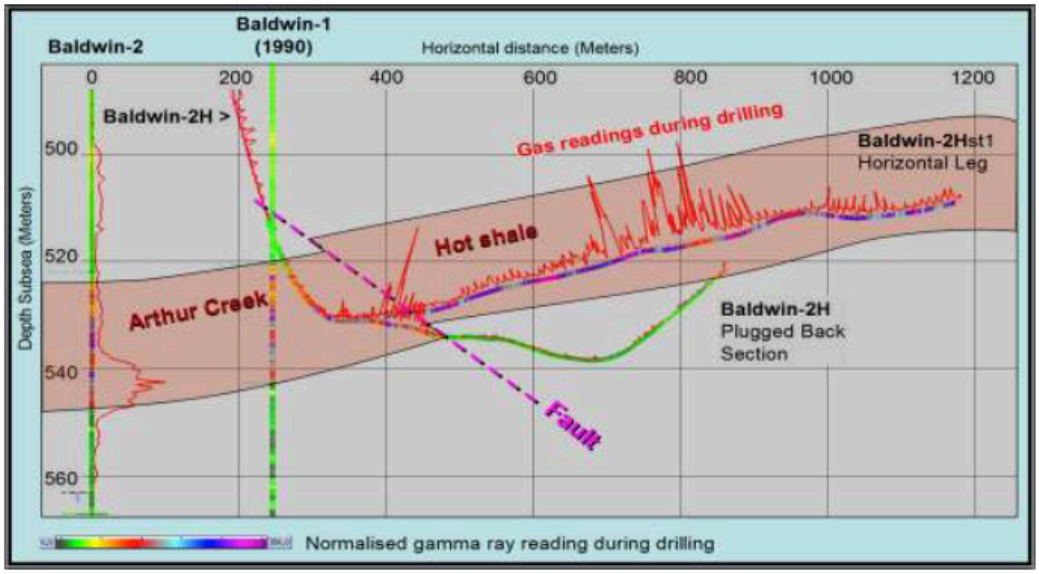
[15] Alawattegama, S. K., Kondratyuk, T., Krynock, R., Bricker, M., Rutter, J. K., Bain, D. J., & Stolz, J. F. (2015). Well water contamination in a rural community in southwestern Pennsylvania near unconventional shale gas extraction. *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, 50,* 516-528. doi: 10.1080/10934529.2015.992684

the disposal of drilling waste. Chemical contaminants included benzene, a known carcinogen, and toluene, a neurotoxicant. Possible mechanisms for contamination include defective cement well casings; spills and leaks from disposal pits; and underground migration of chemicals into aquifers from the fracked zone, which, in this area, is quite shallow.[16]

Risks of 'unexpected' fault lines

In 2011, trials of horizontal hydraulic fracturing by Petrofrontier in the Georgina Basin were ultimately unsuccessful for shale gas extraction. However, these old wells could be leading to ongoing methane and other contamination being brought to the surface. No one from the drilling company (which has since changed hands to Statoil) or the NT Government is monitoring these abandoned wells.

The below is an excerpt from the 2011 PetroFrontier press release (**Attachment B**).



Delays in drilling occurred when the bit tracked into the underlying Thorntonian Limestone Formation after encountering an unexpected fault. Every effort was made to redirect the bit upwards back into the Lower Arthur Creek "Hot Shale", but the bends in the hole became too severe for an effective future well completion.

Fault lines can act as a conduit for methane migration[17]. While in this case the fault eventually led to the unviable nature of this well, the potential increased risk of a long term pollution

[16] 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 & Technology, 50(8). doi: 10.1021/acs.est.5b04970

[17] http://energy.unimelb.edu.au/__data/assets/pdf_file/0019/2331604/Migratory_emissions_20160913.pdf

pathway forming from intersecting this fault line is completely unknown. While the risk from just one well may not be considered great, the risk of a percentage of hundreds or thousands of shale gas wells across the Northern Territory intercepting deep fault lines is worthy of consideration.

One year later in 2012, Petrofrontier provided another media update that is of interest to the NT Fracking Inquiry. Here, they admit that *during the hydraulic stimulation program of the Baldwin-2Hst1 well* (pictured above), *a shallow casing failure occurred and as a result, PetroFrontier was unable to complete the program.* The release continues: *As expected, the multiple casing design protected the shallow aquifers. PetroFrontier plans to carry out remedial work to repair this well so that the planned hydraulic stimulation program can be completed.*[18]

For further detail on the groundwater contamination risks with a Northern Territory context, including details around the fact that some groundwater environments in the Northern Territory are naturally corrosive, please see the International Association of Hydrogeologists (NT) 2015 Submission to the Hawke Inquiry (**Attachment C**).

Methane Contamination

A review by Klohn Crippen Berger Free[19] for the Queensland Department of Natural Resources and Mines considered methane migration from CSG extraction in Queensland. It concluded that gas from CSG development can even occur in water bores that do not experience a water level decline from CSG development. It also found that the presence of free gas in a water bore also directly and indirectly affects its capacity to supply water, unless remedial actions are taken. These impacts have also been reported by numerous landholders dealing with CSG in the Western Downs. They have suffered bore impairment caused not from drawdown, but from excess gas. This has led the Queensland Government to recently amend the Queensland *Water Act 2000* to formally recognise gassy bores as a form of impairment for which CSG companies are required to make good.

Surface Water

After fracking at each well, the large volumes (tens of thousands of litres per well) of hazardous flow back fluid (the 15 - 80% of the fracking fluid mixture that returns to the surface[20]) must be stored and disposed of. Contamination of surface water may occur from release of insufficiently treated or untreated wastewater onto land surfaces or directly into waterways and as a result

[18] Petrofrontier (2013) http://www.prnewswire.com/news-releases/petrofrontier-corp-provides-operational-update-173879181.html
[19] Klohn Crippen Berge 2016. *Potential effects of free gas on bore water supply for CSG development.* Final report to the CSG Compliance Unit of the Department of Natural Resources and Mines.
[20] http://www.karooplaces.com/wp-content/uploads/2011/06/coop_shale_gas_report_final_200111.pdf

of leakage from storage facilities. Soil and surface water contamination may also occur from accidental spills or leakage of fracking fluids at the surface and via surface well blow outs.[21] [22]

Researchers found high levels of iodide, bromide, and ammonium in samples of wastewater from fracking operations in two US shale formations, with the same chemicals found to be present present when fracking wastewater was discharged into rivers and streams at three treatment sites in Pennsylvania and during an accidental spill in West Virginia.[23]

Using geochemical and isotopic tracers to identify the unique chemical fingerprint of Bakken region brines, a 2016 Duke University study found that accidental spills of fracking wastewater have contaminated surface water and soils throughout North Dakota where more than 9,700 wells have been drilled in the past decade. Contaminants included salts as well as lead, selenium, and vanadium. In the polluted streams, levels of contaminants often exceeded federal drinking water guidelines. Soils at spill sites showed elevated levels of radium.[24]

The study concluded that, "inorganic contamination associated with brine spills in North Dakota is remarkably persistent, with elevated levels of contaminants observed in spill sites up to 4 years following the spill events." In a comment about this study, lead author and Duke University geochemist Avner Vengosh said, "Until now, research in many regions of the nation has shown that contamination from fracking has been fairly sporadic and inconsistent. In North Dakota, however, we find it is widespread and persistent, with clear evidence of direct water contamination from fracking."[25]

A 2015 study in Wyoming showed that the arrival of drilling and fracking activities coincided with an increase in salinity in a creek that drains public land in a semi-arid region of the state. The study found that the dissolved minerals associated with the rise in salinity matched those found in native soil salts, suggesting that disturbance of naturally salt rich soils by ongoing oil and gas activities, including pipeline, road, and well pad construction, was the culprit. "As [shale gas and oil] development continues to expand in semiarid lands worldwide, the potential for

---

[21] NTN: Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources; http://www.karooplaces.com/wp-content/uploads/2011/06/coop_shale_gas_report_final_200111.pdf

[22] Fracking: a serious concern for surface water as well as groundwater: http://ec.europa.eu/environment/integration/research/newsalert/pdf/275na3.pdf

[23] Harkness, J. S., Dwyer, G. S., Warner, N. R., Parker, K. M., Mitch, W. A, & Vengosh, A. (2015). Iodide, bromide, and ammonium in hydraulic fracturing and oil and gas wastewaters: environmental implications. *Environmental Science & Technology*, *49,* 1955-63. doi: 10.1021/es504654n

[24] Lauer, N. E., Harkness, J. S., & Vengosh A. (2016). Brine spills associated with unconventional oil development in North Dakota. Environmental Science & Technology, 50(10). doi: 10.1021/acs.est.5b06349

[25] Nicholas School of the Environment, Duke University. (2016, April 27). Contamination in North Dakota linked to fracking spills [press release]. Retrieved from https://nicholas.duke.edu/about/news/ContaminationinNDLinkedtoFrackingSpills

soil disturbance to increase stream salinity should be considered, particularly where soils host substantial quantities of native salts."[26]

Water quantity

According to a 2015 water study from the United States, horizontal shale gas fracking uses the most water, requiring up to 36.6 million litres of water per well27, or around 1200 truckloads of water for just one fracked well. In relation to water use, the European Commission report on fracking notes:

"The hydraulic fracturing process is water-intensive and therefore the risk of significant effects due to water abstraction could be high where there are multiple installations. A proportion of the water used is not recovered. If water usage is excessive, this can result in a decrease in the availability of public water supply; adverse effects on aquatic habitats and ecosystems from water degradation, reduced water quantity and quality; changes to water temperature; and erosion. Areas already experiencing water scarcity may be affected especially if the longer term climate change impacts of water supply and demand are taken into account. Reduced water levels may also lead to chemical changes in the water aquifer resulting in bacterial growth causing taste and odour problems with drinking water. The underlying geology may also become destabilized due to upwelling of lower quality water or other substances." [28]

The potential for negative impacts on water supplies due to extraction of water for fracking operations is down played by industry, which often cites comparatively higher figures for irrigated agricultural production in their own defense. However, the Lock the Gate Alliance encourages the Panel to consider that depletion of ground and surface water resources from fracking operations can have significant impacts once the industry is in full production in a region.

The large number of wells needed to develop unconventional resources and the requirement for multiple fracturing of wells multiplies the overall take of water by the industry. The threat to water resources is greater in lower rainfall regions, and on a regional and local scale where water resources are already under pressure. In particular, future issues could arise in areas where water resources are relied upon by a range of existing industries and may already be subject to over allocation.

---

[26] Bern, C. R., Clark, M. L., Schmidt, T. S., Nolloway, J. M., & McDougal, R. R. (2015). Soil disturbance as a driver of increased stream salinity in a semiarid watershed undergoing energy development. Journal of Hydrology, 524, 123-136. doi: doi.org/10.1016/j.jhydrol.2015.02.020

[27] Gallegos et al, 2015, Hydraulic fracturing water use variability in the United States and potential environmental implications, Water Resources Research Journal.

[28] European Commission: DG Environment (August 2012) Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe

The extraction of water from underground aquifers for fracking has the potential to place significant stress on groundwater systems, particularly if they are already utilized by existing rural industries. This demand on groundwater for supplying fracking operations will be critical in semi-arid regions, where underground aquifers are often the sole or principal source of water, and more broadly, during extended drought periods and during periods of reduced rainfall.

A 2015 Californian study shows that while the volume of water used in fracking represents a small percentage of overall annual water consumption in California, fracking-related water use is disproportionately concentrated in areas of the state already suffering from water shortages, and further drawdowns of these aquifers may interfere with agricultural and municipal water needs[29].

Interestingly, a 2015 research paper from Southwest China states that, "data analysis indicates a significant correlation between water consumption and lateral length of wells."[30] This correlation could be relevant in the NT context, resulting in higher water use if longer horizontal fracs are utilized, as has been mentioned in presentations as part of the NT Inquiry to date.

Whilst industry suggests overall water use could be minimised by reuse of fracking wastewater in new fracking operations, a 2013 US water report notes that whilst the oil and gas industry continues to talk about water recycling technologies, few operators in the US are using recycled fracking water in fracking operations. The study states: "with few exceptions, the rest of the water used for fracking is gone for good from the hydrological cycle" and "data on actual use of recycling are hard to come by, and it appears that these technologies are not yet widely used."[31]

Aquatic ecosystems and biodiversity

There is increasing and ongoing evidence of point source impacts from the UG industry on ecosystems and biodiversity, while large scale regional assessments of impacts have been hampered by lack of baseline data.

[29] Long, J. C. S, Birkholzer, J. T., & Feinstein, L. C. (2015, July 9). Summary report. In: An Independent Scientific Assessment of Well Stimulation in California. California Council on Science and Technology, Sacramento, CA. http://ccst.us/publications/2015/2015SB4summary.pdf
[30] Yang, B. Huanga, X. Yang Q. … (2015) Water Requirements for Shale Gas Fracking in Fuling, Chongqing, Southwest China, Energy Procedia 76 (2015) 106 – 112
[31] Western Organisation of Research Councils (2013) Gone for Good: Fracking and Water Loss in the West, http://www.worc.org/media/Gone_for_Good1.pdf

In 2013, a joint USGS and U.S. Fish and Wildlife Service study documented a causal link between a fracking wastewater spill and the widespread death of fish in the Acorn Fork, a creek in Kentucky.[32]

A survey of streams in Arkansas, led by the University of Central Arkansas, found alterations in macroinvertebrate communities to be related to drilling and fracking operations in the Fayetteville Shale. Fracking activity near streams was associated with greater sediment and more chlorophyll. "This study suggests that land disturbance from gas development affected stream communities."[33]

In 2009, a leaking pipe carrying fracking waste in Washington County, Pennsylvania, polluted a tributary of Cross Creek Lake, killing fish, salamanders, crayfish, and aquatic insect life in approximately three-quarters of a mile of the stream.[34]

A team of environmental scientists, biologists, and engineers, from institutions including the University of Michigan and McGill University, assessed the current state of understanding of the impact fracking and its associated activities have on the ecological health of surface waters. Though various approaches such as geographic information systems and site monitoring provide insights into potential risks to aquatic ecosystems, the authors concluded that inadequate data currently exist. They identified possible outcomes such as, "erosion and sedimentation, increased risk to aquatic ecosystems from chemical spills or runoff, habitat fragmentation, loss of stream riparian zones, altered biogeochemical cycling, and reduction of available surface and hyporheic water volumes because of withdrawal-induced lowering of local groundwater levels."[35]

In Australia, Environmental Engineer Stuart Khan of the University of NSW expressed in 2011 serious reservations about the disposal and use of produced water, claiming that: "Disposing of CSG waters directly to surface waters will significantly epact the quality of those surface waters. Attempts to beneficially reuse CSG water without treatment for application's such as irrigation, poses risks to soil quality and shallow groundwater quality." And further: "poorly managed discharge of reverse osmosis waters to the environment may also pose a risk to some surface water systems by disrupting (diluting) natural mineral and nutrient compositions, essential for

---

[32] Papoulias, D., & MacKenzie, T. (2013, August 28). Hydraulic fracturing fluids likely harmed threatened Kentucky fish species. USGS Newsroom. http://www.usgs.gov/newsroom/article.asp?ID=3677

[33] Johnson, E., Austin, B. J., Inlander, E., Gallipeau, C., Evans-White, M. A., & Entrekin, S. (2015). Stream macroinvertebrate communities across a gradient of natural gas development in the Fayetteville Shale. Science of the Total Environment, 530-531, 323-32. doi: 10.1016/j.scitotenv.2015.05.027

[34] Pittsburgh Post-Gazette. (2009, June 5). Waste from Marcellus shale drilling in Cross Creek Park kills fish. Pittsburgh Post-Gazette. http://www.post-gazette.com/washington/2009/06/05/Waste-fromMarcellus-shale-drilling-in-Cross-Creek-Park-kills-fish/stories/200906050136

[35] Burton Jr., G. A., Basu, N., Ellis, B. R., Kapo, K. E., Entrekin, S. & Nadelhoffer, K. (2014). Hydraulic "fracking": are surface water impacts an ecological concern? Environmental Toxicology and Chemistry, 33(8), 1679-1689.

many aquatic ecosystems. Uncontrolled discharges to ephemeral streams will disrupt natural flow regimes with potentially significant ecological implications."[36]

Additional water risk: Fluid treatments and waste disposal are ineffective and/or cause additional problems

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 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 by reverse osmosis filtration.[37] As the costs and difficulties of dealing with large quantities of wastewater grow, Australian UG companies are trialing reinjection into aquifer formations, despite the risks of seismic events, as experienced in the US.[38]

Recent research from the US highlights the following issues with current waste disposal methods in the US unconventional gas industry:

· Alterations of local hydrology caused by the injection of large volumes of hydraulic fracturing fluids that may have mobilized contaminants left over from legacy oil, gas, and mining operations as well as opened pathways for the migration of fracking fluids themselves.[39]

Identified risks in disposal practices include the use of wastewater for crop irrigation (whereby contaminants may seep from the surface of agricultural areas into groundwater), the use of unlined pits for waste storage and reinjection into potable aquifers.[40]

---

[36] Khan, S. (2011) Submission to the NSW Parliamentary Inquiry into CSG, https://www.parliament.nsw.gov.au/committees/DBAssets/InquirySubmission/Summary/39431/Submission%200330.pdf

[37] Chemicals unable to be treated successfully include bromoform, chloroform, naphthalene, nonylphenol, ctylphenol, 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

[38] Watson, B. A. (2016). Fracking and cracking: strict liability for earthquake damage due to wastewater injection and hydraulic fracturing. Texas Journal of Oil, Gas and Energy Law, 11(1). http://ssrn.com/abstract=2735862

[39] Alawattegama, S. K., Kondratyuk, T., Krynock, R., Bricker, M., Rutter, J. K., Bain, D. J., & Stolz, J. F. (2015). Well water contamination in a rural community in southwestern Pennsylvania near unconventional shale gas extraction. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, 50, 516-528. doi: 10.1080/10934529.2015.992684

[40] Long, J. C. S, Birkholzer, J. T., & Feinstein, L. C. (2015, July 9). Summary report. In: An Independent Scientific Assessment of Well Stimulation in California. California Council on Science and Technology, Sacramento, CA. http://ccst.us/publications/2015/2015SB4summary.pdf

In the Northern Territory, Origin Energy has used unlined pits for the storage of waste water, and then has failed to responsibly remove all contaminates, leaving polluted water in areas that then flooded.

These photos show the state that a shale gas pad was left in after gas fracking activities stopped in mid December 2015.



December 2015, photo supplied



December 2015, photo supplied



December 2015, photo supplied

Water testing from the site showed results common of water associated with the unconventional gas industry: high barium, aluminium, iron & bromine. Please find the spreadsheet of results in **Attachment D**.

The entire area was underwater during the flooding event which stretched from Mataranka to Elliot in late December 2015: http://www.abc.net.au/news/2015-12-29/stuart-highway-closure-flood-elliot-mataranka/7057992

Head of NT Department of Mines and Energy gave evidence to a Senate Inquiry in 2016, where he answered questions in relation to shale gas activities. Here, he gave the impression that ponds did not overflow and that the ponds would have been lined. This provided the current Inquiry Panel insights in to the recent behaviour and attitude to date of the shale gas regulatory system in the Northern Territory.

Transcript: Tuesday, 12 April 2016 Senate Page 1 SELECT COMMITTEE ON UNCONVENTIONAL GAS MINING
BACON, Dr Rachel, Deputy Chief Executive, Department of the Chief Minister
KELLY, Mr Ron, Chief Executive, Department of Mines and Energy Committee met at 8:03
CHAIR (Senator Lazarus):

Senator PERIS: Do you know if you have had shale gas drilling ponds overflowing already in the Territory, from the gas wells that have been drilled?

Mr Kelly: No, Senator.

Senator PERIS: Are the ponds that have been drilled lined to avoid seepage into the groundwater underneath?

Mr Kelly: In the current regime of drilling—because there have not been any wells drilled in the southern part of Australia for some time—in all the new work that is being done, any ponds that may have been or are constructed are certainly lined, but they are only temporary. With regard to the wastewater, or the processed water, that resulted from exploration wells that were drilled last year, we required that all of that processed water be captured, sealed into appropriate containers and trucked away to an approved water treatment processing facility. The reason for that is that, until we have the actual chemical constitution of that water—as it has come back out of the ground, if it has picked up any other elements—and we know exactly what that water looks like, we are unable to approve an appropriate treatment process on-place. So we take the precautionary principle in that regard, and we are not going to let it sit there in an evaporation pond, if you like, while we figure out the best way of treating it. We make sure that it is treated appropriately from the start.

Senator PERIS: Okay. Has the Department of Mines and Energy done water samples of what pollution is present in the shale gas drilling ponds across the Sturt Plateau and the Daly Waters?

Mr Kelly: We have water samples from any of those operations, but I think you would have to tell me which ponds you are looking at, because I am not aware of anything other than what may be there as temporary, protective, storage type measures. There are no long-term dams that are unlined or untested in the Northern [Territory]. (Full transcript available, **Attachment E**)

Spills – a risk to surface and groundwater

New analysis, published Feb. 21 2017 in the journal *Environmental Science & Technology*, revealed 6,648 spills from the fracking industry from just the four states that they studied alone—Colorado, New Mexico, North Dakota and Pennsylvania—in 10 years[41]. The researchers determined that up to 16 percent of fracked oil and gas wells spill hydrocarbons, chemically laden water, fracking fluids and other substances. They found that 75% to 94% of spills occurred within the first three years of well life when wells were drilled, completed, and had their largest production volumes. Across all four states, 50% of spills were related to storage and moving fluids via flowlines. The team also designed an interactive spills data visualization tool (http://snappartnership.net/groups/hydraulic-fracturing/webapp/spills.html) to illustrate the value of having standardized, public data.

In Australia, during the exploration phase of coal seam gas development in NSW, there have been a number of recorded contamination events around the state. Santos' CSG operations in the Forest region of NW NSW recorded at least 20 coal seam gas waste water spills and continuing leaks from evaporation ponds. Santos' records show spills and leaks from all parts of the operations, from evaporation ponds, pipelines, the wastewater treatment facilities and at well sites[42].

Pollution offences occurred under the former site operator Eastern Star Gas. The NSW EPA issued the following statement, "The EPA issued two penalty notices with fines of $1,500 each to Eastern Star Gas for discharging polluted water containing high levels of salt into Bohena Creek in March and November 2010; offences under section 120 of the Protection of Environment Operations Act 1997."[43]

---

[41] Patterson, L. Konschnik, K. Wiseman, H… (2017) Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements, Environ. Sci. Technol., 2017, 51 (5), pp 2563–2573, DOI: 10.1021/acs.est.6b05749 http://pubs.acs.org/doi/abs/10.1021/acs.est.6b05749?journalCode=esthag

[42] Santos Ltd Energy NSW (2014) Report into Eastern Star Gas Limited prepared for Government of New South Wales

[43] NSW EPA (2012) Eastern Star Gas fined for pollution in the Pilliga, http://www.epa.nsw.gov.au/epamedia/EPAmedia12070601.htm

In 2014, Santos was found guilty of polluting an aquifer in the Pilliga Forest[44] with radioactive uranium 20 times safe levels as well as toxic heavy metals[45].

A spill in June 2011 in the Pilliga resulted in 10,000 litres of untreated toxic coal seam gas wastewater containing a mix of heavy metals (including arsenic, lead and chromium), salts and petrochemicals that killed vegetation and wildlife. Santos was found guilty in the NSW Land and Environment Court and fined $52,000[46].

Well integrity failure risks

Issues surrounding well integrity failure pose specific risks across many themes, including surface and groundwater, landscapes, air quality and greenhouse gas emissions and health.

The industry has been arguing for years that they are improving their practice, and science and industry papers have been calling for improvements for decades, yet the problems persist. Well failures have not improved with time – the industry has not engineered a way out of well casing failure and annual flow.

In the spoken presentation to the NT Fracking Inquiry Panel, the Lock the Gate Alliance provided specific insights from 2003 Oilfield Review, published by Schlumberger (**Attachment F**). Here, the industry paper admits, "*Techniques for locating, exploiting and transporting natural gas to our homes and industries have had huge advances since the early days. Despite these advances, many of today's wells are at risk. Failure to isolate sources of hydrocarbon either early in the well construction process or long after production begins has resulted in abnormally pressured casing strings and leaks of gas into zones that would otherwise not be gas-bearing.*"

They also admit, "*Since the earliest gas wells, uncontrolled migration of hydrocarbons to the surface has challenged the oil and gas industry. Gas migration, also called annular flow, can lead to sustained casing pressure (SCP)… The presence of SCP indicates that there is communication to the annulus from a sustainable pressure source because of inadequate zonal isolation. Annular flow and SCP are significant problems affecting wells in many hydrocarbon-producing regions of the world… By the time a well is 15 years old, there is a 50% probability that it will have measurable SCP in one or more of its casing annuli. However, SCP may be present in wells of any age.*"

[44] http://www.epa.nsw.gov.au/epamedia/EPAMedia14021802.htm
[45] http://www.smh.com.au/environment/water-issues/epa-defends-its-actions-over-natural-uranium-in-contaminated-aquifer-20140309-34fhp.html
[46] http://australianresources.com.au/1833/santos-fined-pilliga-spill

A 2014 study published in the Proceedings of the National Academy of Sciences of the United States of America provides a useful and more recent overview of the industry and scientific data produced to that date, specifically considering unconventional extraction.

> *In a technical sense, "well integrity" refers to the zonal isolation of liquids and gases from the target formation or from intermediate layers through which the well passes. In a practical sense, it means that a well doesn't leak. Drilling companies emphasize well integrity because a faulty well is expensive to repair and, in the rarest of cases, costs lives, as in the Deepwater Horizon disaster in the Gulf of Mexico. Drillers use steel casing (pipes), cement between nested casings and between the outside casing and rock wall, and mechanical devices to keep fluids inside the well.*
>
> *Faulty casing and cementing cause most well integrity problems. Steel casing can leak at the connections or corrode from acids. Cement can deteriorate with time too, but leaks also happen when cement shrinks, develops cracks or channels, or is lost into the surrounding rock when applied. If integrity fails, gases and liquids can leak out of the casing or, just as importantly, move into, up, and out of the well through faulty cement between the casing and the rock wall.*[47]

Risk of biogenic hydrogen sulfide gas

The 2012 media release from Petrofrontier in relation to their Georgina Basin fracking program also states: *A successful hydraulic stimulation was performed on the MacIntyre-2H well over nine open-hole stages. However, after recovering approximately one-third of the hydraulic stimulation fluid, traces of biogenic hydrogen sulfide gas, produced from naturally occurring organisms in the completion fluid, were detected and the well had to be suspended.*[48]

According to a 2007 paper, hydrogen sulfide gas (H2S) is a toxic and corrosive gas and a precursor to the formation of sulfuric acid, H2SO4, which causes the destruction of metal and concrete substrates. This bacterially induced process of forming hydrogen sulfide gas and the subsequent conversion to sulfuric acid that attacks concrete and steel within wastewater environments is known as biogenic sulfide corrosion[49].

Biogenic sulphide corrosion of shale gas infrastructure could have major implications for risks to NT water supplies into the future. It is problems rarely admitted by the industry when they talk up their three layers of cement and steel. However, the natural bacterial corrosion of well

---

[47] Jackson, R. (2014) The integrity of oil and gas wells, Proc Natl Acad Sci U S A. 2014 Jul 29; 111(30): 10902–10903. Published online 2014 Jul 9. doi: 10.1073/pnas.1410786111, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121783/*

[48] Ibid.

[49] O'Dea, V. (2007) Understanding biogenic sulfide corrosion, https://www.environmental-expert.com/articles/understanding-biogenic-sulfide-corrosion-36635

casings into the future creates a very difficult risk to ignore and is difficult to measure what impact it could have, particularly in the long term after wells are abandoned.

Conoco Philips authored a paper in 2012 that states:

> *Internal pipeline corrosion in the presence of hydrogen sulfide has become a major issue for both oil and gas industries. Problems resulting from hydrogen sulfide corrosion have started to draw attention to the oil and gas industry since the 1940's. Since then, researchers have done a tremendous amount of work, studying the mechanism of hydrogen sulfide corrosion. However, the corrosion mechanisms initially proposed are still not fully understood and well acceptable around the world. Although the corrosion mechanism is still confusing, many attempts have been made by the industry to mitigate hydrogen sulfide corrosion problems*.[50]

Further, and for broader Northern Territory perspective, the below text is a direct excerpt from the International Association of Hydrogeologists (NT) 2015 Submission to the Hawke Inquiry (**Attachment C**).

> *Deterioration and failure of improperly decommissioned wells will, over time, result in long term release of oil and/or gas into the environment. Pathways in the annulus may develop that would allow oil, gas, and brine to move vertically across geologic formations and contaminate groundwater. Substances dissolved in the brine may include those that occur naturally in the shale formations and others injected during the hydraulic fracturing process.*
>
> *Also upwardly migrating gas, known as stray gas, represents an explosion hazard if not properly vented away from buildings and drinking water wells.*
>
> *The risk that annular pathways will develop increases over time as chemical, mechanical, and thermal stresses causes deterioration of well structures and components. Failure modes of improperly abandoned wells include the formation of cracks in the cement casing or packers, corrosion of steel production casing, faulty valves, and leaking temporary plugs or surface caps. A key paper on the causes of well failure (Dusseault et al, 2000) discusses cement shrinkage as the principle cause of well failure, particularly long after wells have been plugged and abandoned.*

[50] Conoco Philips (2012) Investigation of Effects of Iron Sulfide On Corrosion And Inhibition of Carbon Steel In H2S Containing Conditions, https://www.onepetro.org/conference-paper/NACE-2012-1651

Estimates of well failure rates vary although the more conservative well failure rates found in the literature are between 4.6% and 8.9%. Further, a study from Alberta, Canada of more than 315,000 oil, gas and injection wells of various ages, (Watson and Bachu, 2009), shows that 'injection wells' into which liquids or gasses are pumped are 2-3 times more likely to leak than conventional 'production wells'.

The same study found that horizontal or inclined wells are observed to have significantly higher failure rates than vertical wells. It is universally acknowledged that problems with casing centralisation and cement slumping in horizontal or inclined wells may contribute to the increased incidence of leakage.(Council of Canadian Academies, 2014, Watson and Bachu, 2009).

A well-documented example of groundwater contamination caused by fracking operations from the USA occurred in Pennsylvania, USA (Osborn et al, 2011). It found that about 75% of wells sampled within 1 kilometre of gas drilling in the Marcellus shale in Pennsylvania were contaminated with methane from the deep shale formations. Isotopic fingerprinting of the methane indicated that the deep shale was the source of contaminations, rather than biologically derived methane. In addition, fracking-return fluids have also been known to contaminate drinking water, although the evidence is not as strong as for methane contamination (Horvath & Illgraffea, 2011).

Well integrity is of concern in the NT because some groundwater environments in the NT are naturally corrosive. An example of the effect of corrosive water on cementing and casing in the NT is provided by deep oil exploration wells (McDills and Dakota) drilled in the Perdika/Great Artesian Basin in the 1960s. (The Perdika Basin is one of the prospective unconventional shale gas areas of the NT). Now, some fifty years later, the steel casing has almost entirely corroded away, resulting in inter-aquifer contamination. This well required expensive rehabilitation works to stem artesian flow (Humphreys and Kunde, 2004). This single bore cost the Territory and Commonwealth Governments $500,000 to plug as the company responsible for the well was insolvent. This example highlights the issue of operator insolvency due to the boom and bust cycles of oil and gas development which complicate efforts to hold liable parties responsible and provide for timely environmental reclamation.

7.2 Land

In assessing the rehabilitation of land that has been hydraulically fractured, the European Commission report[51] on fracking notes: "The evidence suggests that it may not be possible fully to restore sites in sensitive areas following well completion or abandonment, particularly in areas of high agricultural, natural or cultural value. Over a wider area, with multiple installations, this could result in a significant loss or fragmentation of amenities or recreational facilities, valuable farmland or natural habitats." A recent US study documents the failure of plant and soil systems disturbed by drilling and fracking activities to return to pre-drilling conditions following rehabilitation- even after 20 to 50 years[52].

An interdisciplinary study published in *Science* 2015 demonstrated that the accumulating land degradation has resulted in continent-wide impacts of the unconventional gas industry in the United States, as measured by the reduced amount of carbon absorbed by plants and accumulated as biomass. This is a robust metric of essential ecosystem services, such as food production, biodiversity, and wildlife habitat, and its loss "is likely long-lasting and potentially permanent." The land area occupied by well pads, roads, and storage facilities built during this period is approximately three million hectares, roughly the land area of three Yellowstone National Parks. The authors concluded that new approaches to land use planning and policy are "necessary to achieve energy policies that minimize ecosystem service losses."[53]

Many of the ecosystem services of the Northern Territory have not yet been adequately mapped to understand what the impacts of degrading this resource will be, and the negative impacts that could flow from that.

The gaps in baseline understanding are exemplified by a recent 11 April 2017 media release from the Northern Territory Government, announcing the release of its new $9.935 million *Mapping the Future* program. The project will support scientific teams to identify potential productive land for future use in regional areas and improve natural resources information.

According to the release: "Minister for Environment and Natural Resources said the program would map the soil, water and biodiversity assets in regional parts of the NT.

---

[51] European Commission: DG Environment (August 2012) Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe

[52] Minnick, T. J. & Alward, R. D. (2015). Plant–soil feedbacks and the partial recovery of soil spatial patterns on abandoned well pads in a sagebrush shrubland. Ecological Applications 25(1), 3-10.

[53] Allred, B. W., Kolby Smith, W., Tridwell, D., Haggerty, J. H., Running, S. W., Naugle, D. E., & Fuhlendorf, S. D. (2015). Ecosystem services lost to oil and gas in North America. Science, 348 (6233), 401-402.

The mapping that takes place over the five year period will;

- Provide data to underpin land use plans for regional growth areas, which will identify areas that are highly suitable for land uses such as agriculture.
- Allow regional communities to make informed decisions on the location of natural resource-based economic development opportunities and local community-based land use planning.
- Attract private investment in natural resources industries based on accurate scientific data.
- Inform the long term management, protection and health of community drinking supplies, while ensuring sustainability of natural and cultural assets such as ground water-dependent ecosystems.

The first year of the program involves extensive planning and consultation with industry and community stakeholders from across the NT to identify prospective areas for mapping.

Scientific teams will be deployed from July 2018 once priority areas have been identified and land access agreements secured. When active, the Department of Environment and Natural Resources will;

- Use drill rigs and corers to obtain soil samples for analysis.
- Measure the flow, quality and quantity of both surface and ground water in or near study areas.
- Use a range of techniques to survey study areas to describe the distribution of native plants and animals, including threatened species."[54]

This is exactly the type of baseline information collection that is required. There is a fair amount of information on where shale gas reserves are most likely found, but data regarding other land uses is scant. Final decision making on the acceptability or otherwise of the shale gas industry and its associated damaging impacts, water use and landscape impacts should only be undertaken after this regional mapping project is completed.

Fragmentation and Biosecurity

There is very little empirical data available on the ecological impacts of fragmentation from unconventional gas development, nor on the biosecurity threats it poses or the actual contribution its development has made to date to the spread of invasive weeds and feral animals.

[54] NT Government (2017) http://newsroom.nt.gov.au/mediaRelease/23051

Research that is available identifies significant ecological impacts arising from landscape fragmentation. A thesis on the landscape consequences of unconventional gas development in Pennsylvania's old growth forest found that gas development increased edge length and the number of forest patches and decreased interior forest cover[55]. A 2012 study in Pennsylvania found that shale gas development would fragment forest cover and entail intensive disturbance of core forests where headwater streams occur[56].

One of the few studies available on individual species impacts from the US, shows marked alterations in deer habitat selection patterns in response to unconventional gas development in Colarado[57]. Deer were forced to alter habitat use to avoid gas activities and infrastructure, leading to a 50% variation during the day time within their critical winter range.

Ecological experts in Australia have identified that '*fragmentation and loss of native vegetation resulting from the considerable surface footprint of CSG infrastructure represent a serious threat to biodiversity, threatened species and landscape function'*[58]. They suggest that, "*Evidence from CSG developments to date indicates that severe effects are possible. Potential impacts include direct clearing of bushland, fragmentation of important remnant vegetation, spread of invasive species and increased fire risk*".

Similarly, the sheer scale of proposed shale production, including the number of likely gas wells and the extent of associated infrastructure, presents genuine risks for the unique natural landscapes of the Northern Territory.

In Queensland, farmers have reported serious invasions of weeds following CSG development. One cattle farmer has initiated legal action against a CSG company after he had to destock his property at Dalby after a sudden infestation of the noxious African lovegrass weed following CSG activities[59].

Lawyers in Queensland representing farmers dealing with the CSG industry consider that weeds may ultimately be one of the biggest legacies of the CSG industry. Shine Lawyers have spoken

---

[55] Bernau, Jeremiah. 2013. Landscape Consequences of Pennsylvania Natural Gas Development: Fragmentation effects of unconventional gas development upon the future of Pennsylvania's old growth forests.

[56] Drohan, P. J., Brittingham, M., Bishop, J., & Yoder, K. (2012). Early trends in landcover change and forest fragmentation due to shale gas development in Pennsylvania: A potential outcome for the northcentral Appalachians. Environmental Management,49(5), 1061 - 1075

[57] Joseph M. Northrup, Charles R. Anderson Jr. and George Wittemyer, "Quantifying Spatial Habitat Loss from Hydrocarbon Development through Assessing Habitat Selection Patterns of Mule Deer," Global Change Biology, 12 August 2015.

[58] Williams J., Stubbs T. & Milligan A. (2012) An analysis of coal seam gas production and natural resource management in Australia. A report prepared for the Australian Council of Environmental Deans and Directors by John Williams Scientific Services Pty Ltd, Canberra, Australia

[59] http://www.abc.net.au/news/2014-08-23/farmer-claims-csg-companies-spread-weeds-on-southern-qld-propert/5661016

out against the weaknesses of biosecurity measures, stating that: '*We are informed by a leading expert that current washdown procedures have difficulty removing more that 10% of the weed or pathogen load from machinery. If correct, no amount of insistence upon constant monitoring of access and the production of weed hygiene declarations (washdown certificates) will truly protect a landholder. Furthermore, having companies or subcontractors able to self-monitor and write the certificates themselves is hardly of comfort*'.[60]

Seismic Activity

Evidence arising in just the past 18 months has had a significant impact on our understanding the links between fracking and waste fluid reinjection with increased seismicity and earthquakes.

January 2016: An international research team investigated a swarm of earthquakes in California's Central Valley that occurred in 2005. Using hydrogeological modeling, the researchers concluded that the underground injection of wastewater from oil drilling operations had contributed to seismicity via changes in localized pressures along an active fault.[61]

February 2016: An article in the Texas Journal of Oil, Gas, and Energy Law exhaustively reviewed the literature on earthquake activity in areas of six states (Arkansas, Colorado, Kansas, Ohio, Oklahoma, and Texas) where fracking takes place or drilling wastes are disposed underground and concluded that courts should impose strict liability for earthquake damage caused either by fracking itself or by the underground injection of fracking fluids. "Earthquakes sometimes occur when subsurface formations are properly fractured. Likewise, the risk of earthquake damage is not substantially mitigated by the exercise of due care when frack fluids are injected into the ground."[62]

March 2016: A summary of the evidence linking drilling and fracking activities to earthquakes appeared in Scientific American. Emerging data suggests that pressure changes caused by fracking wastewater injection can migrate for years before encountering a geological fault and altering stresses in ways that allow for slippage. In this way, earthquake risks can spread out over both time and space—traveling for miles beyond the disposal well and persisting for a

[60] https://www.shine.com.au/blog/coal-seam-gas-law/weeds-csg-insidious-legacy/

[61] Goebel, T. H. W., Hosseini, S. M., Cappa, F., Hauksson, E., Ampuero, J. P., Aminzadeh, F. & Saleeby J. B. (2016). Wastewater disposal and earthquake swarm activity at the southern end of the Central Valley, California. Geophysical Research Letters, 43. doi: 10.1002/2015GL066948

[62] Watson, B. A. (2016). Fracking and cracking: strict liability for earthquake damage due to wastewater injection and hydraulic fracturing. Texas Journal of Oil, Gas and Energy Law, 11(1). http://ssrn.com/abstract=2735862

decade or more as injected fluids travel underground. In spite of increasing scientific clarity about these mechanisms, regulators have been slow to respond.[63]

May 2016: In a study that has "far-reaching implications for assessment of induced seismicity hazards," a Canadian team of researchers determined that hydraulic fracturing itself is linked to earthquake swarms in western Canada, in contrast to the central United States where disposal of fracking waste is the cause of most induced seismicity. Furthermore, lowering the volume of injected fluid may not be sufficient to prevent quakes.[64]

Further study is needed to access the impact of this increased seismicity and earthquakes with contamination to groundwater. The damage from the increased earthquakes must also be considered as a risk across other areas of interest for the NT Fracking Inquiry.

7.3 Air

A 2012 study detected 44 hazardous air pollutants at unconventional gas well sites[65], whilst other recent US studies[66] show that drilling and fracking emissions often contain strikingly high levels of benzene. The NYS Dept. of Health Public Health Review (the NYS Review) noted that "studies provide evidence of uncontrolled methane leakage, emissions of other volatile organic chemicals, and particulate matter from well pads and natural-gas infrastructure [as well as]… intermittently high dust and benzene concentrations."

Exposure to a range of harmful substances associated with unconventional gas operations constitutes a serious health hazard to those working on and living adjacent to or surrounded by UG development. The NYS Review[67] states that emissions from UG operations have the potential to contribute to community odour problems and respiratory health impacts such as asthma exacerbations.

A less discussed impact on air quality is raising ethane levels. According to University of Michigan researchers, the Bakken shale emits 250,000 tons of ethane per year.[68] They found,

---

[63] Kuchment, A. (2016, March 28). Drilling for earthquakes. Scientific American. Retrieved from https://www.scientificamerican.com/article/drilling-for-earthquakes/

[64] Atkinson, G. M., Eaton, D. W., Ghofrani, H., Walker, D., Cheadle, B., Schultz, R. … Kao, H. (2016). Hydraulic fracturing and seismicity in the Western Canada Sedimentary Basin. Seismological Research Letters, 87(3). doi: 10.1785/0220150263

[65] NTN: Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources

[66] See footnotes 3–8, 12, 57, 174 in Fracking Compendium, Vol. 2

[67] A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development: http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

[68] Kort, E. A., Smith, M. L., Murray, L. T., Gvakharia, A. Brandt, A. R., Peischl, J., . . .Travis, K. (2016). Fugitive emissions from the Bakken shale illustrate role of shale production in global ethane shift. Geophysical Research Letters, 43, 4617–4623. doi: 10.1002/2016GL068703

"emissions we observed in this single region are 10 to 100 times larger than reported in inventories. They directly impact air quality across North America. And they're sufficient to explain much of the global shift in ethane concentrations."[69] Ethane is a gas that affects climate and decreases air quality. Ethane contributes to ground-based ozone pollution as it breaks down and reacts with sunlight to create smog. This surface-level ozone is linked to respiratory problems, eye irritation, and crop damage. Global ethane levels were decreasing until 2009, leading the researchers to suspect that the U.S. shale gas boom may be responsible for the global increase in levels since 2010.

Climate Change

Methane is a more powerful greenhouse gas than carbon dioxide – 86 times more powerful when considered over a 20-year timeframe and 34 times more over a 100-year timeframe. The near term consequences of methane emissions are very important in the context of the risks of climate tipping points and near term temperature thresholds over the coming two decades.

A recent report by the Melbourne Energy Institute (MEI) reviewed the latest research on methane fugitive emissions from unconventional gasfields in the US[70]. It found that:

1. Actual measurements above US gasfields have recorded fugitive emissions of up to 17% of production. For comparison, the unconventional gas industry in Australia claims that its fugitive emissions amount to only 0.1% of production[71].
2. 'Top down' methods of measuring fugitive emissions, such as satellite imagery and aerial borne surveys, have revealed methane emissions that are many orders of magnitude greater than emissions recorded from 'bottom up' surveys using ground measurements'.

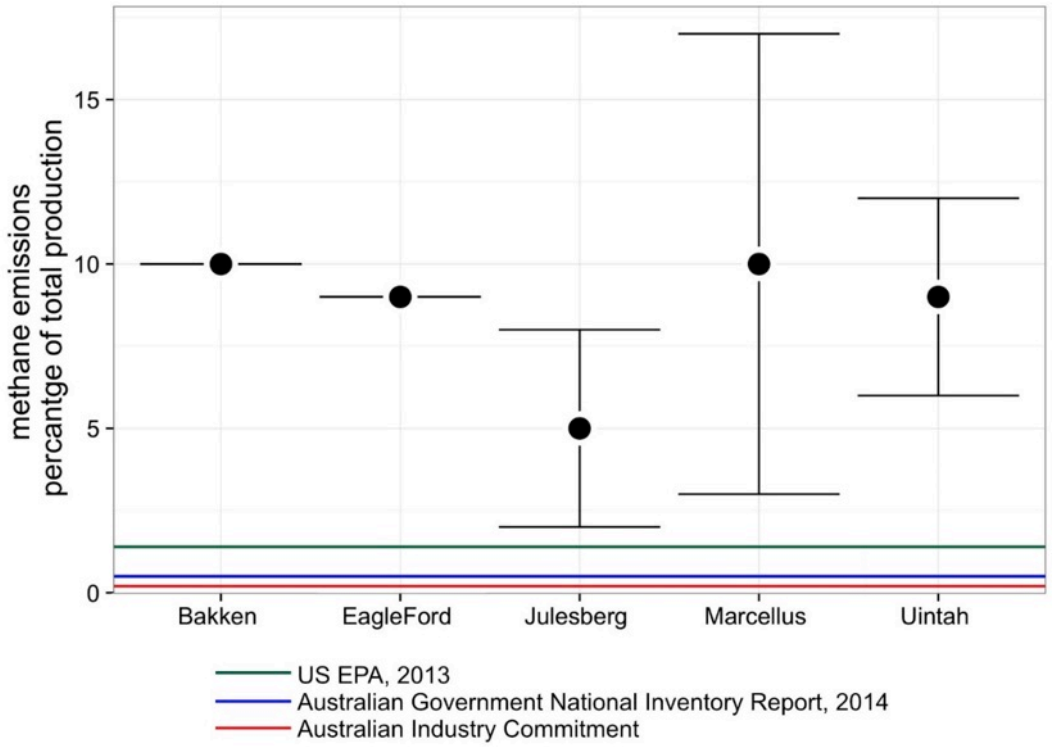
It is widely recognized that at more than about 3% leakage, gas is actually more polluting than coal when used to generate electricity[72].

[69] Moore, C. S. & Human K. (2016, April 26). One oil field a key culprit in global ethane gas increase. Michigan News. http://ns.umich.edu/new/multimedia/videos/23735-one-oil-field-a-key-culprit-in-globalethane-gas-increase

[70] Lafleur, D., Forcey, T., Saddler, H., and Sandiford. M. (2016) A Review of Current and Future Methane Emissions from Australian Unconventional Oil and Gas Production. Melbourne Energy Institute.

[71] Clark, T., R. Hynes, P. Mariotti, A. P. Production and E. Association (2011). Greenhouse gas emissions study of Australian CSG to LNG, Australian Petroleum Production & Exploration Association Limited.

[72] See, for example, Hardisty, P. E., T. S. Clark and R. G. Hynes (2012). "Life cycle greenhouse-gas emissions from electricity generation: A comparative analysis of Australian energy sources." Energies **5**(4): 872-897.



Measured fugitive emissions at US gas fields compared to Australian industry and government reporting.

Comparison of emission estimates and measurements (Table 11 from MEI 2016)

Reported oil and gas-related methane-emission estimates and top-down measurements				
		Basis	**% of production**	**Reference**
Australia	Oil and gas industry media release	limited well-pad measurements	0.02%	Footnote [73]
	Fugitive emissions reported in Queensland CSG-LNG environmental impact statements	factor-based estimates	0.1%	Clark, Hynes et al. (2011), Prior (2011), Hardisty, Clark et al. (2012)
	Australian Government reported (for the year 2014)	largely factor-based estimates	0.5%	See Section 5.3 MEI report
U. S.	U.S. EPA (for the year 2013, latest revision)	largely factor-based estimates	1.4%	See Section 4.6 MEI report

[73] APPEA (2014) http://www.appea.com.au/media_release/csiro-report-points-to-environmental-benefits-of-csg/

	U.S. Denver-Julesberg basin	aircraft measurements	2 to 8%	Petron, Karion et al. (2014), see Table 2 MEI report
	U.S. Eagle Ford Basin (Texas)	satellite-based measurements	9%	Schneising, Burrows et al. (2014), see Table 2 MEI report
	U.S. Bakken Basin (North Dakota)	satellite-based measurements	10%	Schneising, Burrows et al. (2014), see Table 2 MEI report
	U.S Uintah Basin (Utah)	aircraft-based measurements	6 to 12%	Karion, Sweeney et al. (2013), see Table 2 MEI report
	U.S. Marcellus Basin (southwestern Pennsylvania)	aircraft-based measurements	3 to 17%	Caulton, Shepson et al. (2014), see Table 2 MEI report

Emissions Factors Used in Australia

The MEI report found that in Australia to date, there has been almost complete reliance on pre-determined emission 'factors' in reporting of unconventional gas emissions to the UNFCCC. It also noted that actual measurements of emissions have been almost non-existent (confined only to extremely limited bottom up studies), and that there have been no baseline measurements in Australia.

Therefore, it is currently not possible to accurately assess emissions from Australian gasfields, but evidence from the US points to the fact that our emissions reporting, based as it is on factors, is likely to significantly understate the true level of emissions. Specifically, methane leakage rates recorded in the atmosphere at US unconventional gas fields are 10-25 times higher than those the Australian government reports to the UNFCCC (see Figure above).

The report highlighted one particularly notable are of likely underestimation in the use of emissions factors. The emission factor used for reporting methane leaked during the production phase of gas extraction for UNFCCC reports; categorized as *"fugitive emissions-general leaks"* – which is very low at just 0.0058% of production. Within that production

category, emissions are set to zero for the following sources of emissions, despite the likelihood that emissions from these sources are very large:

1. In field compressor stations
2. Water and gas gathering lines and associated venting
3. Water treatment facilities
4. Migratory emissions

The 'production' emissions factor relies on a CSIRO 2014[74] report that claims to have validated the 0.0058% factor, but that report:

- Was artificially restricted to well head emissions only
- Ignored leaks from the large network of gathering lines, compressors and pumps connecting gas wells to the transmission pipeline.
- Noted far larger leaks in the pipeline system outside wellheads that overwhelmed well head measurements, but didn't measure them
- Relied on a very small sample of 43 wells selected by the gas industry

The CSIRO 2014 report, however, gives some insight into the scale of production emissions that were outside its study and that are currently set to zero in Australian reporting, as follows:

> *"We found a significant CH4 emission point from a water gathering line near Well B13. Methane was being released from two vents ... at a rate sufficient rate to be audible a considerable distance from the vents. ... Based on the prevailing wind speed, we estimate that the CH4 emission rate from the two vents was at least 130 [grams per minute].... This is a factor of three more than the highest emitting well examined during this study."*

Recorded Methane Venting in Australia

The substantial nature of emissions from vents has been verified recently with the deployment of a FLIR GF-320 infrared camera in the Queensland coal seam gasfields. An independent energy advisor, Tim Forcey, deployed the camera in February 2017 near Chinchilla and found[75]:

1. Continuous releases of methane from "high-point vents" on water-gathering pipelines
2. Intermittent releases of methane from other gas field equipment
3. Methane bubbling from the Condamine River and Wambo Creek.

Given the very large number of high point vents and other gas field equipment vents which are located throughout the Queensland CSG fields, if the scale of venting detected by the FLIR camera was replicated, it would represent a potentially vast, unmeasured contribution to global warming.

[74] Day, S., M. Dell'Amico, R. A. Fry and H. Javanmard Tousi (2014). Field Measurements of Fugitive Emissions from Equipment and Well Casings in Australian Coal Seam Gas Production Facilities, CSIRO, Australia.
[75] Tim Forcey. 2017. Infrared Video Recording Methane Emissions in the Queensland Coal Seam Gas Fields. February 2017.

Estimates of Emissions and Implications for Paris Targets

Whilst the paucity of data makes it difficult to assess the likely scale of emissions from unconventional gas in Australia, the Melbourne Energy Institute utilised recorded 'top down' measurements from the US to derive a set of estimated emission scenarios for the Australian context and associated liabilities should there be a price on carbon[76].

Table 12 from MEI 2016

Liabilities for differing scenarios for methane emissions from Australian unconventional oil and gas production, in terms of lost value and potential carbon impost.					
Column	**A**	**B**	**C**	**D**	**E**
Case	**Unconven-tional gas production rate**	**Methane emissions rate**	**Methane greenhouse-gas emissions (100 yr – 20 yr GWP)**	**Sales value of lost gas (at $A 10 / gigajoule)**	**Carbon impost ($A 25/tonne CO_2-e; 100 yr – 20 yr GWP)**
	PJ/yr	**% of gas production**	**million tonnes CO_2-e/yr**	**million $A/yr**	**million $A/yr**
1	**1,500 (*)**	0.5	5 - 12	75	115 - 290
2	"	2	18 - 46	300	459 - 1,162
3	"	6	55 - 139	900	1,367 - 3,485
4	"	10	92 - 232	1,500	2,296 - 5,808
5	"	15	136 - 348	2,250	3,443 - 8,712
6	**3,000**	0.5	9 - 23	150	230 - 581
7	"	2	37 - 93	600	918 - 2,323
8	"	6	110 - 279	1,800	2,755 - 6,969
9	"	10	184 - 465	3,000	4,590 - 11,615
10	"	15	275 - 697	4,500	6,887 - 17,423
* 1,500 PJ/yr is approximately equal to current or near-term (2016, 2017) CSG production capacity.					

[76] Lafleur, D., Forcey, T., Saddler, H., and Sandiford. M (2016) A Review of Current and Future Methane Emissions from Australian Unconventional Oil and Gas Production. Melbourne Energy Institute.

As the table above shows, MEI concluded that a 10% methane leakage rate for the production of 1,500 PJ/annum of gas would lead to fugitive emissions of 92MtCO2-e/yr using the 100 year global warming potential of methane, or to 232MtCO2-e/yr using the 20 year GWP.

This means that if the Northern Territory industry were to develop to a similar size as the existing CSG industry in Queensland, which seems likely, then we could estimate a similar level of 92MtCO2-e/yr based on 10% leakage. This would equate to emissions equivalent to fuel combustion from Australia's entire transport sector emissions which were 93MtCO2-e in the last reporting year.

Australia's Paris commitment is to reduce emissions by 26-28% on 2005 levels by 2030. In a recent fact sheet, the Australian Government estimates this will require 900Mt CO2-e of total abatement from 2020 to 2030[77]. Therefore, over a 10 year period, estimated emissions at 10% leakage from 1,500PJ gas production would effectively double our national abatement task.

If the Northern Territory were to increase its production of unconventional gas any further, then our abatement task will become even more unattainable. However, if unmeasured emissions from existing CSG production in Queensland has already effectively doubled our abatement task, then any NT shale gas production makes that task even more unobtainable.

If the 20 year global warming potential of methane is considered, then leakage rates of 10% represent an even more serious threat given the near-term impacts of methane emissions on climate tipping points. This is particularly disturbing as climate records continue to tumble globally. We argue that is a risk that is inconsistent with both NT and Federal Government policy and entirely unnecessary given the competitiveness of renewable energy alternatives.

It is also notable that the conversion of unconventional gas to LNG and transport offshore adds even further to overall life-cycle emissions from exported gas.

In light of the serious risks of large-scale fugitive emissions identified by the MEI 2016 report, they recommended that:

- Reported methane-emission measurements should be independently verified by a regulatory body funded by a levy on the industry.
- Methane emissions volumes should be explicitly limited by regulation.
- Independently collected and analysed methane-emissions baseline data should be established for any area being considered for oil and gas development.
- Piloted and unpiloted aircraft should be used for top-down emission investigations
- Real time, top down methane emissions monitoring should be made publicly available on a website.

[77] Lafleur, D., Sandiford. M. (2016) The risk of migratory methane emissions resulting from the development of coal seam gas in QLD. Melbourne Energy Institute.
http://www.tai.org.au/sites/defualt/files/Migratory_emissions_20170417-LowerRes.pdf

- A widespread network of ground based air quality monitoring towers should be establish.
- Sedimentary basin management plans should be developed.

Other Australian work

Another report released this year by the Melbourne Energy Institute explores the risks of methane gases from a coal seam migrating to the surface as a result of coal seam dewatering and depressurisation for coal seam gas production[78]. It identifies that such migratory emissions are a potentially significant source of greenhouse gases from unconventional gas extraction, but concludes that there is very limited data available to assess the full scale of the risk.

It finds that migration of methane along existing natural faults and fractures is possible and may increase with continued depressurization by unconventional gas mining. It notes that presence of free methane in water bores can be the direct consequence of depressurisation of the coal seams.

It finds that due to a lack available data the likelihood of migratory emissions occurring as a result of gas extraction is difficult to assess, and highlights that to date the presence or scale of such emissions has been completely un-measured. It finds that there is an urgent need for holistic sedimentary basin management plans and integrated geological-hydrological models to allow for a thorough analysis of the risks of gas migration.

The Climate Council has also recently released a report titled 'Pollution and Price: The Cost of Investing in Gas' (**Attachment G**). It concluded that old gas power plants in Australia, such as Torrens Island, are as polluting as coal fired power stations. It also concluded that whilst new gas power plants are less polluting than coal when the entire supply chain of gas production is considered, gas is not significantly less polluting than coal.

It found that overall current levels of reliance on gas power in Australia must be reduced to play our role in limiting global temperature below 2°C. Expanding gas usage is inconsistent with tackling climate change as it locks in emissions for decades into the future.

It also noted that new renewable energy is now cost competitive with new gas. The cost of renewable power and storage, particularly solar, wind and batteries, continues to fall and has no associated fuel costs. This contrasts with rising and volatile gas prices. It also highlighted that the most economic and accessible unconventional gas reserves are being exported now, and that further gas expansion will drive increased reliance on unconventional gas, which is expensive.

[78] Lafleur, D., Sandiford. M. (2016) The risk of migratory methane emissions resulting from the development of coal seam gas in QLD. Melbourne Energy Institute.
http://www.tai.org.au/sites/defualt/files/Migratory_emissions_20170417-LowerRes.pdf

Technologies such as solar thermal, hydro and biomass plants can meet demand for electricity at all times of the day as well as meeting technical requirements for grid stability according to the Climate Council. Combining these technologies with wind, solar PV, and large- scale energy storage, can meet electricity demand round-the-clock.

7.4. Public Health

Drilling and fracking chemicals

A 2017 peer reviewed study has only just been released and provides some very useful evidence for this inquiry in relation to risks and impacts of chemical use of the UG industry outside of just the fracking process itself.

The study found that evaluations for chemicals used in other routine oil and gas development activities, such as maintenance acidizing, gravel packing, and well drilling, have not been previously conducted, in part due to a lack of reliable information concerning on-field chemical-use. Through their extensive research, the results of the 2017 study indicate regulations and risk assessments focused exclusively on chemicals used in well-stimulation activities may underestimate potential hazard or risk from overall oil field chemical use[79].

The National Toxics Network identifies a range of issues in relation to the chemicals used in fracking and their regulation. These include:

- Many chemicals used in fracking operations in Australia have not been assessed for their toxicity to the environment and humans. "The mixtures used in drilling and fracking fluids are also not assessed for toxicity or persistence and can form new compounds when exposed to sunlight, water, air, radioactive elements or other natural chemical catalysts."
- Large numbers of hazardous products were identified in US fracking operations.
- There is a reliance on industry reporting of fracking chemicals in the US, with many potentially toxic chemicals not being reported as they are classed as 'trade secrets'.[80]

As part of the NT Fracking Inquiry Public Hearing process on 10 March 2017, we heard from Halliburton in relation to drilling and fracking chemicals. Halliburton made the claim that, "Any

[79] Stringfellow WT, Camarillo MK, Domen JK, Shonkoff SBC (2017) Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development. PLoS ONE 12(4): e0175344. https://phys.org/news/2017-04-hazardous-chemicals-unregulated-routine-oil.html

[80] National Toxics Network, 2013, Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources http://www.ntn.org.au/wp/wp-content/uploads/2013/04/UCgas_report-April-2013.pdf

fracking chemicals being brought into Australia goes through a rigorous process with NICNAS before it can be used."

Lock the Gate sought further information on this statement from a member of the Australian Government's Department of Health National Industrial Chemicals Notification and Assessment Scheme (NICNAS) Advisory Board and the National Toxics Network.

The feedback we received brought to light the following points:

Under the *Industrial Chemicals (Notification and Assessment) Act 1989* (the Act), chemicals that are already listed on Australian Index of Chemical Substances (AICS) may be used for any industrial purpose (subject to conditions of use, if any), including for purposes related to CSG or shale fracking, without further assessment by NICNAS.

If an ingredient is already on the AICS (this Index includes around 38,000 chemicals) then it can be used with no further assessment. The vast majority (around 85%) of those chemicals have never been assessed, as they were grandfathered into the scheme.

Supposedly new chemicals must be assessed, however there is not evidence it is a 'rigorous' process. Importantly, the assessment only relates to individual chemicals, and not the chemical combination 'products' used by the fracking companies. One problem with fracking chemicals is they are often imported as a 'product' and NICNAS doesn't investigate the entire product ingredients.

It is also worth noting there is no assessment of the interactions between chemicals used in the fracking process and the chemicals released naturally from the coal or shale seams.

NICNAS has established the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework to accelerate the assessment of existing chemicals on the AICS. Specifically, NICNAS was given the task back in 2012 of assessing the safety or otherwise of fracking chemicals under their IMAP program.

However the Federal Minister for the Environment has not released a public outcome of that investigation to date. It is also important to remember it is only for coal seam gas extraction chemicals and not for shale. Plus, the chemicals used in the fracking process are likely to have changed since 2012, and it is not clear (even to those sitting on the NICNAS advisory board) whether newer chemicals have been assessed under IMAP or not.

The investigation will not deal with the impacts on groundwater aquifers nor will it look at the mixture of chemicals released to the environment, which has been highlighted as a serious issue by the EU.

Further, under future reforms proposed by NICNAS, if an individual chemical is deemed to be low-medium risk, then the industry will essentially self regulate and self assess the risks of that

chemical. It is only when a chemical ingredient (NB ingredient, not a product) is a high risk that NICNAS will do any assessment. Again, the chemical combination risks are not considered.

There are a number of very significant impacts on the mental, emotional and physical well-being of communities facing and experiencing the rapid industrialization of their local area for UG development. These impacts are outlined in the following paragraphs.

Health Impacts Associated with Air and Water Pollution

Studies increasingly show that air pollution associated with drilling and fracking operations is a grave concern with a range of impacts, with researchers documenting dozens of air pollutants from drilling and fracking operations that pose serious health hazards[81]. Hazardous air pollutants are released from a range of processes in UG operations. These include: the burning of diesel in machinery, generators, construction equipment and chemical, water, and waste transport vehicles; off-gassing from wastewater holding ponds; flaring and venting at wellheads; and emissions and leaks from wells, pipelines, processing plants and compressor stations.[82]

Importantly, the risks of exposure to harmful substances occur not only as a result of drilling and fracking stages of gas operations but throughout the life time of UG operations from emissions from infrastructure and other processes including silica and sand mining activities, compressor stations, pipelines and wastewater holding ponds. Exposure to harmful substances can also occur through direct skin contact with fracking chemicals and wastes; drinking or bathing in contaminated water and through contaminated dust particulates[83].

The Compendium notes that "among residents living near drilling and fracking operations, documented indicators variously include increased rates of hospitalization, self-reported respiratory problems and rashes, motor vehicle fatalities, trauma, drug abuse, and low birth weight among infants," Some of the public health effects of UG development that researchers have documented, outlined in the Compendium of Fracking Risks, include:

- increased rates of hospitalization for cardiological complaints, cancer, skin conditions, and urological problems;
- increase in frequency of health symptoms reported by residents as distance between households and gas wells decreased; with rashes and upper respiratory problems more prevalent among persons living less than one kilometre from drilling and fracking operations;

[81] Concerned Health Professionals of New York & Physicians for Social Responsibility. (2015, October 14). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (3rd ed.). http://concernedhealthny.org/compendium/
[82] NTN: Toxic Chemicals in the Exploration and Production of Gas from Unconventional Sources
[83] Ibid.

- increases in commercial vehicle accidents;
- a sharp rise in ambulance calls and emergency room visits for drug related cases and oilfield related injuries and accidents;
- increase in infant deaths to six times the normal rate over three years;
- congenital heart defects, and possibly neural tube defects in newborns, associated with the density and proximity of natural gas wells within a 10-mile radius of mothers' residences;
- elevated rates of low birthweight among infants born to mothers living near drilling and fracking operations during their pregnancies;
- reductions in average birthweight and length of pregnancy as well as increased risk for low birthweight and premature birth associated with proximity to fracking operations.[84]

In a 2013 US study, surface and groundwater near areas experiencing high levels of unconventional gas activity in Colorado were shown to contain endocrine-disrupting chemicals (EDC) with moderate to high levels of EDC activity. [85] The concentrations of chemicals detected in surface and ground water were in high enough concentrations to interfere with the response of human cells to male sex hormones and estrogen. 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.

Hydrocarbons and BTEX

A team of researchers established that petroleum-based hydocarbons can break down underground in ways that promote the leaching of naturally occurring arsenic, a known human carcinogen that causes bladder, lung, and skin cancer, into groundwater.[86]

[84] Concerned Health Professionals of New York & Physicians for Social Responsibility. (2015, October 14). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (3rd ed.). http://concernedhealthny.org/compendium/

[85] Kassotis et al (2013) Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region, Endocrinology doi: 10.1210/en.2013-1697 http://www.endo.endojournals.org

[86] U.S. Geological Survey (2015, January. 26) Natural breakdown of petroleum underground can lace arsenic into groundwater. http://www.usgs.gov/newsroom/article.asp?ID=4110&from=rss&utm_source=dlvr.it&utm_medium=facebook#.VavGXIsqdyA

A 2015 routine monitoring at AGL's (now abandoned) Waukivory CSG Project at Gloucester detected elevated levels of toxic BTEX (Benzene, Toluene, Ethylene, Glycene) chemicals in flowback water from wells following hydraulic fracturing. Given that the fracking chemicals and raw water used both tested negative for these chemicals, it was assessed that the likely source of BTEX was the coal seams and that the chemicals were mobilized as a result of the fracking process.[87]

Mental Health and Wellbeing

The social stressors associated with the large-scale heavy industrial activities that accompany UG development take a heavy toll on the mental and emotional health of rural families and communities impacted by UG development. Doctors for the Environment Australia note that "water and air pollution, water shortages, permanent degradation of productive agricultural land and loss of livelihood and landscape… all have mental health consequences for communities living in a gas field."[88]

A 2013 study investigating the impacts of mining and CSG operations on the mental health of landholders in south west Queensland established that these operations placed rural communities "under sustained stress". [89] The study conducted twelve workshops within the region, asking community members, among other things, about the issues, which were affecting their mental health. Study participants reported that mining and CSG operations "significantly impacted or exacerbated issues such as the health, social fabric and economy of the community", and the authors noted that local health services faced "unsustainable pressure". A 2014 article in the Medical Journal of Australia notes that "gas developments can have numerous and considerable social and psychological effects, which may exacerbate more direct health risks."[90]

[87] EPA NSW (2015) http://www.epa.nsw.gov.au/resources/licensing/150311-agl-gloucester.pdf

[88] Doctors for the Environment Australia, Submission to the NSW Parliamentary Inquiry into Coal Seam Gas, 16/09/2011

[89] Hossain D. et al. Impact of the mining industry on the mental health of landholders and rural communities in southwest Queensland (2013). Psychiatry, 21:32-37

[90] Coram, Moss and Blashki (2014) Harms unknown: health uncertainties cast doubt on the role of unconventional gas in Australia's energy future, Med J Aust 2014; 200 (4): 210-213. doi: 10.5694/mja13.11023 https://www.mja.com.au/journal/2014/200/4/harms-unknown-health-uncertainties-cast-doubt-role-unconventional-gas-australias

A 2014 CSIRO study[91] noted that local farmers perceived the nature of CSG development in South West Queensland to date as an "invasion" or "occupation", whilst a previous study in Chinchilla found residents describing a 'tsunami of change'. [92]

Interacting and engaging with CSG companies has also been reported[93] as having a significant negative impact on farmer's wellbeing. The interactions between farmers and CSG companies resulted in issues of stress, conflict and disconnection.

More recently, researchers assessed the contribution of coal seam gas extraction in Queensland to the global stress burden and mental health of Australian farmers. Dr. Methuen Morgan surveyed 378 Australian farmers, predominantly from Queensland and NSW, on the factors associated with their work that can impact mental health and wellbeing[94].

The study, reported in the Journal of Environmental Psychology in 2016, found that farmers concerned about the impacts of coal seam gas on their health, community and the environment, were more likely to report symptoms of depression and decreased levels of wellbeing. It found that farmers who were classified as 'CSG-stressed' exhibited clinically significant levels of psychological morbidity.

7.5 Aboriginal People and their culture

The Lock the Gate congratulates the Fracking Inquiry for taking the time to visit many Aboriginal communities across the NT. We have received feedback through our networks that many of the visits have been too short, not fitting in with local practices that allow time for a larger and more representative group from a community to participate. We have been told that interpreters not been used to their full capacity. We appreciate there is a second round of remote consultations mid 2017 and aim for this quick feedback to help plan even more effective future communications.

Land Ownership

[91] Huth N.I., Cocks B., Dalgliesh N., Poulton, P., Marinoni O., Navarro J. (2014) Farmers' perceptions of coexistence between agriculture and a large scale coal seam gas development: working paper, June 2014, CSIRO, Australia.
[92] Walton, A.M., McCrea, R., Leonard, R., Williams, R., 2013. Resilience in a changing community landscape of coal seam gas: Chinchilla in Southern Queensland. Journal of Economic and Social Policy 15, Article 2
[93] Huth N.I., Cocks B., Dalgliesh N., Poulton, P., Marinoni O., Navarro J. (2014) Farmers' perceptions of coexistence between agriculture and a large scale coal seam gas development: working paper, June 2014, CSIRO, Australia.
[94] Morgan, M., Hine, D., Bhullar, N., Dunstan, D., and Bartik, W. Fracked: Coal Seam Gas Extraction and Farmers Mental Health. *Journal of Environmental Psychology* 47 (2016), 22-32.

Many Aboriginal people across the Northern Territory have been outspoken in their concerns around the impacts of fracking gasfields on their country, around their rivers and across their cultural landscape.

Traditional Owners from Watarrka (Kings Canyon) National Park worked with the Central Land Council and the EDO NT to build a legal and political campaign over several years to prevent the NT Government from granting Palatine Energy Pty Ltd an exploration licence over the park[95]. After travelling to Canberra to lodge a heritage application, traditional owners were eventually successful in preventing oil and gas development in the Park[96].

In Elliot, an area targeted for shale gas exploration fracking, a local family with Traditional Country across that region wrote a song '*No Mining In Our Land*' in language and released it on You Tube in 2016 to help spread their message.

The You Tube description reads: *Watch this film clip from me - Ethan Dixon - and my mum - Janey Dixon. It is sung in our language Mudburra and filmed on location at Marlinja - 25kms from Elliott, Northern Territory. We don't want fracking on our land.*

The full song with captions is available at: https://www.youtube.com/watch?v=-hscad3Sl68

Across Arnhem Land, a group of Traditional Owners formed a local action group, Protect Arnhem Land, in response to fracking applications covering their Land and Sea Country. Their website: http://www.protectarnhemland.org/ provides video and interviews where you can hear first hand from Traditional Owners on the issue of oil and gas fracking applications in their communities. Their Facebook page *Protect Arnhem Land* has thousands of followers from across the world. One family from Maningrida worked with a documentary maker to produce a song about their life and battle, titled, *Stingray Sisters*. This documentary was featured on *ABC Lateline* in August 2016 and their five-minute overview is available here: http://www.abc.net.au/lateline/content/2016/s4518129.htm

In Mataranka, Traditional Owners from the region including Jilkminggan, across Mangarrayi and Alawa Land Trusts and out to Ngukurr led a rally through the main street of Mataranka in 2016 calling for protection for the Roper River Catchment from Fracking.

[95] Central Land Council (2014) http://www.clc.org.au/media-releases/article/kings-canyon-traditional-owners-reject-mining-in-watarrka-national-park

[96] Akerman, A. (2015) The Australian http://www.theaustralian.com.au/business/mining-energy/nt-bows-to-traditional-owners-watarrka-fracking-protests/news-story/223024db0d2da968835c656abc739cd8



Photo credit: Jeff Tan, 2016

To better understand what the on ground impacts of shale gasfields on Aboriginal people could be, we have to look to other parts of the world where it has been developed. The First Nations people of Canada have been experiencing the on ground impacts of gas development, first for conventional gas, and then for shale gas requiring hydraulic fracturing for many decades. Their experiences offer lessons that could be considered in this context.

A 2014 Powerpoint presentation from the Fort Nelson First Nation group from Canada covers insights and issues similar to those that have been raised as risks by Aboriginal people in the Northern Territory.

For example, their presentation reads:

Fort Nelson First Nation (FNFN) rights, interests and lands

• *FNFN's experience with hydraulic fracturing*

  – Significant adverse impacts on land, water, air and treaty rights

- *BC LNG export poses tremendous risk to FNFN Inadequate regulatory framework*
- *Inadequate consultation and accommodation*
- *FNFN bearing greater burden than benefit*

Over the past ten years there has been enormous oil and gas development in FNFN territory, with more anticipated.

• Hydraulic fracturing and horizontal drilling technologies have brought rapid change to FNFN territory

• Regulated by the Province of BC (Oil and Gas Commission) on an incremental basis, with little or no attention to cumulative impacts

- *Habitat fragmentation & loss (caribou, grizzly bear, bison)*
- *Increased predation (caribou, moose)*
- *Populations of furbears decline with industrial development (lynx, marten, fisher, beaver)*
- *Introduction of invasive Species*
- *Reduction in plant and ecotype diversity*
- *Contamination*
- *Rare plants lost*
- *Fragmentation of forested lands reduces ecological vitality*

As of June 2013, the OGC had approved the use of up to 2,623,000 m3 /day or 20,405,000 m3 /year (equivalent to +8,000 Olympic swimming pools) for fracking in FNFN territory

• Significant hydrologic impacts (reduced stream flow, drought vulnerability, degraded fisheries habitats and wetlands)

Please see the full presentation here: http://www.legassembly.gov.yk.ca/pdf/rbhf_FNFN-Presentation.pdf

Fort Nelson First Nation also have uploaded a useful time lapse video of the industrialisation of their lands over the decades, first from conventional gas, and more recently from shale gas fracking.

http://lands.fnnation.ca/sites/default/files/industry_activity_2.mp4

7.6. Social Impacts

Infrastructure - onshore unconventional gas led to a degradation of public resources in QLD

In 2013, the University of QLD published in depth research into the impacts of mining and onshore gasfields across the regional QLD communities where they were operating. The research team interviewed people from across all sectors of the local communities to gather a broad range of evidence and feedback on the impacts[97].

[97] Everingham, J., Collins, N., Rodriguez, D. Cavaye, J., Vink, S., Rifkin, W. & Baumgartl, T. (2013) Energy resources from the food bowl: an uneasy co-existence. Identifying and managing

Their detailed research found that while those working in the coal seam gas industry in the Darling Downs region had a positive view of the impact of the industries, people working in local businesses, agriculture, government and the community sector consistently believed UG development and mining had led to a deterioration of:

• Financial capital- revenue streams and economic resources.

• Built capital- local infrastructure including buildings, transport, equipment and communications.

• Human capital- skills, knowledge, abilities and good health.

• Social capital- organisations, networks and relationships, based on shared values, mutual trust and reciprocity.

The main reasons for these social and financial impacts are the loss of skilled staff to the gas industry and the increased cost of labour, rent, transport and goods and services for local businesses.

The outcomes of discussions are summed up in the below table. It is worth noting that even stakeholders representing the mining and gas sector conceded that built capital such as roads in the area were made worse due to the operations of mining and gas in the area.

cumulative impacts of mining and agriculture. Project report. CSRM, The University of Queensland: Brisbane.

Stakeholders groups	Financial capital	Human capital	Built capital	Social capital	Natural capital
Gas	Better	Better	Worse	Better	Better
Mining	Better	Better	Worse	Better	Better
Agriculture	Worse	Worse	Worse	Worse	Worse
Local business	Worse	Worse	Worse	Worse	Worse
Local government	Worse	Better	Worse	Same	Same
Community	Worse	Better	Worse	Worse	Worse
Advocacy	Worse	Worse	Worse	Worse	Worse

Table sourced from report by The Australia Institute (2015) Be careful what you wish for[98].

Community cohesion and wellbeing:

The Queensland and NSW experience with the expansion of coal seam gas operations has shown that when this industry is forced upon communities against their wishes, there is potential for significant conflict and social upheaval and disruption as a result, even at the exploration phase of the industry. Lock the Gate members and local community groups report a range of impacts from proposed and actual UG development on their mental and emotional wellbeing. These include:

- A sense of injustice that they do not have the right to refuse access to companies for UG activities and that this industry is being forced on an unwilling population.
- Fear and anxiety about the impacts of the UG industry on their family's health and the quality of the air and water they rely upon.
- Concern about the impact of UG development on the economic viability of their farms and property values.
- A sense of anger and betrayal that governments are supporting industry rather than communities in the development of the UG industry.

[98] Ogge, M. (2015) Be careful what you wish for. Report for The Australia Institute

- A sense of anger that the industry is being pushed ahead rapidly without proper consideration of the impacts and before proper scientific studies have been done and baseline data collected.

In discussing the broader social impacts of UG development, Doctors for the Environment Australia note: "Informed consent of landholders is often lacking in the contract process when mining companies first approach landholders about unconventional gas extraction…. The injustice and powerlessness that this engenders contributes to solastalgia and poorer mental health outcomes." Overall, DEA maintain that UG development can "divide previously close-knit rural communities, increasing tension and disharmony."

The lack of a veto right for landholders in relation to UG development, the stress involved in dealing with UG companies (often against their will), the lack of full information and disclosure on the realities of UG development, and the often underhanded tactics employed by companies contributes to a sense of powerlessness, betrayal and frustration amongst landholders and affected communities. According to DEA, in eastern Australia, "the stress and disruption caused to farmers has already been shown to force some of them to leave a CSG drilling area, allowing once productive lands to lapse into disuse," whilst in the US "longtime residents are moving, unable to bear the changes the gas industry has wrought on their landscape and community."

In their submission to the 2015 Victorian Parliamentary Inquiry[99] DEA note:

> *"The migratory, boom and bust nature of UG developments can carry significant social and psychological effects for those who live in communities near operations and on those who may travel to work at these developments. A study[100] of impacts of mining and unconventional gas operations on landholders in Queensland found that these operations placed rural communities "under sustained stress", with study participants describing significant impacts on the health, social fabric and economy of local communities.*"

The health and social impacts of UG development will necessarily have a flow on negative impact on the overall wellbeing of rural communities, as well as the functionality of other industries in which rural residents are engaged. This impact will be magnified due to the fact that farming and rural communities are the very same communities who are already at most risk from the adverse health effects of drought, climate change and the degradation and depletion of Australia's river systems and groundwater resources.[101]

---

[99] Doctors for the Environment Australia (2015) http://www.parliament.vic.gov.au/images/stories/committees/EPC/Submission_416_-_Doctors_for_Environment_Australia_.pdf

[100] Hossain D. et al. Impact of the mining industry on the mental health of landholders and rural communities in southwest Queensland (2013). Psychiatry, 21:32-37.

[101] Doctors for the Environment Australia, Submission to the Inquiry into Coal Seam Gas, 16/09/2011

The impacts of the use of fly-in, fly-out and drive-in, drive-out workforces, used extensively in existing unconventional gas developments in Australia, also has a range of negative social impacts which were documented in a recent Parliamentary Inquiry[102]. The use of FIFO and DIDO workforces have come under scrutiny for their negative influence on community cohesion, increased rents and other living expenses, and their association with elevated levels of alcohol and drug use, as well as mental health issues and violence.

Crime – risk of increase:

A recently release paper from the Journal of Environmental Economics and Management shows that the energy boom in the United States has affected regional crime rates throughout the country. Researchers found positive effects on rates of various property and violent crimes in shale-rich counties. In 2013, the cost of the additional crimes in the average treatment county was roughly $2 million[103].

The Western Criminological Review Journal found in 2013 that law enforcement and human service personnel reported that the rapid growth in oil and gas producing areas and communities leads to increased crime and other social ills. Researchers made a comparison of 2012 crime rates in a matched sample of counties revealed that crime rates were higher in oil impacted counties. A pre-post analysis found that violent crime in boom counties increased 18.5% between 2006 and 2012 while decreasing 25.6% in a matched sample of counties that had no oil or gas production[104].

A Multi-State Shale Research Collaborative published a report in December 2014 on the relationship of the shale drilling to crime, traffic fatalities, STDs and rents. Researchers found that communities with the highest intensity of natural gas drilling have seen increased rate of crime, motor vehicle fatalities and sexually transmitted diseases. While the influx of

[102] House of Representatives Standing Committee on Regional Australia. Cancer of the bush or salvation for our cities? Fly-in, fly-out and drive in, drive-out workforce practices in regional Australia. Canberra: Commonwealth of Australia, 2013.
http://trove.nla.gov.au/work/176479103?selectedversion=NBD50509223

[103] James, Smith et al, 2017, There will be blood: Crime rates in shale-rich U.S. counties, Journal of Environmental Economics and Management Volume 84, July 2017, Pages 125–152, http://dx.doi.org/10.1016/j.jeem.2016.12.004, http://www.sciencedirect.com/science/article/pii/S0095069616305459

[104] Ruddell, Rick, Dheeshana S. Jayasundara, Roni Mayzer, and Thomasine Heitkamp. 2014. "Drilling Down: An Examination of the Boom-Crime Relationship in Resource Based Boom Counties" Western Criminology Review 15(1):3-17 (http://wcr.sonoma.edu/v15n1/Ruddell.pdf).

energy workers hasn't significantly increased population figures, it coincided with a surge in rental prices across the Marcellus Shale region[105].

Employment – risk that jobs projections from onshore unconventional gas are overstated by industry

The 2015 APPEA commissioned Deloitte Access Economics report clearly states in the executive summary on page four that the jobs figures were modeled in an "aspirational scenario" and "they do not necessarily represent expected outcomes", requiring "upper bound assumptions to materialise". Page five reveals their jobs figure is not due to eventuate until the year 2040[106].

Their report not only relied on a high international gas price that no longer exists, but also on the opening up of six onshore gas basins across the Territory, which would require thousands of gas wells across tourism regions and important water basins.

Independent modeling of realistic figures, based on a realistic oil price and volumes of shale gas that are appropriate to bring to market is required.

We applaud the approach of the Panel in obtaining independent economic analysis to feed into the inquiry. We trust this will be based on a true cost benefit analysis of industry impacts and realities of the sector, plus acknowledgment of any economic 'externalities' that could be factored in.

Onshore gas jobs have a negative impact on agricultural jobs

The Office of the Chief Economist's 2015 Review into the Socioeconomic Impacts of Coal Seam Gas in QLD revealed that researchers produced "evidence that agricultural jobs have been affected negatively: 1.8 agricultural jobs lost correlating with every CSG job created."[107]

That means that for every 10 unconventional gas jobs created in QLD, 18 agricultural jobs were measured to be lost. This negative jobs figure for agriculture was measured and reported in a peer-reviewed paper by Fleming and Measham in 2015[108].

[105] Multi-State Shale Research Collaborative, 2016: http://www.pennlive.com/midstate/index.ssf/2014/12/fracking_brought_spikes_in_vio.html

[106] Deloitte Access Economics, 2015: https://www.appea.com.au/wp-content/uploads/2015/08/APPEA_Deloitte-NT_Unconv_gas_FINAL-140715.pdf

[107] Office of the Chief Economist, 2015, Review of the socioeconomic impacts of coal seam gas in QLD, https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/coal-seam-gas/Socioeconomic-impacts-of-coal-seam-gas-in-Queensland.pdf

Boom Bust

The scale of the 'bust' after the short unconventional gas construction period ends is severe, and long-term job opportunities are extremely limited. Queensland Treasury figures reveal that more than 10,000 FIFO/DIDO jobs have been lost in the Surat Basin since the CSG construction boom peaked in 2014. In June 2014 there were 14,490 non-resident jobs in the region, and by June 2016 that had reduced to just 3,820 jobs[109], similar to pre-CSG levels.

Long-term employment is low because the oil and gas industry is highly capital intensive. The Office of the Chief Economist estimates that the entire oil and gas industry in Australia employed just 29,000 people in 2015/16[110], which is less than a quarter of the Australian workforce. That is an extraordinarily low employment given that Australia is set to become the world's largest exporter of gas.

The gas industry frequently also makes claims about delivering substantial flow-on jobs in regional communities, particularly in the services industry, and job multipliers are frequently used to derive large job estimates. However, research into the local economic impacts of CSG in Queensland provides evidence, which disputes those claims. Specifically, research by Fleming and Measham for GISERA found that job spillovers into non-mining employment in the Surat Basin were negligible[111]. The table below provides a summary of their findings.

Table 4.2. CSG employment spillovers over different sectors

	Elasticity	Additional job for each new CSG job
Local goods sector		
Construction	0.832 (0.426) *	1.412
Professional services	0.704 (0.259) **	0.412
Retail trade	0.011 (0.140)	0.024
Services†	-0.205 (0.230)	-0.732
Traded sector		
Manufacturing	0.068 (0.199)	0.160

Notes: Elasticity values are 2SLS estimations for coefficient ψ in equation (2). The number of CSG wells in an SLA is used as instrument for the log change of mining employment. Values estimated using sample 3 (n = 48). F-stat first-stage = 10.74. Robust clustered std. errors at LGA levels in parentheses. *p < .10. **p < .05.
†Services sector include employment in accommodation, rental agencies, transport and 'other services'.

[108] Fleming and Measham, (2014) Local economic impacts of an unconventional energy boom: the coal seam gas industry in Australia, The Australian Journal of Agricultural and Resource Economics, 59(1), pp. 78–94, http://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12043/full
[109] http://www.qgso.qld.gov.au/products/reports/surat-basin-non-resident-pop-proj/surat-basin-non-resident-pop-proj-2017-2023.pdf
[110] https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Resources-and-energy-quarterly.aspx
[111] Fleming, D. and Measham, T. (2013) Local economic impacts of an unconventional energy boom: the coal seam gas industry in Australia. Report to the Gas Industry Social and Environmental Research Alliance (GISERA). June 2013. CSIRO, Canberra.

Amenity – risk of adverse impacts on those living on the land

A recent CSIRO study[112] examining farmers' perceptions of coexistence between agriculture and a large scale coal seam gas development in Queensland found that "issues regarding atmospheric pollution (dust, light, noise) has a significant impact on many aspects of farmers' lives." The impact of significantly increased traffic, both on and off the farm, was also a significant concern to famers.

The expansion of CSG production in Queensland has demonstrated the potential for UG developments to severely disrupt virtually every aspect of agricultural production and potentially even remove the land from production.

In the course of its work supporting landholders and communities facing the impacts of unconventional gas developments, Lock the Gate Alliance hears firsthand about the myriad effects these development are having on the livelihoods, health and well-being of Australian farming families living adjacent to and surrounded by gas activities. These harmful impacts include: intimidation, coercion and bullying by UG companies; intolerable noise and light pollution from flaring, traffic and UG infrastructure; contamination and depletion of water in farm bores; rivers bubbling with methane; bores running dry; stock losses associated with pipeline construction and water contamination; costly and time consuming interruptions to farming operations; huge trucks and heavy machinery on small local roads affecting lifestyle, safety and road infrastructure; dust impacts on pasture; increases in weed infestation; industry workers leaving mess from pipeline construction in farm paddocks; workers destroying fences and leaving gates open; properties not able to be sold; mental health impacts resulting from dealing with companies and the impacts of industry development; and physical health symptoms including respiratory ailments, headaches, rashes, nausea and vomiting, and nose, throat and eye irritations.

For many affected landholders, these impacts affect all facets of life and are making their living situation untenable. Personal testimonies of a number of affected landholders can be viewed in a series of short films compiled by the Lock the Gate Alliance talking about the impacts on them: https://www.youtube.com/watch?v=4OG9JkzB_3M

In relation to the cattle industry, there have been measured impacts of exposure to fracking related spills in the United States. A 2012 study by Bamberger and Oswald cited the following example:

> *Two cases involving beef cattle farms inadvertently provided control and experimental groups. In one case, a creek into which wastewater was allegedly dumped was the*

[112] Huth N.I., Cocks B., Dalgliesh N., Poulton, P., Marinoni O., Navarro J. (2014) Farmers' perceptions of coexistence between agriculture and a large scale coal seam gas development: working paper, June 2014, CSIRO, Australia.

source of water for 60 head, with the remaining 36 head in the herd kept in other pastures without access to the creek. Of the 60 head that were exposed to the creek water, 21 died and 16 failed to produce calves the following spring. Of the 36 that were not exposed, no health problems were observed, and only one cow failed to breed. At another farm, 140 head were exposed when the liner of a wastewater impoundment was allegedly slit, as reported by the farmer, and the fluid drained into the pasture and the pond used as a source of water for the cows. Of those 140 head exposed to the wastewater, approximately 70 died and there was a high incidence of stillborn and stunted calves. The remainder of the herd (60 head) was held in another pasture and did not have access to the wastewater; they showed no health or growth problems. These cases approach the design of a controlled experiment, and strongly implicate wastewater exposure in the death, failure to breed, and reduced growth rate of cattle.[113]

A follow-up study published in 2015 by the same authors further investigated 21 case studies from five states. They found that the distribution of symptoms in animals and humans affected by nearby fracking operations was, since 2012, unchanged for humans and companion animals. In food animals, reproductive problems decreased over time while respiratory problems and growth problems increased. Researchers also found, "More than half of all exposures were related to drilling and hydraulic fracturing operations; these decreased slightly over time. More than a third of all exposures were associated with wastewater, processing and production operations; these exposures increased slightly over time."[114]

Cumulative risks – Gaps between company promotion and on ground impacts

The question of well spacing and impact on the landscape has played a role in discussions in the NT Fracking Inquiry to date. Some industry proponents argue that the landscape impacts will be less than the real-life invasive gasfield images that are available from satellite images via Google Maps, or aerial photographs taken by local residents in gasfield areas.

Of interest to the Panel is this 2010 video released by Australian unconventional gas driller Santos. The short video, titled *CSG Multi well pad drilling: reducing our impact,* features discussion of how Santos will reduce impacts on local roads from 5 wells on one well pad.

The two minute video is available online here:
https://www.youtube.com/watch?v=NCdkybhPb6w

[113] Bamberger, M. and Oswald, R (2012). IMPACTS OF GAS DRILLING ON HUMAN AND ANIMAL HEALTH, NEW SOLUTIONS, Vol. 22(1) 51-77, 2012, http://www.psehealthyenergy.org/data/Bamberger_Oswald_NS22_in_press.pdf

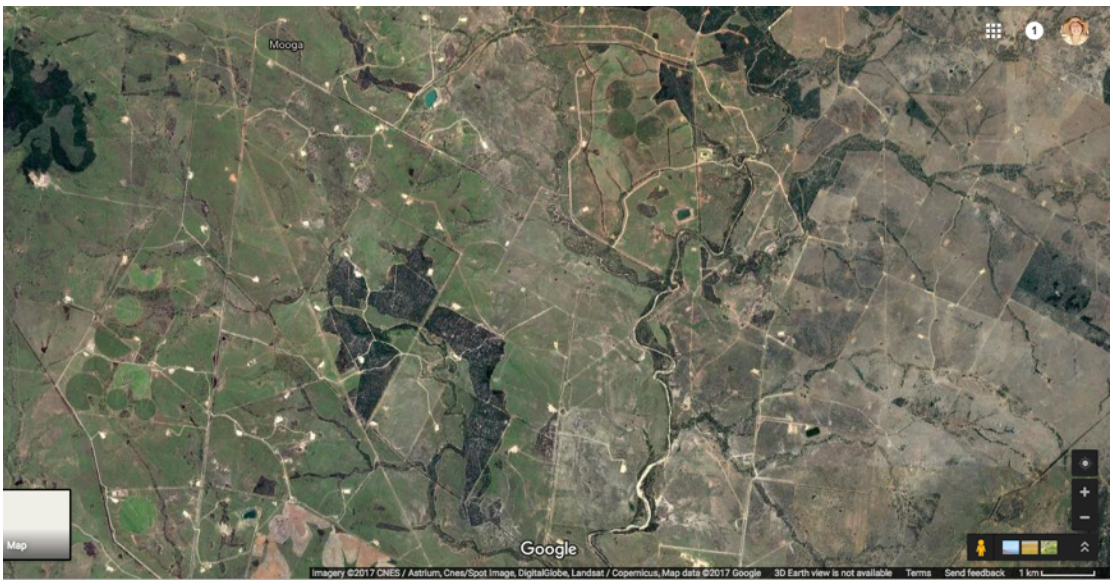
[114] Bamberger, M. & Oswald, R. E. (2015). Long-term impacts of unconventional drilling operations on humans and animal health. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, 50, 447-59. doi: 10.1080/10934529.2015.992655

Screenshot from the Santos video:



However, this technology has not been widely used by Santos in QLD. Or if it has, it has had limited impact on reducing surface impacts. Over six years since this video was released, Santos has cleared thousands of CSG pads across QLD, and has recently gained Federal approval for a further 6100 CSG wells in QLD.

Please note these more recent images of Santos unconventional gasfields in QLD that form part of their GLNG gas project. You can note by the scale that the cleared gas pads are at approximately 1 km spacing.





And below is a photo taken while travelling through the QLD Arcadia Valley in 2015, where flare stacks from wells looked to be just hundreds of metres apart. The middle flare is closest and most obvious. Please note the other flares, one on the far left of the shot and the other on the far right of the shot.



The aim in showing photos of coal seam gas fields in QLD is not to say that on ground impacts of shale gasfields will be exactly the same (although as noted there are many similarities). These photos help demonstrate the clear gap between what the Santos promotional video said in 2010, and the reality that has played out across a larger scale in the years following. In this case, the company had a promotional position that was not necessarily implemented widely or the lived experience of those impacted by the industry.

7.7 Economic Impacts

Energy Security

Based on the experience of UG extraction in QLD, evidence shows that there is a risk that energy security in the Northern Territory will be jeopardised if shale gas *is* developed.

The advent of UG in QLD was designed to fuel export liquefied national gas (LNG) terminals in Gladstone. The demand from those gas terminals is around three times the demand of the East Coast domestic market and has led to gas shortages and price hikes across the East Coast of Australia. With the commissioning of LNG export terminals from Darwin, and proposed gas pipelines from the NT to QLD and/or SA, the NT is not immune to the energy security risks faced in other jurisdictions in Australia that have risen from an expectation of high yields of unconventional gas.

Currently, the Northern Territory has a secure contract for plentiful, affordable offshore conventional gas until 2032[115].

The following statements from economists Acil Tasman in 2013 give further information on the current conventional gas available to the NT:

The Blacktip field is located in shallow water 110km off the northern coast of Australia in the Timor Sea's Bonaparte Basin. The field is 100% owned and operated by Eni. The gas produced at Blacktip is transported through a 108km long, 18in diameter subsea pipeline to an onshore gas processing facility at Wadeye. It is then transported via the 286 km Bonaparte Gas Pipeline which connects to the Amadeus Gas Pipeline at Ban Ban Springs.

Blacktip commenced production in 2009, delivering gas to the Northern Territory's Power and Water Corporation (PWC) under a 25 year supply contract with supply rising to 18,000 boe/day (about 38 PJ/a) over the life of the contract. According to a notification by PWC to the Australian Competition & Consumer Commission in 2006, the supply of gas under the Blacktip Gas Supply Agreement (GSA) represented all of PWC's forecast demand for gas from 2012 until 2032. The same notification pointed out that the total contract quantity under the GSA exceeded Eni's then-current proved (P1) gas reserves in the Blacktip field, but also noted that there was potential for further recoverable gas to be found in prospects in Eni's tenements in and around Blacktip. The field has proven and probable (2P) reserves of around 900 bcf (960 PJ) of which about 625 PJ are committed under the PWC 25-year contract.[116]

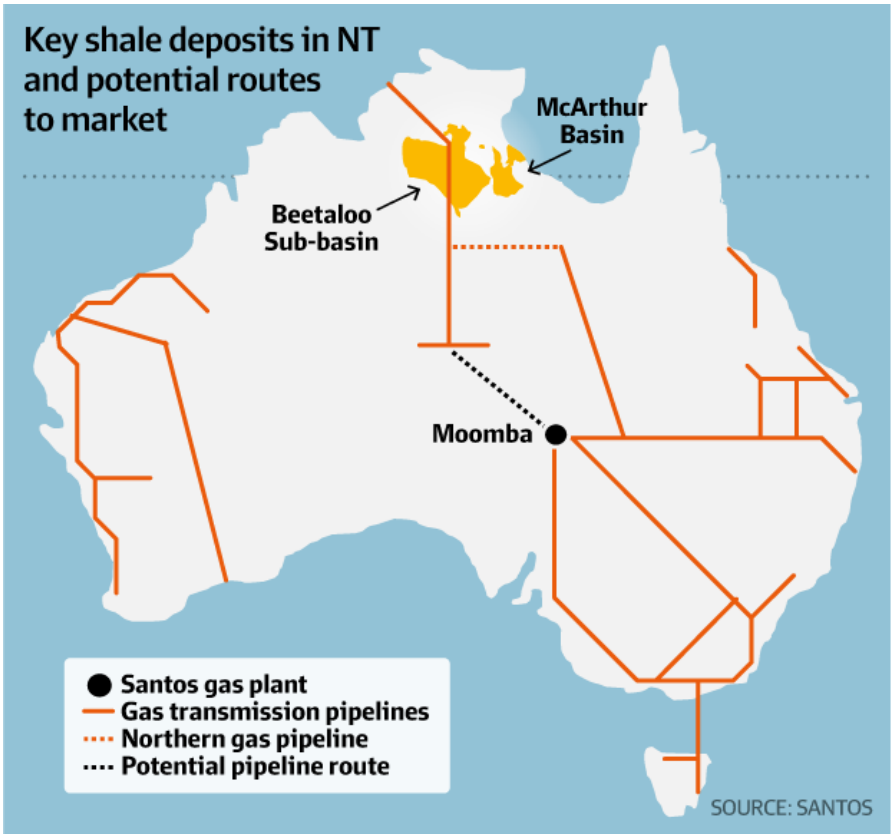
A re-negotiation of that Eni contract with Power Water to allow for unconventional gas to enter the NT domestic market would lead to price risks, supply uncertainty risks and would have a destabilizing impact on the Territory's economy.

Other Industries

On Friday 31 March, the Australian Financial Review released a map of where gas producers would like to be able to access in the NT by the end of 2017[117].

[115] Australian Competition and Consumer Commission, http://registers.accc.gov.au/content/index.phtml/itemId/750462/fromItemId/729985/display/notification
[116] Acil Tasman (2013) Economic impacts of Katherine to Gove Gas Pipeline, Prepared for Pacific Aluminium, https://ntepa.nt.gov.au/__data/assets/pdf_file/0003/287535/Appendix-A-Economic-Evaluation.pdf
[117] Australian Financial Review, 2017, http://www.afr.com/business/energy/gas/beetaloo-emerges-as-beacon-for-east-coast-gas-20170329-gv9add

The map, inserted here and supplied to the Australian Financial Review by Santos, includes significant tourism areas of the NT including Mataranka thermal springs and large tracts of the Roper River catchment in the proposed gasfield region.



There are further economic risks that we recommend are added to the risk tables in the Paper.

Credit Availability – risk of loan problems for landholders

In a submission to the NSW Legislative Council *Inquiry into the Management of the Murray-Darling Basin – Impact of Mining Coal Seam Gas*, Rabobank, the world's leading specialist in food and agribusiness banking, listed the risks from unconventional gas mining to include reductions in farm productivity, efficiency, land values and credit availability. Further Rabobank states, "Should the trend toward concurrent CSG mining and agricultural activities continue on agricultural land ... problem loans or defaults will rise"[118].

[118] Rabobank (2011) Submission to the Senate Inquiry into the management of the Murray-Darling Basin – impact of mining coal seam gas http://www.aph.gov.au/DocumentStore.ashx?id=5bfff958-7e81-41e7-94d3-c1f463ce8c26

This prediction has already begun to become a reality for some landholders in QLD who have hosted unconventional gas mining on their properties. For example, in 2016 it was revealed that a QLD family were unable to obtain a bridging loan using their property for equity, on the grounds that the QLD property has four coal seam gas wells on it.

The email from the Commonwealth bank stated, "Long form valuation has revealed coal seam gas wells on the land, making the security unacceptable for residential lending purposes."

A copy of the refusal email is embedded here, supplied by the journalist Joshua Robertson via Twitter, who uncovered the story in September 2016[119].

[119] https://www.theguardian.com/environment/2016/sep/30/commonwealth-bank-coal-seam-gas-makes-property-unacceptable-as-loan-security

Commonwealth Bank
Commonwealth Bank of Australia
ABN 48 123 123 124

From: Retail Credit Decisioning
Sent: 01/07/2016
To: [redacted]
SUBJECT:
Date: 01/07/2016

[redacted]

Customer Name: [redacted]
Facility:
Product/s: 2 Year Fixed Rate Home Loan (TP)
Account No:
Loan Amount: $500,000.00

If not already provided to the Bank, please supply supporting documents as soon as possible clearly identifying with the application Bank Reference Number. Supporting documents are required for the application to progress further.

Unfortunately, we are unable to provide assistance with the above application at the present time as the application does not meet the Banks approval conditions. If application details change please resubmit the application.

We provide the following comments:
The Application fails to meet the Bank?s lending criteria due to the follow reasons: Security unacceptable

1) Long form valuation has revealed 4 gas wells on the land, making the security unacceptable for residential lending purposes.

Application is declined, and this decision supersedes any former decisions.

[redacted]

If you would like to discuss this please contact your local Mortgage Services.

Further information can be obtained on http://www.commbroker.com.au using the Bank Reference Number above or contact your local Mortgage Services centre.

Commonwealth Bank
Retail Credit Decisioning

Royalties – risk that onshore gas royalties are likely to be far less than forecast

The Northern Territory can look to QLD for actual figures on the onshore gas industry and contribution to the economy through royalty payments. The uncomfortable reality is that QLD has reaped very little of the economic royalties that it was promised and that QLD Treasury forecast.

The QLD Treasury mid-year review in 2013-14 forecasted $482M for petroleum royalties to flow during 2015-16[120].

However, the reality shows that in Queensland, the Mid Year Fiscal and Economic Review reported actual royalties from onshore oil and gas were $36M in total from all CSG and conventional gas in 2015-16[121]. That equates to only 7.5% of projected royalty payments, compared to what was expected just three years earlier. The reality is down by $446M.

A deeper look shows that those royalty payments were made from 5,127 coal seam gas wells that were producing that year[122].

Origin Energy has taken the QLD Government to the Supreme Court challenging the entire system of royalties and the rights of the QLD Government to levy them.

Furthermore, as reported in the Australian Financial Review on 28 April 2016, the royalty spat between the Queensland government and a major gas consortium flared up with a petroleum exploration company claiming big liquefied natural gas producers used transfer pricing to reduce their royalties bill.[123]

Taxation – risk that UG extraction companies will not pay their fair share of corporate tax in Australia

In late 2016, the Australian Tax Office revealed large companies in Australia that paid no corporate tax in the 2014/15 financial year, these included:

- Origin Energy Ltd, total taxable income $12,200,600,757, paid zero corporate tax,

[120] QLD Treasury, 2014, https://www.treasury.qld.gov.au/publications-resources/mid-year-review/mid-year-review-2013-14.pdf

[121] Queensland Government's Mid Year Fiscal and Economic Review 2016-17, https://www.treasury.qld.gov.au/publications-resources/mid-year-review/mid-year-review-2016-17.pdf#mid-year

[122] Queensland Government data: CSG Production, 6 Monthly Statistics

https://data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics/resource/63a8a6cc-7fb6-4040-b4e7-9d453b14d3ed

[123] AFR 2016, http://www.afr.com/news/politics/origin-lng-consortium-used-transfer-pricing-to-cut-taxes-20160426-gofb0q

- Santos Ltd, total taxable income $3,389,399,798, paid zero corporate tax[124].

Unprofitable – risk that NT shale gas is not profitable, leads to bankruptcies

In shale gasfields of the United States, Bloomberg reported that many fracking companies were losing money on shale drilling. A damning case study of shale drilling in Oklahoma revealed that the drilling was financed on cheap debt, with drillers spending $2 for every $1 they made from shale.

The Bloomberg report includes: *As Stanley Druckenmiller, an investor with one of the best long-term records in money management, said of Texans in January 2015: "Those guys know how to gamble, and if you let them stick a hole in the ground with your money, they're going to do it." Shale wasn't sustaining the frenzy; cheap debt was*.[125]

A 2016 Reuters report revealed a wave of bankruptcies across the United States that year[126]. One question for the Northern Territory Fracking Inquiry might be: who pays the clean up bill if these shale gas drilling and fracking companies go bankrupt? How do these economic risks relate to regulatory risks and failure to protect the environment and local communities?

The United States examples are particularly relevant to the Territory, due to the high cost of proposed shale gas operations here. In October 2016, Core Energy Group provided an Outlook Report to the SA Government and industry round table. The report includes the below table, outlining that NT Unconventional gas is the most expensive gas to extract in all of Australia[127].

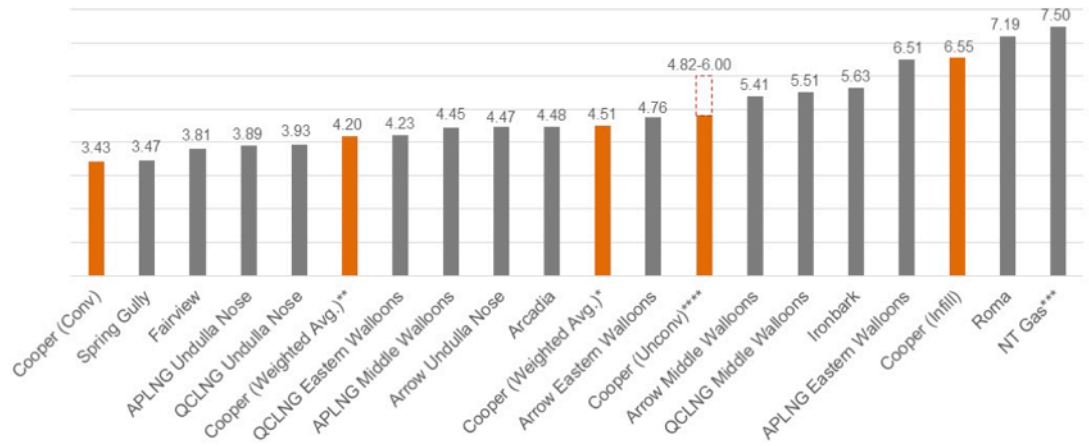
[124] ABC report based on ATO data, December 2016, http://www.abc.net.au/news/2016-12-09/tax-data-transparency-ato/8106178

[125] Bloomberg, 2016, https://www.bloomberg.com/news/articles/2016-03-10/the-shale-reckoning-comes-to-oklahoma

[126] Reuters, 2016, http://www.reuters.com/article/us-usa-shale-telecoms-idUSKCN0XV07V

[127] Core Energy Group, 2016, Cooper-Eromanga Basin Outlook | 2035

Figure 1.9 Comparison of Cooper Basin and Competitor Marginal Cost of Supply (ex-field) | AUD/GJ



* Represents the weighted average of the CBJV Conventional gas and the CBJV infill program, under the assumption that infill gas would meet the existing horizon contract shortfall.

** Represents the weighted average of the CBJV Conventional gas and unconventional plays, under the assumption that gas from unconventional reservoirs would meet the existing horizon contract shortfall and the contestable market.

*** NT Gas is estimated to have a range of AUD6/GJ (Blacktip ex-field) to AUD7.50/GJ for the higher cost unconventional plays.

Social Licence to Operate

While the NT Government deemed the matter of 'social licence to operate' outside the formal terms of the Panel's deliberations, the phrase has arisen both during presentations from the gas industry and community representatives throughout the inquiry, as it is a widely used concept. While not a legal concept, the Lock the Gate Alliance sought information from researchers at the EDO NSW on its meaning and how a social licence to operate might be applicable in relation to the Fracking Inquiry.

Please see **Attachment H** for a detailed overview and referenced research on this matter.

7.8. Land Access

Compensation

Landholders loose millions every year by hosting unconventional onshore gasfields

In 2016, the CSIRO released a report into the total losses to gross revenues incurred by farmers who host unconventional gasfields on their properties. The new spatial modeling, using a methodology developed by CSIRO after years of research, found that the alienation of

productive farmland for CSG infrastructure in Queensland results in losses in gross economic returns of up to 10.9%[128].

The research, published in the Land Use Policy Journal, found that in relation to the chosen study area in the Western Downs: "In the scenario assessment the total losses to gross revenues incurred by the existence of CSG infrastructure per property varied between $1.32 m and $3.29 m and averaged $2.17 million… Access tracks and lease areas contribute most to economic losses".

The Lock the Gate Alliance notes that the methodology was estimating economic losses based solely on reduction in land area and did not attempt to quantify losses resulting from disruption to operations, dust generation, spills and leaks of wastewater or the spread of weeds. Therefore, total losses to landholders will undoubtedly be far higher.

We understand that the UG industry in the Northern Territory is claiming that the surface impacts of a shale gas industry will be very different to the QLD CSG reality, however that is yet to be seen, with all exploration wells so far demonstrating the same one well one pad technology that is utilized around the world.

While farmers do receive some compensation for hosting gas mining companies on their land, landholders have been suggesting that access agreements and compensation payments should be made publicly available and must also be agreed to by the Territory Government. This would help ensure there can be no confusion as to the impacts the industry is having on landholders' assets as they host gas companies on the Northern Territory Government's behalf.

Consultation

I have been provided the written information that was used in a negotiation meeting with the Garawa Traditional Owners from around Borroloola in 2012 (**Attachment I**).

This is a useful overview that provides insights into what companies are disclosing (and failing to disclose) to Land Councils and Traditional Owners through their bid for land access in the Northern Territory.

While the presented materials give some good insights, the benefit of hindsight now shows that there was a failure to disclose any chemical use and there was a failure to explain in any form what the ultimate development outcome would look if exploration was approved, which then led to production. In short, there is no mention that a gasfield in the region could entail hundreds or even thousands of wells drilled and fracked, truck movements, extensive

[128] O. Marinoni', J. Navarro Garcia, 2016, A novel model to estimate the impact of Coal Seam Gas extraction on agro-economic returns, Land Use Policy, Volume 59, 31 December 2016, Pages 351–365, http://www.sciencedirect.com/science/article/pii/S026483771630076X

associated infrastructure, roads and associated scale of workers living in the area, as has occurred across the world with this industry.

In this case, it is my understanding that the Traditional Owners in this case exercised their veto right, however it is unknown what the materials provided in other negotiations have been in cases where Traditional Owners have provided their consent.

For insights into the consultation process, Lock the Gate has sought further examples from landholders in QLD.

This 14-minute video provides very useful insights into the gap between what a landholder thought would take place based on the negotiation phase, and what his lived experience of dealing with the industry has been. He signed an access agreement for unconventional gas extraction by Origin Energy (one of the major gas companies seeking to access unconventional gas in the Northern Territory).

I have obtained permission from the video maker to share this video with the Panel: https://vimeo.com/212700855/70d67dbd16

This screen shot from the video shows of one of the high point vents (venting methane) on this property:



Video credit: Brian Monk

Please note that this landholder raises many similar concerns to those landholders interviewed in short videos mentioned earlier in this submission. Again, these impacts of a coal seam gas operation are important when considering the impacts of shale gas extraction, as the

companies, the company practises, the overseeing regulation and the land based impacts share similarities worthy of serious consideration by the Panel.

The Lock the Gate Alliance argues these information gaps are unacceptable. The misleading picture that onshore unconventional gas companies provide to landholders and Traditional Owners in order to obtain a signature on an access agreement is unacceptable. The fullest possible disclosure of all impacts to property, to the landscape, to health, to Traditional landscapes, Aboriginal dreaming sites and songlines, and to waterways that will result of an onshore unconventional gasfield in full production must be put clearly on the table as part of the negotiations. Information must be public. Landholders must have access to lawyers that are independent of gas company appointed lawyers.

Due to the evidence of large information gaps that have aided the sign off of exploration licences and access agreements to date, the Lock the Gate Alliance recommends that the panel consider whether already granted exploration licences should be revoked and the process restarted. This would offer landholders and Traditional Owners the benefit of the information that the Panel is collecting. This would allow landholders to make informed decisions for the future of their land. This should be accompanied with the right of veto, again to provide fair options and full information.

Insurance

Farmers and other landholders have raised major concerns about the likelihood that they may ultimately be liable for any negative impacts caused by hydraulic fracturing. In 2014, the NSW Chief Scientist released a report, which concluded that the CSG industry there was markedly under-insured and that landholders were likely to bear a substantial risk as a result[129].

Meat and Livestock Australia has provided general guidance for livestock producers in regard to CSG operations on livestock property. It notes that there is a genuine risk that landholders may ultimately be responsible for liabilities arising from unconventional gas activities if they lead to:

1. Someone being injured on the property
2. Damage to the property
3. Damage to a neighbouring property
4. Livestock or produce is injured, damaged or contaminated[130]

It notes that landowners need to be fully informed about the terms and scope of gas companies insurance cover, and need to be included in any policy as an interested party. It highlights particularly the liability that may accrue to a landowner with CSG operations on their property

[129] NSW Chief Scientist and Engineer, 2014 http://www.chiefscientist.nsw.gov.au/latest-news/chief-scientist-and-engineer-calls-for-tougher-insurance-regime-for-csg-industry

[130] Meat and Livestock Australia. (2014) Coal Seam Gas Operations on Livestock Property: General Information for Livestock Producers.

if any harm is caused to adjacent properties, stating that '*Contamination of soil, pasture or groundwater could also result in contamination of neighbouring properties as well as livestock which, if then processed and consumed, could breach Australian food standards or importing country requirements for meat. While a landowner may have some recourse against a CSG operator, the landowner may still have primary responsibility*'.

It also notes that landowners may be forced to cover the costs of the clean-up of contamination, stating that '*Environmental regulatory authorities may also exercise statutory powers to impose clean-up obligations on the landowner if contamination occurred. These costs may not always be recoverable from the CSG operator under the relevant legislation.*'[131]

Notably, the Rural Industries Research and Development Corporation cite a case study in QLD where a landowner was advised by their supply chain partners that they would be liable for any contamination caused by CSG activities. Neither the CSG company nor the insurer would agree to indemnify the landholder against that risk[132].

Legal advice received by the landholder was that the Conduct and Compensation Agreement on offer from the CSG company only provided indemnity to a shelf company and that the agreement waived future compensation rights. Any compensation for a contamination event would need to be pursued through the Courts.

The major implications for landholders and livestock producers in particular, are that:

1. The onus of proof in any contamination event is almost certain to reside with the landholder.
2. The inadequacies of baseline monitoring by companies and the prohibitive costs of monitoring for landholders, means that proving contamination is likely to be extremely difficulty.
3. Farmers who sign National Vendor Declarations for livestock that may have been contaminated by contact with UG waste are likely to be liable for any harm incurred.
4. UG companies are refusing to include provisions in access agreements to accept liability for any contamination that may occur.
5. UG companies in Australia are under-insured and do not have adequate insurance to cover the types of risks that CSG activities bring.
6. Some graziers have reported that insurers have examined the risk to them of UG contamination and found it too high to offer insurance.

[131] Ibid.

[132] Clarke, M. (2013) Principles for Negotiating Appropriate Co-existence Arrangements for Agricultural Landholders, Rural Industries Research and Development Corporation https://rirdc.infoservices.com.au/items/12-114

7.9. Regulatory framework

Current onshore petroleum statutes were typically developed to manage historical conventional gas operations, which, as outlined in this submission, are very different in their scale and intensity than conventional operations, with correspondingly far greater potential for impacts on land, water and air. Consequently, the roll out of the unconventional gas industry across Australia has taken place within a regulatory environment that is grossly inadequate to the task of managing this spatially intensive industry and the new and often experimental processes and methods that it employs.

In the NT, the current legislation under which the UG gas industry is operating fails to address a whole range of factors. Government has been playing policy catch up as this industry is rolled out without proper consideration of the possible or likely impacts. Some of the issues that current legislation fails to adequately address include: impacts that occur during the exploration phase of development; cumulative impacts across multiple projects; use of untested chemicals and chemical cocktails in fracking processes; treatment, storage and disposal of unprecedented volumes of saline wastewater (that also contains fracking chemicals and other toxic substances present in the rock substrates such as heavy metals and radionuclides); leaking methane emissions and air pollution impacts and resultant human health risks. In addition to the failure to properly address the risks, there is also an absence, across both Federal and Territory jurisdictions, of legislated mechanisms to ensure that adequate baseline data relating to air, water and soil systems is gathered prior to commencement of UG activities. Without proper baseline data, there is no way to measure and quantify impacts that do occur, let alone manage or mitigate those impacts.

Recent findings from the US show that regulations are simply not capable of preventing harm[133] and relying on regulatory frameworks alone to manage the risks associated with fracking is not a viable solution for governments.

Regulation is ineffective both because the number of wells and attendant infrastructure in unconventional gas operations is so large and keeps increasing and, more importantly, because some of the shale gas fracking industry's many component parts, which include the subterranean geological landscape itself, are simply not controllable.

For instance, a new study on fracking-related air pollution in northeastern Colorado shows that even though the volume of toxic emissions per well might be decreasing, overall air quality in

[133] Concerned Health Professionals of New York & Physicians for Social Responsibility. (2016, November 17). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (4th ed.). http://concernedhealthny.org/wp-content/uploads/2016/12/COMPENDIUM-4.0_FINAL_11_16_16Corrected.pdf

the shale field continues to deteriorate as the rapid, continuing increase in the number of wells cancels out improvements to air quality brought about by more stringent regulations. Similarly, the *Compendium of Fracking Risks* details the results of a new study from Texas which raises the possibility that methane can migrate into aquifers through *unseen* cracks and fissures in the rock surrounding the wellbore in ways that no cementing and casing protocols, however strictly applied, can prevent. Additionally, new findings from West Virginia show how previously abandoned wells can become re-pressurized during nearby fracking operations and serve as conduits for the contamination of drinking water. The *Compendium* notes that, "no set of regulations can obviate these problems".

Water and Regulation – US EPA Report

Perhaps the most notable finding of the US EPA Investigation into the impacts of hydraulic fracturing on water resources was that it simply did not have sufficient data to actually properly assess impacts. The EPA concluded that '*data gaps and uncertainties limited EPA's ability to fully assess the potential impacts on drinking water resources both locally and nationally*'. That is an extraordinary admission of the failure of proper baseline assessments and of systematic monitoring[134].

Despite being limited only to considering the impacts on drinking water resources, and not looking further at impacts on agricultural water supplies, the study found that there were certain conditions under which the impacts can be more frequent or severe. Top of that list of conditions was fracking water demand in times or areas of low water availability, particularly in areas of limited or declining groundwater resources. It seems likely that those conditions would apply equally to agricultural water supplies as they do to drinking water, and it raises serious alarm bells about the likely risks to vital groundwater resources in the Territory.

Self Regulation Risks

In addition to the regulatory issues outlined from the US, the scale of unconventional gas operations make regulatory enforcement and monitoring a difficult and expensive undertaking which is not economically feasible for governments within existing funding priorities and frameworks. In existing UG operations such as those in Queensland, and even across the relatively small footprint of the conventional gasfields in the Northern Territory, the role of monitoring has largely been left to the industry if it is done at all. Typically enforcement agencies are under resourced and under staffed. The fact that there has been little baseline monitoring of existing water, air and soil parameters prior to the roll out of the UG industry in Australia also means that impacts will not be measurable, if and when they occur.

[134] EPA USA (2017) "Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources". https://www.epa.gov/hfstudy

Non-Compliance Allegations from QLD

A Statement of Claim filed by whistleblower, Ms Sally McDow, in a civil case against Origin Energy, makes a number of allegations pertaining to the APLNG CSG project in Queensland, including that potential gaps in the monitoring equipment which is used to calculate petroleum royalties payable to the Queensland Government may have led to the potential loss of 'tens of millions of dollars' to taxpayers, but was not reported to authorities[135].

Other specific APLNG allegations include 'multiple water containment breaches' and failure in pipeline maintenance[136]. More broadly, in relation to Origin activities, there are additional allegations pertaining to hundreds of gas wells that had not been properly maintained for 10 years or more and that had not been plugged and abandoned[137] and other instances of aquifer contamination and leaking of gas and oil[138].

A most disturbing allegation is that Origin was engaged in a deliberate strategy of non-reporting of breaches in order to minimise costs, and that hundreds of incidents were going unreported to relevant authorities and regulators[139]. More specifically, it is alleged that senior management were opposed to reporting the true state of compliance with the APLNG project until the project was finished and producing income 'in 2017'[140].

This fair work case has now been discontinued[141], and it is likely that the serious potential non-reporting and non-compliance matters which it exposed will never be properly investigated or brought to light.

NT Context: lessons from offshore conventional gas in relation to regulation

We can look to past investigations into oil and gas operations in the Territory to learn more about where the weaknesses are likely to be into the future. While there has not been a comprehensive independent investigation into the onshore conventional gas operations in Central Australia, there was a fairly recent investigation of the offshore practices.

On 5 November 2009, the then Hon Martin Ferguson AM MP, Minister for Resources and Energy, announced a commission of inquiry into the uncontrolled release of oil and gas from the Montara Wellhead Platform in the Timor Sea. The commission of inquiry was established

[135] Page 22 of the Amended Statement of Claim filed on 23rd January 2017
[136] Page 22
[137] Page 26
[138] Page 27
[139] Page 21
[140] Page 21, Amended Statement of Claim filed on 23rd January 2017
[141] https://www.comcourts.gov.au/file/Federal/P/VID920/2015/3744249/event/28905029/document/945311

under Part 9.10A of the Offshore Petroleum and Greenhouse Gas Storage Act 2006, and had nearly all the powers of a Royal Commission.

The Commissioner David Borthwick AO PSM provided the Montara Commission of Inquiry Report to Minister Ferguson on 17 June 2010.

The Montara Commission of Inquiry found that the company, PTTEP Australasia (PTTEPAA), "Did not come within a bull's roar of sensible oilfield practice". It also found major issues with the regulation of the site by the Northern Territory's Department of Resources. The Commission of Inquiry issued a scathing critique of the NT Government's regulatory role, with Commissioner Borthwick pointing particularly to the amount of revenue received by the NT Government, vis-à-vis the amount it spent on regulation.

The Commission specifically recommended that the Federal Government remove the regulatory powers from the NT Government and give them to a single national regulatory body.

The following statements of the Commissioner in the formal report to the Federal Government[142] highlight the major issues with the regulators approach:

• *The NT DoR did not do its job by ensuring the company's WOMP or the Phase 1B Drilling Program complied with good oilfield practice. In short, the NT DoR did not take adequate steps to ensure that PTTEPAA actually complied with the requirement of good oilfield practice.*

• *The inquiry finds that the NT DoR's regulatory regime was totally inadequate, being little more than a 'tick and flick' exercise. In particular, the inquiry does not agree with the Northern Territory's characterisation (before the Inquiry's public hearing) that the approach the NT DoR adopted followed 'contemporary regulatory practice'. The information provided to the inquiry indicates that, in contrast to the approach adopted by the NT DoR, the Victorian regulator undertakes monitoring, inspection, audit and compliance regime.*

• *The relationship between the NT DoR and PTTEPAA had become far too comfortable. Indeed, one contributory factor to PTTEPAA's own lax standards was the minimalist approach to regulatory oversight by the NT DoR.*

• *The inquiry formed the view that the resources and expertise that the NT DoR devoted to its task as delegate of the DA were inadequate (effectively only one person, who appeared to have a limited ability to fulfil this task). The Minister should consider removing this delegation from the NT DoR.*

[142] Commissioner David Borthwick AO PSM (2010) Report of the Montara Commission of Inquiry, http://www.iadc.org/wp-content/uploads/2016/02/201011-Montara-Report.pdf

Summary of initial regulation recommendations

The Lock the Gate Alliance looks forward over the course of the inquiry to ongoing and productive discussions in regards to whether this industry should proceed in the Northern Territory, and if it were to proceed in any form, what potential regulatory mechanisms should apply.

Based on the evidence of known, deleterious impacts from unconventional gas identified in this submission and the additional major risks it poses to water resources, public health and the social fabric of communities, we believe that there is currently no sound basis to proceed with the industry in the Northern Territory.

In particular, the land use intensification, the risks to groundwater and the potential scale of fugitive emissions, all represent strong reasons why the industry should not proceed in any form at present. These problems are intensified by the evidence that substantial liabilities will accrue to landholders and that major legacy issues will continue long after gas companies have packed up and gone.

In terms of intergenerational equity, there are perhaps no two issues as fundamental as water resources and climate, and unconventional gasfields will genuinely threaten both. The precautionary principle dictates that we do not proceed with damaging activities when there is so much uncertainty about their impacts. There is enough evidence presented in this submission to make an extraordinarily strong argument against any unconventional gas development until all of these uncertainties have been fully resolved. The burden of proof must fall on the unconventional gas industry to prove that it will not cause the harms identified in this submission, and until it can do so, it should not be given approval to operate in the Northern Territory.

Some initial recommendations are listed below:

1. A continuation of a moratorium on any new unconventional shale gas mining or exploration should be continued across the Northern Territory until further important research has been completed. This must include the completion of proper baselines assessments for water quality, quantity and flow rates, geological data, health impact assessments for target communities, ecological values and air quality data including methane concentrations.
2. These baseline assessments must be transparent, legally verifiable and publicly available. If unconventional gas developments are to proceed in any areas of the Territory into the future, these publicly held baseline assessments will be critical for ensuring any future pollution can be quantified and responsible companies can be held to account. The Lock the

Gate Alliance does not support any continuation of shale gas extraction activities in the Territory before these baseline assessments have been completed.

3. Baseline assessments must be accompanied by systematic monitoring of each of the attributes listed above to assess change against baseline. All baseline assessments and monitoring should be conducted independently, be made publicly available, and be paid for by a levy imposed on the industry.
4. Due to the inherent and measured risks and impacts associated with shale gas extraction wherever it has been undertaken, exclusion zones are required to protect land, water and communities from the impacts of the industry. We recommend exclusion zones and buffer areas around agricultural land, all significant groundwater and surface water resources, identified cultural landscapes and tourism icons, national parks and other ecologically important areas, and residential dwellings from shale gas exploration and extraction impacts.
5. We acknowledge the growing body of evidence related to high methane emissions from unconventional gas extraction and processing activities. To prevent methane emissions from unconventional gas in the Territory making a major contribution to global warming, laws must be amended to set strict allowable limits on methane emissions and to mandate that operations that do not meet those limits will not be allowed to operate. The laws must also mandate strict independent measurement and accounting of greenhouse gas emissions from shale gas operations. All of the recommendations made by the Melbourne Energy Institute, and reproduced above, in relation to fugitive emissions, should be implemented.
6. Requirement for full hazard assessments and compulsory disclosure of all chemicals used in unconventional gas mining, and prohibition of the use or production of chemicals or chemical mixtures that are harmful to human health or the environment.
7. Amend the laws to prevent UG companies using the threat of the Land Court to intimidate and coerce landholders and Native Title holders into signing access agreements, and implement powers to create legislation to give landholders, Traditional Owners and communities the right to say “NO” to unconventional gas operations at both an exploration and production proposal stage of development.
8. Include a requirement that all gas companies who seek to operate in the NT must hold comprehensive environmental insurance to cover all risks, and legislate to make gas companies responsible for any downstream impacts or impacts to neighbouring landholders.
9. Put in place world’s best practice rehabilitation requirements that include:
    - Requirement for payment of upfront cash bonds to cover the full cost of rehabilitation
    - Rigorous estimation of bonds based on best practice calculations, the use of a mandatory government calculator, strong contingencies and no discounts
    - A mandated progressive annual rehabilitation ratio of 1:1 disturbance to rehabilitated area

- Prior to any approvals being given gas companies must be required to provide a fully-costed gasfield closure plan which has been subject to stakeholder engagement and sign-off.

10. Amend laws to create a strict liability for gas companies for any spread of weeds or feral animals or any impacts on biosecurity or farm operations, and to create a strong fit and proper person test which precludes the granting or transfer of licences to financially inadequate companies or any companies with a record of non-compliance with environmental or company laws.
11. A fully independent Ombudsman should be created to act as an umpire in disputes between landholders, Traditional Owners or communities and gas companies. The Ombudsman should have wide powers to compel gas companies to provide information and to act responsibly and prevent harm to people and businesses affected by their operations.
12. To address negative social impacts of FIFO workers, new QLD state legislation bans 100% FIFO workers for projects[143]. Despite having many shortcomings, the Queensland legislation is at least a start and it would be worthwhile for the Northern Territory Government to investigate this matter further and look to improve on it.

[143] Minister for State Development and Minister for Natural Resources and Mines The Honourable Anthony Lynham, November 2016, http://statements.qld.gov.au/Statement/2016/11/8/queensland-government-moves-to-deliver-choice-for-resource-communities-workers

NATURAL RESOURCES COMMITTEE

FRACKING

Balcony Room, Parliament House, Adelaide

Friday, 4 December 2015 at 10:10am

(OFFICIAL HANSARD REPORT)

PARLIAMENT OF SOUTH AUSTRALIA

WITNESSES—*continuing*

INGRAFFEA, ANTHONY, Dwight C. Baum Professor of Engineering and
Weiss Presidential Teaching Fellow, Cornell University.....283

MEMBERS:

Hon. S.W. Key MP (Presiding Member)
Hon. R.L. Brokenshire MLC
Hon. J.S.L. Dawkins MLC
Hon. G.A. Kandelaars MLC
Mr J.P. Gee MP
Mr C.J. Picton MP
Mr P.A. Treloar MP

WITNESS:

INGRAFFEA, ANTHONY, Dwight C. Baum Professor of Engineering and Weiss Presidential Teaching Fellow, Cornell University

[Via Skype videoconferencing]

956 The PRESIDING MEMBER: Thank you very much for your time today, Professor Ingraffea. We have a number of people here in the Balcony Room in Parliament House, and we also have the media here, so no pressure, but we are looking forward to hearing from you. As you know, our committee, the Natural Resources Committee, is looking at the issue of fracking in the South-East of South Australia, and we have our members here. Can you see us, or can you only hear us?

Prof. INGRAFFEA: Yes, I can see you all very fine, thank you.

957 The PRESIDING MEMBER: Good. I would like to introduce the committee to you. We have the Hon. Robert Brokenshire, the Hon. John Dawkins and the Hon. Gerry Kandelaars. Those three gentlemen are all part of our Legislative Council, our upper house. We have Mr Jon Gee, who is the member for Napier, and my name is Steph Key, and I am the member for Ashford. Jon and I are in the lower house, the House of Assembly. Next to me is our research officer, Barbara Coddington, and on my other side is our executive officer, Patrick Dupont.

Because this is a parliamentary hearing, I just need to read you your rights so that you know your status. We have some people here from Hansard who are taking down what you have to say, which you will get a copy of. As I said before, we also have media people here who are very interested in what you have to say, as well as a gallery of interested both members of parliament and people from the community who are here to hear you. I will just get on with the introduction and then hand it over to you.

Prof. INGRAFFEA: Okay.

958 The PRESIDING MEMBER: Perhaps you could just wave if you cannot hear at any stage—that might work—because we can see you.

Prof. INGRAFFEA: Sure.

959 The PRESIDING MEMBER: You have agreed to give evidence to the Natural Resources Committee in South Australia by electronic means from a location outside Australia. Accordingly, parliamentary privilege may not apply in the same way that it would have if you had given evidence in South Australia. Should you publish your evidence to a third party, that publication may be subject to defamation laws in the state in which you publish it.

We really appreciate your attendance today. The committee is a standing committee of the Parliament of South Australia. Its powers and functions are set out in the Parliamentary Committees Act 1991. Sections 28 and 31 of the Parliamentary Committees Act set out the privileges, immunities and powers of this committee and the protection afforded to witnesses. Section 26 of the Parliamentary Committees Act provides that members of the public may be present during the examination of witnesses; as I said, we have a number of members here.

A request to make a statement in private will be considered by the committee and, if agreed to, members of the public will leave the room for the duration of that statement. So, if you feel that you would like to say something just to the committee, that can be arranged.

Prof. INGRAFFEA: Okay, thank you.

960 The PRESIDING MEMBER: The audio of today's proceedings will be streamed electronically within the parliamentary precinct, and the transcript of these proceedings will be available to the public once you have had an opportunity to ensure they are factually correct. As you know, today's hearing is in relation to fracking, unconventional gas inquiry. Could you introduce yourself and then continue with your presentation. As I said, thank you very much. We appreciate your doing this, so over to you, professor.

Prof. INGRAFFEA: Before I start, I am going to try to share my computer screen and make sure that works. Can you see my screen now?

961 The PRESIDING MEMBER: Yes, thank you. I will ask one of the committee members to move and second that your presentation form part of our evidence.

Moved by Hon. R.L. Brokenshire.

Seconded by Hon. G.A. Kandelaars.

Carried.

Prof. INGRAFFEA: Let me begin by thanking you very much for giving me the honour to give testimony to your committee. I'm taking this very seriously, and I'm going to do my very best to report to you facts, data, information that I believe to be completely true, and I will deliver it in the most honest way I can.

While you were speaking to me, there were a couple of times when the sound dropped out. I think that's because of the long distance we are communicating over Skype, so if I say something, if you see my mouth moving but you don't hear anything, let me know and I'll go back and repeat.

962 The PRESIDING MEMBER: Thank you.

Prof. INGRAFFEA: For your benefit, you will also note that in the lower right-hand corner of each of my slides there is a number, so if you have any questions about any particular information on any of these slides you can make a note and tell me later during Q&A and we can return to that particular numbered slide.

963 The PRESIDING MEMBER: Thank you.

Prof. INGRAFFEA: Let me begin with some preliminary comments. Did the screen change? Are you now looking at slide No. 2?

964 The PRESIDING MEMBER: Yes.

Prof. INGRAFFEA: Good. First, bravo, my compliments. I've extracted two quotes here from your interim report of past November and I've underlined two particular lines in those quotes. The first one is:

> Fracking is only one part (though a complex one) of the overall process of gas extraction.

I can tell you that I have had interaction with many legislative and regulatory bodies in the US and around the world over the last six years and you are the first—the very first—legislative body to acknowledge that the issue about which we are speaking is not fracking: it's shale gas in its entirety—in its entirety. Fracking is a part, as you notice, but it's one of only many parts, and as you will hear during the rest of my testimony, in my opinion it is that part that brings with it the least risk.

So, I think it's perfectly appropriate, knowledgeable and wise of you to up-front acknowledge that we're really talking about in South Australia everything having to do with shale gas development, storage, transmission and end use. So, my compliments.

I would also note that you are only one of three legislative bodies that I am aware of on the entire planet that decided to do an inquiry into shale gas before any production occurred in

your territory. Again, my compliments. If you are curious to know who the others are, I'll let you know later, but you're in good company.

965 The PRESIDING MEMBER: Thank you.

Prof. INGRAFFEA: Having said wonderful, laudatory complimentary things, I want to go to my second opening comment which perhaps you won't find so delectable. When I was first contacted to give testimony to your committee and I started to investigate the geology, geochemistry and hydrocarbon history of your state, I was frankly astounded. I couldn't figure out why in South-East South Australia you are really seriously considering developing shale gas.

The reason I say that is because, in a way, similar to a couple of states in the United States like Illinois, North Carolina, Maryland, where there might be, but have not yet been confirmed, some shale gas resource, those states in the US have gone to great lengths to go through the entire process multiyear—all kinds of debate, all kinds of legislative gnawing and gnashing of teeth—and when they finally did some investigation they found out there was nothing there.

My second point is, as you know, the negotiations in Paris about climate change are underway right now and the fundamental basis for those negotiations is to decrease the development and use of fossil fuels. With only the possibility of a relatively small shale gas resource in one corner of South Australia, and with the science acknowledging that we need to keep roughly three-quarters of all the undeveloped fossil fuels underground if we are going to meet our climate-change objectives, I'm a little concerned that South Australia has already done its part to produce fossil fuels; you are producing oil and gas in the north-east.

At some point you as a state and you as a legislative body are going to have to decide which of your fossil fuels you are not going to develop. So, I think I have told you already, by implication, that I would hope you do not develop the shale gas fields in the south-east corner of your state for these reasons and other reasons I am about to describe.

The rest of my testimony will be built around your terms of reference, of which there are four, and I will explicitly address each of those. But before I do that I want to make sure we are on the same page about what we are talking about here when we say shale gas development because of all the legislative and regulatory bodies with which I have had interaction very few of them have appreciated the fundamental differences, and there are two of them, the two fundamental differences between developing shale gas and developing conventional gas. So, I want to take a few moments to make sure that you understand what I mean by those two fundamental differences.

One of them is spatial intensity and I will show what that means in a couple of pictures, but here I am using a graphic produced by one of our gas companies, Chesapeake, that tries to depict, in essence, the entire process of getting shale gas out of the ground. What you will notice is that there is a regular grid of pads, roughly three kilometres by 1½ kilometres, and some thousands of metres in south-east South Australia—I suspect 3,000 to 4,000 metres underground—there is a shale layer, and supposedly in that shale layer there is gas, methane.

That shale is effectively impermeable. That's the reason why the oil and gas industry has waited till the very end of its epic to try to get gas and oil out of the ground through shale, because it basically doesn't want to give it up. To give it up, as you can see here, they have to drill a lot of wells, and they have to drill the wells not only vertically but deviated and laterally. When they have done that, this whole process that is depicted in this picture is inherently inefficient.

By that, I mean current data from all the shale gas production in the United States, across all the plays in the United States, shows that a process that is being depicted here with this density of wells produces only 7 to 10 per cent of the gas in place. It's inherently inefficient, and that is why they have to drill so many wells and they have to drill the laterals so close together. So, that is underground spatial intensity and surface spacial intensity.

They also have to use what I call the second fundamental difference, and that's technologies of scale. To get gas out of shale, everything is bigger, longer, more powerful. So let me show you through a series of pictures what I mean by technologies of scale and spatially intense development. I am looking at slide No. 6. I hope you are too. This is a Google Earth image of an area just west of Dallas, Fort Worth, Texas, and this is in the Barnett shale play, the oldest and most mature shale play in the US, where they are currently over 15,000 wells drilled in the last 15 years.

Every one of the white dots that you see in this picture is a pad. I am going to go to the next slide and zoom in, and you will notice that the scale will change from a four-kilometre scale to a one-kilometre scale, and again (I hope you can see my cursor) every one of these white dots, either a small dot or a larger rectangular dot, is a pad.

So, I am sure you are all geographically unchallenged, and you will note that this is an area that is roughly five kilometres by four kilometres, and there are over 60 pads in this area. That is spatial intensity. Why spatial intensity? Because the shales are inherently impermeable; whether it is South Australian shale or Texas shale, it is impermeable, and to get 7 to 10 per cent of the gas out of it you have to beat it to death with many wells.

I am extracting another quote from your interim report, and I want to point out that this quote is inherently incorrect. It says that since multiple wells will be drilled with horizontal segments from one pad there will be reduced overall impact on the landscape compared to coal seam gas. Well, show me reduced impact here. Right now in South-East Australia you have no impact, so any impact is great impact. This is spatially intense impact and it's the only way that any operator can get reasonable production out of a shale play.

I'm going to ask you to use your imagination now and let's go to the South-East corner of South Australia. I suspect some of you have been to the Jolly 1 well. Here it is, here is Penola. You will note that this map I'm showing you right now is to the same scale as this one, so I'm going to ask you to use your imagination and map these 60-plus pads into that area, and ask whether that is spatially intense and whether there is significant area impact. I think the answer to both those questions is yes.

Technologies of scale: I mentioned that getting gas out of shale is difficult. Everything is longer, bigger, higher, deeper. I listed a bunch of aspects of shale gas development to emphasise what I mean by technologies of scale.

Larger drill rigs: you drill not only 2,000 or 3,000 metres down, but you're going to have to turn that well and drill another 2,000 or 3,000 metres laterally. That requires very large drill rigs that we call them triples. Those drill rigs require much more diesel horsepower on the drilling engines than traditional drill rigs. More diesel horsepower, more noise, and more NO_x emissions.

Fracking equipment: the fracking that has occurred in the north-east part of your state is traditional fracking. It uses perhaps a few hundred thousand litres of fracking fluid. To get gas out of shale you will need 20 million litres of fracking fluid per well. You will also need pressures three or four times higher than are currently being used for frack jobs in your state. I'm using English units here in Australia but typically 15,000 pounds per square inch of fluid pressure, so higher fluid volume, higher pressures—you will need 25,000 horsepower pumps.

Because you're pumping 20 million litres of flowback down the well, you're going to get five to 10 to 15 million litres back up the well as flowback. That's waste; it's contaminated fluid, no longer drinkable, no longer able to be put back into the water cycle. So you have to figure out what to do with large volumes of fluid waste from each well, and remember that each well is on a multi-well pad. There are going to be longer and larger flares and venting of methane; more truck traffic to bring water, fracking chemicals, pumps, proppant—10 to 20 times more truck traffic than for conventional wells.

Every one of these pads is connected by a pipeline, so you're going to see a lot of pipeline construction and that disturbs the surface, and more and large compressor stations and processing plants. Compressor stations to increase the pressure from the wells that rapidly deplete—that's another characteristic of shale gas wells that make them different from conventional gas wells. The depletion rate is extremely quick. The pressure drop is extremely quick. That means you need compressor stations to get the gas out of the gathering lines and into your transmission lines. If you develop the gas and it turns out to be wet, you will need processing plants. Throughout this whole process you will have much higher emissions than you would have on conventional well pads because everything is bigger, longer and more powerful.

With that as background—those two fundamental differences—let's address each of your terms of reference. The first one I choose to address is the risks of groundwater contamination. I'm going to take you to the state of Pennsylvania. The state of Pennsylvania overlies the Marcellus

gas play which is the largest shale play in the world. The state of Pennsylvania prides itself on having very tough regulations; regulations that have twice been revised in the last five years.

We published a study in a peer-reviewed journal last year where we attempted to determine how many of those shale gas wells were leaking. That's what we mean here by 'impairment rate'—what percentage of the shale gas wells drilled in Pennsylvania in the Marcellus were known to be leaking within the first five years of their having been drilled. We compared that leak rate in the shale gas wells to the leak rate in the non-shale gas wells and we used the statistics provided to us by the Pennsylvania Department of Environmental Protection—that's the regulatory body in Pennsylvania—and their records show that shale gas wells were showing a leak rate of about 6.2 per cent in the first five years as compared to an overall failure rate in conventional wells of 1 per cent—one in 100 conventional wells and six in 100 shale gas wells.

In some regions of the state where drilling occurred very, very quickly, where operators were totally inexperienced, the failure rate in the wells was almost 10 per cent—one in 10—within the first five years, leaking. If you have leaking gas wells, you have a risk to groundwater contamination.

I am going to show you another map. This is a map of the state of Pennsylvania, and I am going to draw a correlation between the leaking gas wells and the contaminated water wells. This is from an industry presentation to its shareholder group. You will note that the south-western region of Pennsylvania and the north-eastern region of Pennsylvania are the areas where the gas in place has the highest density and where the largest number of shale gas wells have been drilled. Keep that picture in mind.

This is the same state of Pennsylvania and this is a map which colour codes the density of complaints by private landowners of water well contamination. The counties that are coloured here (and that's not all of the counties but it comprises most of the north-eastern region and the south-western region), in those counties there have been over 2,300 complaints of water well contamination from shale gas wells. The colour gives you the density of complaints.

We will visit Bradford County again. There have been over 400 individual complaints from landowners in that county of their water wells being contaminated by shale gas development. In Greene County in the south-western corner there have been over 600 complaints.

A complaint isn't the truth, necessarily. If someone complains that their water well is contaminated doesn't mean it has been, so the Pennsylvania Department of Environmental Protection, as the regulatory body, is legally required to investigate each of these cases, so you can imagine the workload that that regulatory body has had in one state, having drilled 9,000 shale gas wells and received over 2,300 complaints.

Of those 2,300 complaints, 260 of them have been determined by the state to be positive, that is, yes: your water well was contaminated by methane or another hydrocarbon from nearby shale gas development. That's a 10 per cent hit rate, so far. Over 1,000 of those complaints have not yet been investigated. There is just too much of a workload to do it.

Let's go to the next term of reference: the effectiveness of existing legislation and regulation. You provided me with your Petroleum and Geothermal Energy Regulations version 2013. I think those are the most up-to-date: if they aren't, let me know now. I read them thoroughly and then I started doing word searches on them. The first word I searched for was 'shale', and the word 'shale' does not occur in your regulations, nor do the words 'green completions'. I could go on and on. There are many examples in which your regulations are, in my opinion, laissez-faire. They are not explicit with respect to important elements regarding wellbore integrity.

The reason I can say that is that I have read the regulations of virtually every shale gas producing state in the United States and all of the shale gas producing provinces in Canada. I have read those regulations and analysed those regulations, and I can tell you that your regulations are not yet up to snuff, compared to those of peer states and provinces.

I mentioned previously that our state of Pennsylvania, which saw commercial shale gas development in 2007 has twice made major revisions to its regulations to account for the fact that the regulations that were in existence in 2007 were not appropriate for shale gas development. As the regulatory body learns from the mistakes of industry, they revise their regulations.

I am strongly suggesting that, as additional homework for your committee, you do a thorough review of regulations from other regulatory bodies if you have not already done so, and I think you will see what I mean when I say that your current regulations are vague, laissez-faire, written such that the industry is given all the responsibility to interpret things the way they want and the state in this case is left, in my opinion, holding the bag.

I would suggest that you start with the regulations in Pennsylvania. It is the place where we have the largest shale gas development going on in the US and I also suggest that you look at the regulations that were written for New Brunswick, Canada. They do not yet have any shale gas development but they are one of the bodies that I mentioned before that did a very thorough investigation and actually wrote regulations before allowing it. I think you will find stark differences between those two sets of regulations and those for South Australia.

I want to show you some other pictures of what shale gas development looks like. I know some of you have visited other states in Australia to see where some shale gas development is going on, but I am not sure you have seen what it really looks like when it gets going. This is a seven-well pad in Pennsylvania. Here is the pad and there are seven wells here. You will notice that there are a number of retention ponds for both waste and fresh water. You will notice large vegetation removal. These are no longer the small pads that you are used to for conventional oil and gas development. They are large.

Flowback impoundments: I did not see anything at all in your regulations regarding surface containment or underground containment or tank containment or lake containment of flowback. This is a major issue in the United States. It was when it got started in Texas in 2000: it is still a major issue now. Where do you put the waste? Where do you store it temporarily? How do you protect the public from the noxious odours from the waste and from surface spills from transporting and storing the waste?

Flaring: the word 'flare' does occur in your regulations, but it does not say anything about when the flaring has to start, when the flaring has to stop. Flaring for a shale gas well can go on for weeks—not hours, weeks. That is a 200 metre tall flare 120 dB at its base.

I already mentioned compressor stations. Compressor stations have evolved. I didn't see anything at all in your regulations regarding the different types of compressor stations that can be installed. Noise pollution and gaseous emissions from compressor stations are common and are common complaints. If you have wet gas, you're going to need processing plants. Think of them as mini-refineries—again, lots of noise, lots of flares, lots of noxious emissions.

In sum, shale gas development, as it is practised, requires a large number of spatially intense, large, multi-well, clustered pads and significant ancillary infrastructure—pipelines, compressor stations, flowback storage, truck farms, processing units. All that has to be taken into account by regulation.

I want to conclude by pointing out that you've done tremendous homework. Again, I am lauding your committee for the research it has done, but there's more research available, so I'm pointing you here to the largest current database archive of peer reviewed science literature on shale gas. My organisation put this together starting about a year ago. I want to point it out to you. This is a bar graph that shows the publication history of peer reviewed science on shale gas development, actually shale and tight gas development. You will note that in 2009, a few years after things had started in the US, there was a total of six peer-reviewed publications in the entire world—six. What you're seeing now is exponential growth. We're now seeing about one new publication per day.

Fifty per cent of all the published peer-reviewed science on shale gas has been published in the last 1½ years. We didn't know much when we got started in the US. You're in a much better position; you haven't started. I'm a professor and I'm used to giving people assignments, but it would be way above me to give you the assignment of reading all 650 of these papers. But you are now aware of them; you can't duck the issue. The science is now there. You're in a much better position to make informed decisions about what you're going to do with shale gas development and what you're going to put into your regulations if you go ahead with it. You have no excuse for ignorance. Many states in the US went ahead without this knowledge—you can't.

We have taken that database and divided it into 12 categories to make it easier. This is a screenshot which shows all the categories listed on the left. You pick a category and it will show

you every one of the papers, and to the extent that we have the legal right to distribute the paper, you can download it from this website. If we do not have the legal right to distribute it, you can go to your library and get it.

If you do an analysis of some of these subtopics, you will find startlingly clear consensus. These are science papers. If we ask what the science says about health impacts, human health impacts, you can go into that database and you will find that there are 16 peer-reviewed papers, so far only 16 peer-reviewed papers, on health impacts. Of those 16 papers, 87 per cent of them—14—say the health impacts are bad. None of them say the health impacts are good. Thirteen per cent of them say we haven't measured any health impacts.

It is a similar situation on air quality: 92 per cent find negative impact, bad impact on air quality; 8 per cent say no measurable impact on air quality. Water quality impacts: three-quarters of the papers published so far find that there have been bad impacts on water; about one-quarter say no measurable impact. There's a growing consensus, the number of papers is growing, and the consensus is growing, and it's now your responsibility to learn about this and decide what to do about it.

To summarise: again, because of the two fundamental differences between shale gas development and conventional gas development—spatial intensity and technologies of scale—I am making the following four assertions with regard to your terms of reference. The risks of groundwater contamination in your state, if you go ahead with shale gas development, are very high. Why would they not be? What makes you think you're going to be different from Pennsylvania?

Fracking is not the issue with water contamination. Well bore integrity and surface spills are the issue so again, you are wise to make sure that your committee is investigating not just fracking but all aspects, including drilling, wellbore integrity, surface fills, transportation of chemicals, transportation of waste, and the impacts on the landscape. I showed you images and photographs; I showed you maps. They will be considerable. You will be changing the landscape of that part of your state.

The effectiveness of existing legislation and regulation: I think your regs are wholly insufficient in their current state. They do not address the problems and the issues that have occurred in other provinces and other states that have been addressed and revised in much tougher regulations.

I didn't say anything at all at this point about the potential net economic outcomes to the region and the rest of the state, partially because the economics in Australia are different from the economics in the US, but I would point out that in the US the shale gas boom has busted. It's done; it's over. Let me repeat that: the shale gas boom is over in the US. The US will never again produce as much shale gas as it did in 2014. All the major shale gas plays are in decline except for one.

Shale gas is an extension of the fossil fuel era. It is not a 100-year supply. It is not a 50-year supply. In the US, it will wind up being about 10 to 15 years' supply. That's my testimony. I want to thank you once again for allowing me to testify to you. I would be anxious to try to address any questions you have at this point.

966 The PRESIDING MEMBER: Thank you, professor. We appreciate your comprehensive presentation and also overview. We do have some questions from our members. Mr Brokenshire, do you want to start the ball rolling?

967 The Hon. R.L. BROKENSHIRE: Thank you, Chair, and thank you, professor. On one of your slides, professor, you had a photograph of Barnett, Texas, where there were 15,000 wells, and there was a lot of agricultural production still occurring with and around those wells. Are you seeing coexistence or are there problems in production declines, being able to operate the agriculture properly there, and any possible issues regarding livestock and contamination?

Prof. INGRAFFEA: Sometimes the sounds breaks up, and I'm not sure that I heard, but I think you're referring to this slide and impacts on livestock?

968 The Hon. R.L. BROKENSHIRE: Yes, livestock and cropping, cereal cropping, etc. You can clearly see a lot of arable country there and a hell of a lot of wells.

Prof. INGRAFFEA: I'm glad you asked that question. I can point you to a paper that was published just recently addressing exactly that issue, not only in the Barnett play but also in the Bakken play in North Dakota and the Marcellus play in Pennsylvania, that investigated animal health impacts, both direct, because animals need to drink water, and indirect, because of the air impacts, dust impacts and the surface spills. There is now a one-paper database in the open literature that discusses exactly the question you asked.

There are impacts. There is a lot of anecdotal information, certainly in an area like this which is known for not only its farm but its cattle grazing. There is a well-known incident in the Haynesville shale play, which is in Louisiana, in which a few dozen cattle died within a day because they unfortunately drank from a spill, a flowback spill. Flowback, as you know, is salty, and livestock frequently are attracted to salty water, and they drank it and they died. That's anecdotal. There are anecdotal cases in Pennsylvania and North Dakota which are similar—livestock dying.

But the big picture here is yet to be painted. When you see this image I am showing you, and you have all those wells and all the air emissions and all of the possibilities for water contamination—I don't know what to say. I am not an animal health expert. I am not a crop-growing expert. I defer to the veterinarians and the agronomists who are saying that there is a growing concern that this high density of development inside of what was an agricultural area, inside of what was a grazing area, is problematic.

That is another basic problem with shale gas in general: it envelops you. If you look over on the right here, this is a housing development. There are places in Dallas, Fort Worth, where you have multimillion dollar homes with shale gas wells in their backyard and compressor stations across the street. Because of the spatial intensity, the companies drill where they can.

In most jurisdictions in the US, zoning law does not trump oil and gas law. You can have a community that has zoned residential areas, but oil and gas law trumps that. If someone owns the mineral rights—I guess, in Australia, the state owns the mineral rights—if the state decides to put an oil or gas well in the middle of a residential area—I suspect that they wouldn't; in the US they would because the mineral rights are owned by private individuals. That's a long answer to your question, and probably an unsatisfactory one, but I did the best I could.

969 The Hon. J.S.L. DAWKINS: Thank you very much, professor, for your evidence to us this morning. As a bit of a follow-on from the Hon. Mr Brokenshire, I wonder whether you could tell me what the attitude of the farmer organisations in Pennsylvania, North Dakota and perhaps the other states you have described to the shale gas activity—

Prof. INGRAFFEA: I can't hear the question, I'm sorry.

970 The Hon. J.S.L. DAWKINS: Okay, I will repeat it. I wonder whether you could tell me what you know of the attitude of the farmer organisations that exist in Pennsylvania, North Dakota and the other relevant regions to the gas activity, particularly in relation to what the Hon. Mr Brokenshire just asked you. Also, has there been a focus from the agricultural sectors on being able to produce clean, green agricultural products, particularly in exports? If so—

Prof. INGRAFFEA: I'm sorry, I really apologise. I wish I could be there with you, but I only got every third or fourth word. If someone could repeat the question very close to the microphone and loud, I will do my best to answer, but I'm sorry—

971 The Hon. J.S.L. DAWKINS: I do not want to shock you, but I will come even closer. I have never been accused of having a quiet voice. Firstly, about the attitude of farmer organisations in Pennsylvania and North Dakota particularly.

Prof. INGRAFFEA: Sorry, the attitude of?

972 The PRESIDING MEMBER: Farmers and farming organisations.

973 The Hon. J.S.L. DAWKINS: Farming organisations. The groups of farmers who have bodies that represent them. We call them here the National Farmers' Federation or Primary Producers South Australia.

Prof. INGRAFFEA: I think what I am hearing you say is the 'attitude of farmers'?

974 The Hon. J.S.L. DAWKINS: And their peak bodies, the organisations that represent them to government and to politicians.

Prof. INGRAFFEA: I am going to try something. I am going to try to stop sharing my screen and maybe the sound will come through better. Just try it now.

975 The Hon. J.S.L. DAWKINS: Okay, I will try again; I apologise.

Prof. INGRAFFEA: No, you shouldn't apologise; it's my fault because I am not there.

976 The Hon. J.S.L. DAWKINS: Not at all. I suppose I am interested in the attitude of the peak bodies that represent farmers in North Dakota and Pennsylvania in relation to the activity you have described to us, and also if those bodies and individual farmers focus on a clean, green image when marketing their products. And, if so, has there been any impact?

Prof. INGRAFFEA: Okay, I think I'm finally getting it. Let's see if my answer comes close to your question. In the US, as I mentioned before, in general mineral rights are not owned by the state, they're owned by individuals and, in cases like Pennsylvania and Texas that I'm describing here, those individuals very often are farmers.

So, on the one hand you have farmers who might be struggling to make ends meet. Texas has had drought for five years. Pennsylvania farmers are getting very low prices for their dairy. They saw shale gas development as a godsend. It was magic. It was like winning the lottery.

At first, they welcomed shale gas development with open arms. They were all going to become 'shaleionaires'. They were going to get big cheques for free in their mailbox every month. Then, the water started going bad and then the cheques started getting smaller and then the bust happened and the cheques stopped altogether. Many farmers became millionaires overnight, or close to it. Many of them improved their farms, they bought new equipment, improved their stock herds. Many of them sold out and moved to Florida. They said, 'Why do I want to be a farmer anymore? I'm a millionaire.' So, you saw a whole range of responses.

The farming organisations, in general, had been pro shale gas development because they see it as additional income for farms which, in many cases, were struggling. On the other hand, we have a growing organic farming industry in the US and the organic farming industry is uniformly against shale gas development for obvious reasons. They can no longer sell their product. No-one will buy from an organic farm that is surrounded by shale gas wells.

So, we have a complex situation in the US. I suspect it's much different than the situation you have in South Australia. I don't know what you can derive from what I've just said that's helpful, but I'm imagining, since the state owns the resource, if a farmer in South Australia finds that his livestock or his livelihood on that farm is being impacted negatively, then I would think the state would reimburse him for that. That's part of the cost. This isn't pure profit for the state. There are negatives here.

977 The Hon. J.S.L. DAWKINS: Thank you very much for that answer.

Prof. INGRAFFEA: Was that close?

978 The Hon. J.S.L. DAWKINS: Thank you, yes.

979 The Hon. G.A. KANDELAARS: What has been the impact in terms of US energy markets in relation to shale gas? Hasn't it given the US independence in terms of energy sources?

Prof. INGRAFFEA: Again, I can't hear you. I think the clue here is you have to get that microphone right up next to your mouth and shout.

980 The Hon. G.A. KANDELAARS: What has been the impact in the US in terms of energy independence as a result of shale gas?

Prof. INGRAFFEA: What is the impact on energy independence from shale gas? Excellent question. Let me back up a step and say that the US currently consumes 20 million barrels of oil per day. Last year, the US produced nine million barrels of oil, mostly from its shale deposits. That's the new thing: shale oil, not shale gas. I will get to gas in a minute. The huge shale oil deposits in North Dakota and Texas allowed the US to go from roughly six million barrels of production per day to almost 10 million and then it peaked and dropped. It peaked in 2014 and it's on its way down. So,

the US will never be oil energy independent. It never was, it never will be. It can't be. We consume too much and we can't produce enough.

Let's turn to shale gas. Six years ago the US was producing and consuming 23 trillion cubic feet of gas per year. We're now producing and consuming almost 26 trillion cubic feet of gas. We are gas energy independent.

Before the shale gas we were on our way to becoming gas energy dependent. We were starting to import natural gas from the Middle East and from Canada. We no longer do that. So shale gas has made the US gas independent. The US is not energy independent. We are not fossil fuel independent because we will never produce enough oil, but we are gas independent. But, as I pointed out before, the shale gas boom has bust.

We produced 26 trillion cubic feet in 2014. Our Energy Information Administration is predicting that by 2016-17 total production of shale gas will start to decline. Most industry analysts are expecting that we will run out of shale gas at the current rate at which we are producing it, without exporting any of it, in about 10 to 12 years. If we start exporting it, we will be out of it in a much shorter period of time. It's a flash in the pan. I don't know if you use that phrase down there, but here today, gone tomorrow.

981 The PRESIDING MEMBER: We do, mainly to do with gold production. You're talking about the industry having gone bust. Where is shale gas being produced at the moment in the US?

Prof. INGRAFFEA: I mentioned that there is one shale gas play that is increasing, and I'm going to go back and show you where that is. You can see my screen again?

982 The PRESIDING MEMBER: Yes.

Prof. INGRAFFEA: Remember this is Pennsylvania, and this is a colour map which shows the density of gas in place per square mile. This is a billion cubic feet per section, that's a billion cubic feet per square mile surface. You will notice that here we're talking about the Marcellus gas in place, and here we're talking about Devonian and Marcellus and Utica gas in place. So, beneath the Marcellus shale in Pennsylvania, Ohio and West Virginia, there is a Utica shale; it is about another thousand metres down.

Production from the Utica shale is continuing to increase, but it is a small percentage of all the shale gas produced in the US. All of the major shale gas plays—the Marcellus, the Fayetteville, the Haynesville, the Barnett—they're all in decline as of this year. So most of the shale gas is now coming out of the Marcellus, but it's no longer growing: it's now decreasing.

983 The PRESIDING MEMBER: Thank you very much. I think we are going to have to leave it there.

Prof. INGRAFFEA: This picture says a lot more than I talked about. These colours mean everything. The industry talks about 'hot spots', not hot in terms of temperature but hot in terms of the gas in place. This is all the Marcellus, all this blue is Marcellus, but most of Marcellus is useless— 50 billion cubic feet per square mile is nothing, it's uneconomic. Yes, we have a huge play in terms of 20,000 square miles, but only a relatively small section of it is going to produce a lot of gas, and that's characteristic of shale gas.

If you go ahead and start doing exploration wells in the South-East, they will find the same thing. They will find an exploration well where there might be a lot of gas, and they will move one kilometre away and they won't find any or that it will not be economic to produce. Not all shale plays produced are born the same, and there is no such thing as uniform production across a play.

That's what we learned in the US and that's what you should be aware of. It could be that in the South-East you have a few wells that will be gushers, and you will have dozens that won't be economic, or it could be just the opposite; you don’t know. You don’t know until you drill a lot of wells, but if you drill a lot of wells you had better be prepared for the consequences.

984 The PRESIDING MEMBER: Can I thank you very much for your evidence today. We really appreciate your time. Despite the technical problems, we've really learnt a lot from you today. Thank you very much.

Prof. INGRAFFEA: We got over it. We're good, we got over it. Thank you very much for the opportunity.

[Skype videoconference concluded]

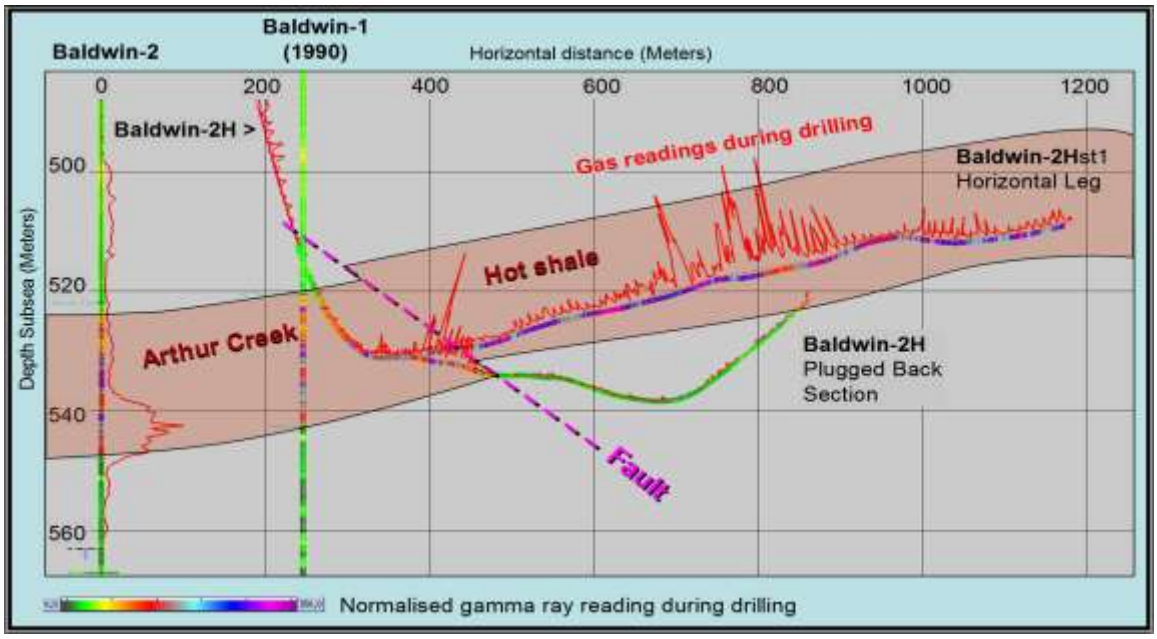
PETROFRONTIER CORP. ANNOUNCES SUCCESSFUL DRILLING OF BALDWIN-2Hst1 HORIZONTAL WELL IN THE GEORGINA BASIN, AUSTRALIA

Calgary, Alberta – October 11, 2011 (TSX-V: PFC) - PetroFrontier Corp. ("PetroFrontier") is pleased to announce that it has successfully drilled Baldwin-2Hst1, Australia's first horizontal well in the Lower Arthur Creek "Hot Shale" Formation in the southern Georgina Basin in the Northern Territory, Australia. Baldwin-2Hst1 is located in the southwestern part of EP 103 in the Southern Georgina Basin. PetroFrontier has a 100% working interest in EP 103 and is the operator. EP 103 covers 3.16 million gross acres and accounts for approximately 27.2% of PetroFrontier's net acreage in the Northern Territory, Australia.

The "Hot Shale" formation is comprised of interbeds of shale, silt, sand and carbonate, is slightly radioactive and is easily identified on gamma ray logging tools. The "Hot Shale" is petroliferous, up to 40 metres thick and extensive in area. The "Hot Shale" is geologically and mechanically analogous to major unconventional oil plays in North America such as the Bakken and Eagleford. These unconventional oil plays require the use of advanced horizontal drilling and completion techniques to be economic.

Baldwin-2Hst1 reached a total measured depth ("MD") of 1,948 metres and remained within the main target zone in the Lower Arthur Creek "Hot Shale" for 875 metres while directionally drilling up a regional dip of 1.7 degrees. Positive hydrocarbon indications were recorded along the entire length of the horizontal section, with elevated gas readings and evidence of heavier hydrocarbons present.

The following diagram is a vertical cross section showing Baldwin-1 (drilled in 1990), Baldwin-2, the successful horizontal leg (Baldwin-2Hst1) and the plugged back horizontal section. Baldwin-2Hst1 was kicked off from Baldwin-2 above the field of view in the plot. The color variation along the well path shows the recorded gamma ray log with green indicating low gamma values (sands or carbonates) and blue indicating high gamma ray values (shale). The red values along the well paths show the variation in total gas values.



Delays in drilling occurred when the bit tracked into the underlying Thorntonian Limestone Formation after encountering an unexpected fault. Every effort was made to redirect the bit upwards back into the Lower Arthur Creek "Hot Shale", but the bends in the hole became too severe for an effective future well completion. The new horizontal section kicked off along the regional dip established by the plugged back portion of the well and was successfully steered through the Lower Arthur Creek "Hot Shale". Total gas recorded in Baldwin-2Hst1 averaged 240 units over the entire horizontal section, commonly peaking above 1,000 units, with maximum recorded values over 2,500 units. The gas recorded contained heavier hydrocarbon fractions up to pentane ("C5") over much of the horizontal section. Conventional gas ratio analysis indicates very wet gas to oil for the most of the well with occasional definite oil signatures in places. However, this interpretation may be biased towards gas due to the nature of the reservoir being intersected.

Following the interpretation of the full suite of logs acquired in the pilot hole, a mechanical earth model was constructed with very positive indications for the ability to fracture stimulate Baldwin-2Hst1. Fractures developed in the vertical plane of the well, transverse to the horizontal well path, are predicted by the model, with excellent containment indicated from the bounding layers both above and below the possible pay zone. In addition, natural fractures were observed. These will assist in the initiation of the stimulation fractures and aid in growing the complexity of the fracture treatment. This should have a positive impact on flow rates.

X-ray diffraction ("XRD") analysis has shown little presence in samples of clay minerals often associated with sensitivity to water-based frac fluids. The XRD results, combined with further confirmation in laboratory sensitivity tests, have given Petrofrontier the confidence to fracture stimulate with water, which is an important factor in keeping the stimulation costs as low as possible.

Although these findings are encouraging, this well remains a high-risk exploration venture and yet to be proven. Readers are cautioned that no reserves or production has been proven by this well.

PetroFrontier plans to suspend Baldwin-2Hst1 and then move Major's TXD-SS2018 rig to the second location in the current program, MacIntyre-2, located in the northeastern corner of EP 127, approximately 60 km to the northwest of the Baldwin location. Once released from Baldwin-2Hst1, the rig is expected to commence drilling MacIntyre-2 in approximately three weeks following minor rig modifications. PetroFrontier has redesigned and re-engineered the MacIntyre-2 well to be drilled as a deviated pilot hole kicking off to a horizontal in the Lower Arthur Creek "Hot Shale". This new well design is expected to result in greater drilling efficiencies and substantial cost savings.

Once MacIntyre-2 has been drilled, PetroFrontier intends to frac and complete the well using multi-stage open hole techniques. Final results will then be released from MacIntyre-2 and the completions crew will return to Baldwin-2Hst1 to conduct a similar completion program there. It has always been PetroFrontier's strategy to frac MacIntyre-2 first and Baldwin-2Hst1 second in to order minimize costs.

PetroFrontier is using Schlumberger, the Australian representative of Packers Plus, to run the multistage open hole completion string and conduct the fracture stimulation program. PetroFrontier is the first company to introduce to Australia these open hole horizontal and multi-stage fracing technologies to unlock unconventional oil potential. These technologies have been widely successful in unlocking North American unconventional oil reservoirs such as the Bakken formation. The use of these technologies is expected to give PetroFrontier every chance of establishing commercial production.

"PetroFrontier's long range exploration planning includes accurately defining the regions of oil and gas maturity within the basin to help target our exploration efforts," stated Paul Bennett, CEO of PetroFrontier. "We believe that within our lands the full range of hydrocarbon

maturation is present and this will allow PetroFrontier the flexibility to chase the best economics for the play, whether it is pure oil or various mixtures of oil and gas."

About PetroFrontier Corp.

PetroFrontier is an international oil and gas company engaged in the exploration, acquisition and development of both conventional and unconventional petroleum assets in Australia's Southern Georgina Basin. PetroFrontier's common shares are listed on the TSX Venture Exchange under the symbol "PFC". Founded in 2009, PetroFrontier is one of the first companies to undertake exploration in the Southern Georgina Basin in Australia's Northern Territory. PetroFrontier's head office is based in Calgary, Alberta and operations office is in Adelaide, South Australia.

Forward-Looking Statements

This press release may contain forward-looking information that involves substantial known and unknown risks and uncertainties, most of which are beyond the control of PetroFrontier, including, without limitation, statements pertaining to management's future plans, drilling program and operations. All statements included herein, other than statements of historical fact, are forward-looking information and such information involves various risks and uncertainties. There are no reserves, economics or results associated with the well. There can be no assurance that such information will prove to be accurate, and actual results and future events could differ materially from those anticipated in such information. A description of assumptions used to develop such forward-looking information and a description of risk factors that may cause actual results to differ materially from forward-looking information can be found in PetroFrontier's disclosure documents on the SEDAR website at www.sedar.com. Any forward-looking statements are made as of the date of this release and, other than as required by applicable securities laws, PetroFrontier does not assume any obligation to update or revise them to reflect new events or circumstances. Neither the TSX Venture Exchange nor its Regulation Services Provider (as that term is defined in the policies of the TSX Venture Exchange) accepts responsibility for the adequacy or accuracy of this release.

For further information contact:

Susan Showers, Manager, Investor Relations

PetroFrontier Corp.
Suite 320, 715 5 Ave. S.W.,
Calgary, Alberta, Canada T2P 2X6
Telephone: (403) 718-0366
Toll Free: (877) 822-7280
Fax: (403) 718-3888

Email: info@petrofrontier.com
Website: www.petrofrontier.com

NORTHERN TERRITORY BRANCH OF IAH AUSTRALIA

Submission to the Northern Territory Government's Hydraulic Fracturing Inquiry



Northern Territory Branch of the International Association of Hydrogeologists

30 May 2014

Acronyms

ACOLA	Australian Council of Learned Academies
CSG	Coal seam gas
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
ESD	Ecologically Sustainable Development
IAH	International Association of Hydrogeologists
IAH(NT)	NT branch of the International Association of Hydrogeologists
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
NT	Northern Territory
NTG	Northern Territory Government

'Hydraulic fracturing' is commonly referred to by the term 'fracking'.

'Top End' refers to the monsoonal northern region of the NT.

Contents

Acronyms i
Summary ii
Recommendations iii
1 Introduction 1
1.1 The International Association of Hydrogeologists 1
1.2 Significance of Northern Territory's groundwater resources 1
1.3 The Shale Gas Industry in the NT 4
2 Hydraulic Fracturing and Groundwater in the NT 5
2.1 Decommissioned wells and 'well integrity' failure 5
2.2 Financial mechanisms to manage risk of well failure and other environmental impacts 6
2.3 Groundwater contamination from surface storages 8
2.4 High water demand for fracking 9
2.5 Groundwater management issues 9
3 NT Legislation and the Protection of Groundwater Resources 10
4 The NT EPA's Proposed EIS approach to Hydraulic Fracturing Projects 11
References 14

Summary

Groundwater is often called the forgotten resource. It lies beneath our feet and supplies bores, springs and it maintains flows to our rivers. It is fundamental to human settlement and development in the Northern Territory.

The IAH(NT) is concerned about the impact of a burgeoning unconventional shale gas industry on the groundwater and surface water environment of the NT. This position paper outlines those concerns and submits a range of recommendations aimed at developing the best possible approach to groundwater impact management.

The IAH(NT) recognises that the unconventional gas industry has the potential to greatly benefit the economy of the NT and the Australian nation, and is a component of the developmental program of Government. The potential value of this resource can be illustrated by the preliminary profit prediction data from current exploration activities of Armour Energy, the company's mean prospective resource is estimated to be worth many billions of dollars *(Armour Energy, NT Trade Commission presentation 19/5/2014*).

It is clear that the unconventional shale gas industry and its activities within the NT will require careful management to prevent unintended consequences to natural resources, human health, and to mitigate the risk of long-term environmental damage. Should current profit predictions be realised, the NT government should become sufficiently resourced from the proceeds of unconventional shale gas extraction to fund the effective long term management of the impacts of this industry on the groundwater environment of the NT.

In the next 25 years, tens of thousands of new unconventional gas wells may be drilled in the NT. IAH(NT) believes the potential exists for contamination of aquifers and surface waters should well integrity be compromised, and/or 'produce' water surface storage facilities fail. We are concerned that the deterioration and failure of improperly decommissioned (also known as 'abandoned') wells could, over time; result in long-term release of oil and/or gas into the environment.

It is important to note that because groundwater flow is slow, it can take decades or longer for contamination to become a recognised problem. Therefore, considering the impacts on shale gas on groundwater must be framed in the context of decades or even centuries.

The cost of well remediation is potentially high. In one instance, the cost to NT and Commonwealth governments to plug a deteriorated, leaking oil well (McDills), (following the responsible company's insolvency) in the Simpson Desert, was around $500,000. Even more expensive well plugging examples have been incurred in the US.

It is the IAH(NT)s view that a funding requirement on the owner of a gas well at a level that matches reclamation costs would provide the best mechanism to ensure maintenance of well infrastructure, reduce environmental impacts, and protect the Northern Territory from costly liabilities stemming from the failure of some gas wells. Mitchell and Casman (2011) investigated a range of mechanisms for generating the funds required to minimise the risk of adverse economic, environmental, and human health effects of improperly decommissioned shale gas wells. They concluded that generating the funds required directly from the revenue stream during the most lucrative years of gas production had the lowest impact on an operator's internal rate of return. IAH(NT) members recommend that this funding approach is adopted in the Northern Territory.

At present the Territory budget is severely limited and groundwater monitoring and assessment programs are constrained by lack of resources. Generally, the

groundwater environment of the NT is poorly understood. In addition, we believe that the NTG does not currently have the local skill set to effectively predict and manage the impacts of fracking on water resources.

Skilled personnel with expertise in the earth and water sciences will be required to adequately assess and manage the fracking impacts and ensure protection of vital water resources. These technical experts would ideally be assembled in a single agency to collate and assess data pertaining to unconventional shale gas development and operations and generate advice to regulators and industry.

In recognition of the NT's social and economic dependency on groundwater, the NTG needs to invest in strengthening institutional provisions and building institutional capacity for its improved management before groundwater resources and consumers are adversely impacted. The onus is on the NTG to produce a robust regulatory framework to achieve environmental and water resource protection.

Recommendations

Section 2.2 Financial mechanisms to manage risk of well failure and other environmental impacts

2.2.1 Funds adequate to match reclamation should be generated directly from the revenue stream during the most lucrative years of gas production. These funds should be held by the NTG to assure against any long-term liabilities from unconventional shale gas extraction.

Section 2.3 Groundwater contamination from surface storages

2.3.1 The proponent should aim to treat and re-use the flowback and produce water within the fracking process. Storage should be in lined ponds with a flood immunity of 1,000 years.

2.3.2 The QLD Dam Safety Regulations should be applied until such time as NT Dam Safety Regulations are developed.

Section 2.4 High water demand for fracking

2.4.1 'High-value' aquifers as defined in Sections 1.2 should be avoided as groundwater sources for unconventional gas shale fracking operations. In the arid parts of the NT the use of scarce low salinity water and aquifers used for drinking water supplies should be avoided.

2.4.2 Extraction of water for shale gas operations should be managed within National Water Initiative Principles as they may have significant impacts on local groundwater systems (Cook et al. 2013).

2.4.3 Re-use and re-cycling of produce water should be the first source of water used by fracking proponents before any additional water allocations from natural water resources will be considered.

Section 2.5 Ground water management issues

2.5.1 The groundwater data paucity in shale gas basins should be addressed through an investigation program funded through royalties from shale gas production.

2.5.2 The NTG must invest in a skilled labour force and capacity building to be able to adequately manage and review permit applications and data provided by

proponents and the on-going environmental risks/ impacts of the fracking industry.

Section 3 NT Legislation and the Protection of Groundwater Resources

3.1 IAH(NT) recommends that the outcomes of the Inquiry are fed into the ongoing water resources legislative reform to:

- *Ensure that the roles and responsibilities of the regulator and industry under new or revised legislation are clear;*
- *Advise whether the provisions under the Petroleum Act adequately cover the activities associated with the relatively new (for the NT) phenomena of hydraulic fracking;*
- *Review the penalties associated with overuse or pollution of water resources through fracking activities, commensurate with the cost associated with that overuse or pollution;*
- *Provide transparent and effective regulations and companion codes of practise to guide both industry and Government;*
- *Include Dam Safety regulations;*
- *Employ qualified Hydrogeologists in these regulatory fields; and,*
- *Clarify roles and responsibilities in legislation, and precedence of legislation.*

Section 4 The NT EPA's Proposed EIS approach to Hydraulic Fracturing Projects

4.1 An agency whose major business is water should be established within the NTG. This agency should be resourced with relevantly skilled experts who can facilitate a coherent legislative framework.

4.2 A comprehensive assessment of local and regional groundwater resources be undertaken prior to use by the fracking industry.

4.3 Pre-fracking groundwater baseline studies should include measurement of natural methane levels in groundwater.

4.4 Drilling and groundwater data from gas fields should be made available to the NT Water Resources division (Department of Land Resource Management) to facilitate better understanding of the groundwater environment of the NT.

4.5 Funds for the NTG to engage resources (internal and external) for the assessment of permit applications, resource assessments and impact assessments should be provided by proponents as part of the application fee and licensing process.

1 Introduction

1.1 The International Association of Hydrogeologists

The International Association of Hydrogeologists (IAH) is a professional association encompassing those disciplines related to groundwater, its occurrence, utilization, testing and management.

IAH was established to foster closer ties, cooperation and information exchange related to the study of groundwater and operates as a truly international scientific and educational organisation. The IAH is a non-government and non-profit organisation and is supported by over 3,500 members internationally representing over 135 countries.

The IAH has the following objectives:

1. To promote international and national cooperation between involved scientists and engineers.
2. To sponsor international and national technical/management meetings and symposia on hydrogeology.
3. To publish hydrogeological reports, papers and maps.
4. To establish investigation commissions and working groups to report on special topics.
5. To encourage the international application of relevant approaches and techniques for the benefit of the hydrological and human environment.

This submission focuses on the challenges facing water resource management in relation to hydraulic fracking in the NT and has been drafted by the members of the Northern Territory (NT) branch of IAH Australia. All contributors work in a professional capacity across a range of industries in the NT related to groundwater and surface water management.

Recommendations have been provided on how these issues may be addressed.

1.2 Significance of Northern Territory's groundwater resources

The Northern Territory is underlain by numerous aquifers. Due to the ancient nature of NT geology, and the aridity of central and southern NT, high-yielding, freshwater aquifers are uncommon, and consequently of very high value.

The groundwater systems of the NT are generally poorly understood due to the vast terrain, sparse borehole distribution and lack of imperatives for groundwater exploration. There are undoubtedly aquifers which remain undiscovered and unexplored. Bearing this in mind, the following describes the *known* major features of the NT groundwater environment relevant to this inquiry.

The groundwater systems of the top end vary in some key features from those in the arid central and southern regions. The monsoonal climate ensures that most top end aquifers are recharged every year in the wet season, resulting in groundwater of very low salinity. Thus, top end groundwater and surface water systems can be considered to be some of the freshest, most pristine waters in Australia and may be regarded as being of national significance.

Top end hydrogeology also features numerous sites where groundwater and surface water are highly connected, primarily where rivers intersect porous rock aquifers such as sandstones. This is indicated where perennial creek or river flow occurs such as for the Daly, Roper and Flora rivers and numerous Arnhem Land and Gulf river systems. These rivers continue to flow long after the rains have ceased because they receive groundwater flow from adjacent aquifers.

The groundwater-fed surface water systems of the NT are an important feature of the landscape, these include Berry Springs, Mataranka Springs, Redbank Gorge waterhole, as

well as other innumerable sites scattered across the Territory. They are generally fully intact and associated with highly significant biotic assemblages of national and international significance, as recognised by the World Heritage Listing of Kakadu National Park. These biotic assemblages are also known as 'groundwater dependent ecosystems' (*http://www.bom.gov.au/water/groundwater/gde/*).

An interesting and unique feature of the top end groundwater-fed rivers systems are the 'tufa' dams as shown in Figure 2. Features like these and the Mataranka Hot Springs are major tourism drawcards.

The southern two thirds of the NT are located in the arid-zone where surface water resources are virtually non-existent. Unlike in the humid tropics, few arid-zone groundwater systems receive modern recharge. The groundwater in these systems was received in wetter climatic periods thousands and millions of years ago. The main water supply for Alice Springs, the Mereenie Sandstone aquifer, receives minimal modern recharge and as such the water take essentially 'mines' the groundwater resource. Thus, for many arid-zone aquifers in the NT, there is no 'sustainable yield' since the resource, once removed, will not be replaced.

The lack of modern recharge also means that groundwater in the arid-zone is commonly of poor quality, brackish to saline, with high concentrations of ions such as fluoride and nitrate. Where fresh groundwaters occur it is not unusual for salinity to increase downward with freshwater aquifers overlying brackish or saline aquifers. Current water bore construction methods are directed at maintaining strict separation between the freshwater aquifers and the (generally) underlying saline aquifers.

The ancient rocks of central and southern NT are generally of low porosity therefore aquifers in these areas are of limited extent. The central region of the NT is dominated by the extensive Georgina and Wiso Basins. The hard limestone and dolomite formations of these basins form aquifers where fractures are found and/or dissolution processes have led to the formation of karst. On the Barkly Tableland and the Sturt Plateau hundreds of bores tap these aquifers for the pastoral industry.

Overlying these ancient rocks, a relict drainage system in central Australia, referred to as 'palaeovalleys', contains groundwater which is of variable quality. Major central and southern NT industries including the Yulara Tourist resort, Ti Tree horticulture, Granites-Tanami gold mining and numerous settlements in southern NT depend entirely on fresh-water occurrences in the palaeovalley aquifers. The palaeovalley systems remain largely untested and unexplored.

In summary, good quality aquifers are difficult to find in central and southern NT, highlighting the value of any fresh, moderate-high yielding aquifers that can be found. Figure 1 shows the more extensive aquifers of the NT extent in relation to the currently known prospective unconventional gas areas in the NT.

The groundwater resources underlying the NT are critical for modern human settlement and development with the exception of the Darwin and Katherine areas where surface water is the main water supply. Users of groundwater include the towns of Tennant Creek and Alice Springs, over 100 remote communities, the tourism industry (e.g. Yulara), the mining and petroleum industries, the horticultural industry, and pastoral industry. Irrigation developments around Darwin, Katherine and Mataranka and the Douglas/Daly region all rely on groundwater from major karstic aquifers of the Daly Basin. Ti Tree Basin provides the water resource for the horticultural industry. In addition, the recreational and commercial fishing industries in the top end depend on the groundwater-fed flows to the major river systems to maintain aquatic ecosystem health and therefore fish stocks.

The NT Water Act (1992) governs the investigation, allocation, use, protection, controls and management of groundwater. Under this Act, groundwater use is managed by the NT Government. To date, seven Water Control Districts have been declared in areas where increasing usage has necessitated the need for closer management.

A process of consultation with existing water users and other stakeholders supports the development of 'Water Allocation Plans'. These plans create rules for the distribution of water between the different users. The environment is given priority as a 'water user'. Sustainable water use and maintenance of the natural environment are two of the main goals of allocation plans. With the increasing pressure for development of the resource and recent changes in rainfall patterns, good management of groundwater is critical.

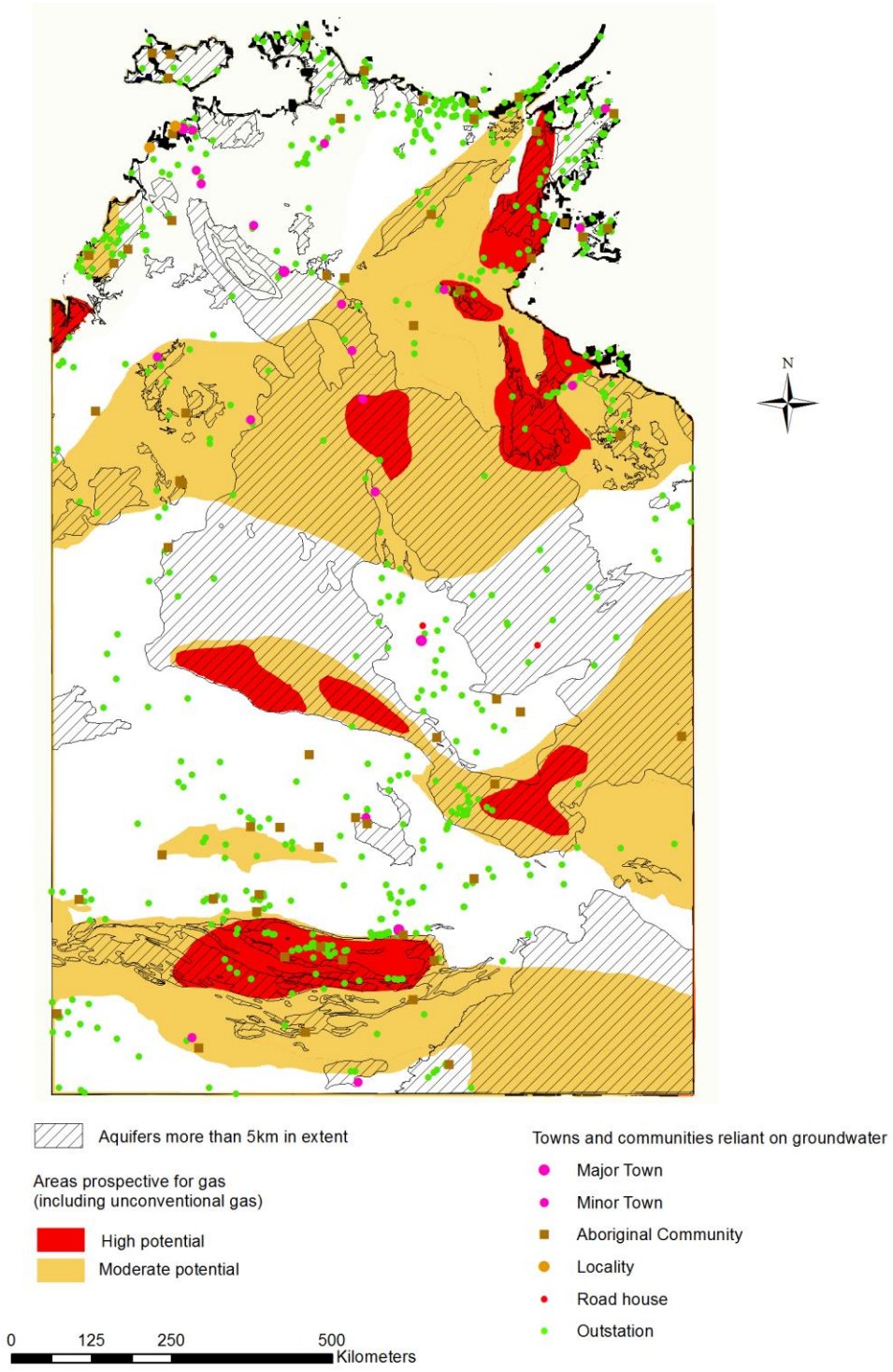


Figure 1: An overview of NT aquifers of >5km extent and prospective unconventional shale gas areas.

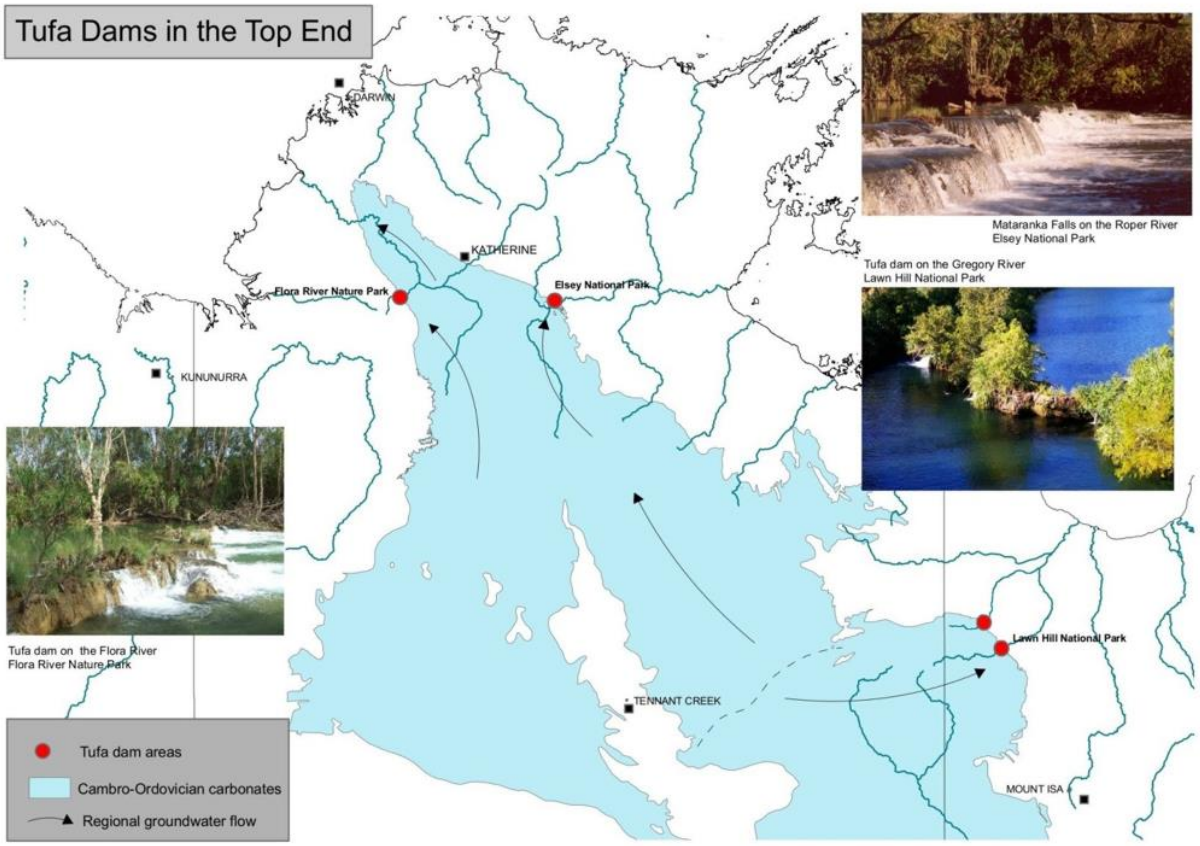


Figure 2.Major Cambro-Ordivician Aquifers, Regional Groundwater Flow Directions and the Location of Tufa Dams.

1.3 The Shale Gas Industry in the NT

Shale gas basins within the NT include the McArthur Basin, the Beetaloo Sub-basin, Wiso Basin, Georgina Basin, Amadeus Basin and Pedirka Basin (Figure 1). There may also be potential for coal seam gas within the Pedirka Basin (Munson, 2014).

Development of unconventional shale gas reserves in the Northern Territory is complicated by their remote locations, the great (>1000m) depth of the bores, the need for fracking due to the low permeability of the shale (as compared with coal seam gas) and the subsequent need for water to frack.

The potential demand on water resources for use in fracking operations in Australia has been estimated by the Canberra-based geoscience resource specialists 'Frogtech' (*FR*om *O*il to *G*roundwater) in its report *'The Potential Geological Risks Associated with Shale Gas Production in Australia'* commissioned by the ACOLA secretariat in 2013 as part of its report on the future of unconventional gas in Australia. Their water demand estimates, modified for the NT as some basins extend into other states, are presented in Table 1.

Basin	Basin Area (km^2)	No. Shale Gas wells	Total Water needed for fracking (GL)	Annual Fracking water demand (GL)	Ground-water Sustainable yield (GL/yr)	Ground-water extraction (GL/yr)
Amadeus	133,110	10,399	156	6.2	100	14
Georgina	228,120	17,849	268	10.7	171	9
McArthur	196,288	15,351	230	9.2	2,360	21
Wiso	154,310	12,126	182	7.3	116	4
All NT					**6,499**	**127**

Table 1: Estimated potential groundwater use per shale gas basin (Assuming well spacing of 800m, assuming 15 ML/well, 25 year well field life span) (from Frogtech, 2013) Table modified for the NT using Land and Water Audit 2001 data.

The economic potential for the use of hydraulic fracturing to develop hydrocarbon deposits in the Territory is very large. It is estimated that more than 67,000 shale gas wells may be drilled in these basins, with a combined water for fracking demand of more than 1,000 GL over the life of the bores (Frogtech, 2013). To put this in perspective, the annual groundwater extraction for the NT is estimated as being 127 GL.

The combined Best Estimate Recoverable Resource for the Amadeus, Beetaloo, Bonaparte, Georgina, McArthur and Pedirka Basins as summarised by Cook et al (2013) as totalling more than 140 tcf, and the combined Recoverable Resource to be more than 19 tcf. However, Cook et al. acknowledge that these resource estimates are constrained because (a) there has been little or no exploration or drilling in most basins, and, (b) the geology is not known in detail.

The NTG submission to the *Joint Select Committee's Inquiry into Development in Northern Australia* (February, 2014) recognises that land and water resources are critical to economic development. Indeed, the NTG submission acknowledges that there is a need to more fully understand earth (geology) and water resources through the NTG proposed partnership with COAG and other state governments to:

> '*invest in and accelerate the completion of investigations and research to fully understand Northern Australia's soil, vegetation, water and marine resources and development potential*' as well as *'…Northern Australia's minerals, oil and gas development potential*'.

The IAH(NT) supports this intent but in a modified form because it will not be possible to 'fully understand' water in the NT. More realistically, there will be an incremental increase in the understanding with an incremental decrease in the risk.

2 Hydraulic Fracturing and Groundwater in the NT

The following are considered by IAH(NT) to be the major groundwater-related concerns in regard to the proposed unconventional shale gas operations in the NT:

2.1 Decommissioned wells and 'well integrity' failure

Deterioration and failure of improperly decommissioned wells will, over time, result in long-term release of oil and/or gas into the environment. Pathways in the annulus may develop that would allow oil, gas, and brine to move vertically across geologic formations and contaminate groundwater. Substances dissolved in the brine may include those that occur

naturally in the shale formations and others injected during the hydraulic fracturing process. Also upwardly migrating gas, known as stray gas, represents an explosion hazard if not properly vented away from buildings and drinking water wells.

The risk that annular pathways will develop increases over time as chemical, mechanical, and thermal stresses causes deterioration of well structures and components. Failure modes of improperly abandoned wells include the formation of cracks in the cement casing or packers, corrosion of steel production casing, faulty valves, and leaking temporary plugs or surface caps. A key paper on the causes of well failure (Dusseault et al, 2000) discusses cement shrinkage as the principle cause of well failure, particularly long after wells have been plugged and abandoned.

Estimates of well failure rates vary although the more conservative well failure rates found in the literature are between 4.6% and 8.9%. Further, a study from Alberta, Canada of more than 315,000 oil, gas and injection wells of various ages, (Watson and Bachu, 2009), shows that 'injection wells' into which liquids or gasses are pumped are 2-3 times more likely to leak than conventional 'production wells'.

The same study found that horizontal or inclined wells are observed to have significantly higher failure rates than vertical wells. It is universally acknowledged that problems with casing centralisation and cement slumping in horizontal or inclined wells may contribute to the increased incidence of leakage.(Council of Canadian Academies, 2014, Watson and Bachu, 2009).

A well-documented example of groundwater contamination caused by fracking operations from the USA occurred in Pennsylvania, USA (Osborn et al, 2011). It found that about 75% of wells sampled within 1 kilometre of gas drilling in the Marcellus shale in Pennsylvania were contaminated with methane from the deep shale formations. Isotopic fingerprinting of the methane indicated that the deep shale was the source of contaminations, rather than biologically derived methane. In addition, fracking-return fluids have also been known to contaminate drinking water, although the evidence is not as strong as for methane contamination (Horvath & Illgraffea, 2011).

Well integrity is of concern in the NT because some groundwater environments in the NT are naturally corrosive. An example of the effect of corrosive water on cementing and casing in the NT is provided by deep oil exploration wells (McDills and Dakota) drilled in the Perdika/Great Artesian Basin in the 1960s. (The Perdika Basin is one of the prospective unconventional shale gas areas of the NT). Now, some fifty years later, the steel casing has almost entirely corroded away, resulting in inter-aquifer contamination. This well required expensive rehabilitation works to stem artesian flow (Humphreys and Kunde, 2004). This single bore cost the Territory and Commonwealth Governments $500,000 to plug as the company responsible for the well was insolvent. This example highlights the issue of operator insolvency due to the boom and bust cycles of oil and gas development which complicate efforts to hold liable parties responsible and provide for timely environmental reclamation.

The McDills example could be considered to be an expensive example of what plugging a well can cost. The following example highlights that the McDills example is not unique. In Pennsylvania, in 2010, Cabot Oil & Gas Corporation estimated that it spent $2,190,000 to properly abandon three vertical Marcellus Shale gas wells.

2.2 Financial mechanisms to manage risk of well failure and other environmental impacts

Other Australian jurisdictions have considered financial mechanisms to address petroleum industry-related environmental impact concerns. For instance, one of the recommendations from the 2012 NSW Parliamentary Inquiry into coal seam gas operations:

> *'6.40 ..... They recommended that coal seam gas companies be required to pay 'high value (in dollar terms) and long term (50 years minimum)' security deposits, which would be refunded if long-term monitoring showed that there were no ill-effects of coal seam gas activities.'*

Commenting on the issue of how to hold coal seam gas companies to account for damage that may emerge many years, or decades, into the future, the National Water Commission called for the implementation of: *… 'bonds and sureties that deal with uncertainty and the timeframes associated with potential impacts'.* Given that these timeframes may extend for 100 or more years, current systems may need to be re-evaluated.

Events unfolding in relation to CSG in NSW demonstrate the imperative for the NT to plan for adequate time and money to be set aside to ensure ongoing well integrity to protect the NT environment.

The economic potential for the use of hydraulic fracturing to develop hydrocarbon deposits in the Territory is very large. Well head prices in the USA per thousand cubic feet of gas have varied between $2 and $6 over the last 15 years with occasional peaks over $8. While in Europe and Australia the price has varied between $3 and $10 over the last 15 years with occasional peaks over $10.A trillion cubic feet of gas equates to 1,000,000,000 thousand cubic feet. Armour Energy's 18.8 Trillion Cubic Feet of unconventional gas Mean Prospective Resource in the NT would have a wellhead value that over the past 15 years could have had a value of between $37.6 billion and $188 billion depending on the market the gas is exported to and the time the gas was sold.

In the Territory, petroleum royalties are 10% of the gross value at the wellhead of all petroleum products produced from a licence area as well as application fees and annual fees. The Territory government must ensure that some of the funding generated from these fees and the 10% royalty is used to develop a compliance program that effectively manages both the short and long term impacts on groundwater of development that utilises hydraulic fracturing to develop the Territory's hydrocarbon resources.

It needs to be highlighted that in the unconventional gas industry economics are dominated by high initial gas production rates. In some unconventional gas fields more than 80 % of the net present value of gross revenue may be realized in the first 10 years of a well with a projected life of 40 years, or more. The steep decline in production may drive divestment of assets by primary exploration and production companies well before the expected closure of an unconventional gas well. This may result in the transfer of marginally producing assets to a smaller independent operator who may not be able to fund the effective reclamation of a well.

It is the view of the IAH(NT) that a funding requirement on the owner of a gas well, at a level that matches reclamation costs, would provide the best mechanism to ensure maintenance of well infrastructure, reduce environmental impacts, and protect the Northern Territory from costly liabilities stemming from the failure of some gas wells. Mitchell and Casman (2011) investigated mechanisms for generating the funds required to minimise the risk of adverse economic, environmental, and human health effects of improperly abandoned shale gas wells. They concluded that generating the funds required directly from the revenue stream during the most lucrative years of gas production had the lowest impact on an operator's internal rate of return. IAH(NT) members recommend that this funding approach is adopted in the Northern Territory.

Recommendations:

> *2.2.1 Funds adequate to match reclamation should be generated directly from the revenue stream during the most lucrative years of gas production. These funds should be held by the NTG to assure against any long-term liabilities from unconventional shale gas extraction.*

2.3 Groundwater contamination from surface storages

'Flowback' is the excess fracking fluid, water and proppant that returns to the surface once the hydraulic fracturing event is complete and the pressure is released. 'Produce water' is that which returns to the surface in mixture with oil and gas. Approximately 30-70% of the fracking fluid injected into the shale is recovered and the gas is extracted from this fluid.

The recovered fluid is generally temporarily stored in sealed dams near the well (for evaporation and subsequent burial), or in above ground tanks for re-use in future hydraulic fracturing treatments. From there the water may be treated in a number of different ways including desalination, transport to another location, mixing with surface water or reinjection into decommissioned wells (common in the US) or saline aquifer.

In Australia, groundwater was found to be contaminated recently due to leakage from a surface coal seam gas wastewater storage pond in northern NSW at the Bibblewindi Water Treatment Plant in the Pilliga. Routine groundwater sampling revealed elevated levels of naturally occurring elements including arsenic, lead, and uranium. The EPA fined Santos $1,500 for the pollution incident, however, the cost of cleaning up contaminated groundwater would far outweigh these sorts of fines. (http://www.miningaustralia.com.au/news/santos-csg-project-contaminates-groundwater)

Safe containment, treatment and disposal of wastewater at the surface is particularly difficult in the monsoonal north. There have been a number of mine sites in the top end where surface containment of waste water has failed (Ranger Uranium Mine, Redbank Copper Mine, Mt Todd Gold Mine).

One of the problems with trying to manage containment dams in high rainfall areas is that the NT currently has no dam safety regulations.

The key concerns of the recovered fluid are:

- unregulated release to surface and groundwater resources and subsequent impact on the aquatic environment
- leakage from on-site storage ponds leading to groundwater and surfacewater contamination
- improper pond construction, maintenance and decommissioning
- incomplete treatment
- spills on-site and
- waste water treatment accidents.

Recommendations:

2.3.1 The proponent should aim to treat and re-use the flowback and produce water within the fracking process. Storage should be in lined ponds with a flood immunity of 1,000 years.

2.3.2 The QLD Dam Safety Regulations should be applied until such time as NT Dam Safety Regulations are developed.

2.4 High water demand for fracking

Fracking is highly water intensive. An estimated average of 15 megalitres is required per well (Frogtech, 2013). A well field may consist of hundreds or thousands of wells each using this amount. Frogtech calculated the groundwater requirement for potential shale gas fields in the NT as shown in Table 1.

Unregulated pumping of large volumes of water from an aquifer may induce drawdowns which adversely affect other users and the surface water environment.

Over allocation due to fracking industry water demands may become deeply problematic in the NT, which, apart from parts of the Top End, is largely devoid of surface water resources. Most of the shale gas resources in Australia are located either wholly or partly within the arid and semi-arid zone. Groundwater will often be the sole water resource available for fracking. In these areas, natural groundwater recharge rates are particularly low. For instance, the water requirement for the proposed unconventional shale well field in the Beetaloo Sub-basin may impact other users, such as the pastoralists, who depend on water resources in the overlying limestone aquifers for stock watering.

Recommendations:

2.4.1 'High-value' aquifers as defined in Sections 1.2 should be avoided as groundwater sources for unconventional gas shale fracking operations. In the arid parts of the NT the use of scarce low salinity water and aquifers used for drinking water supplies should be avoided.

2.4.2 Extraction of water for shale gas operations should be managed within National Water Initiative Principles as they may have significant impacts on local groundwater systems (Cook et al. 2013).

2.4.3 Re-use and re-cycling of produce water should be the first source of water used by fracking proponents before any additional water allocations from natural water resources will be considered.

2.5 Groundwater management issues

The value of groundwater must reflect its true place in our society. In the NT there is virtually zero cost recovery for groundwater management. Fees and charges which reflect the level of groundwater management required to effectively manage the impacts on groundwater from hydraulic fracturing for hydrocarbon deposits are called for. This cost should be borne by both the industry using the technology and the NTG which benefits from the royalties obtained once production commences.

As outlined in section 2.2 above, with the high economic potential of shale gas development, it is necessary that funds acquired directly from the revenue stream be available to resource rectification of legacy issues, including well plugging, if required.

Most water bores in the NT are relatively shallow (<150 m). For this reason, any deep groundwater systems which gas wells may intersect, are largely unexplored. The few exceptions include the GAB and Amadeus Basin. Therefore the geology and the hydrogeology, particularly of deeper aquifers, is not well understood. It is evident that to determine potential impact of hydraulic fracking activities across these Basins, there needs to be much improved hydrogeological conceptualisation which requires investment in assessment.

Over the last few decades, the number of experienced NTG hydrogeologists has declined due to changing funding priorities. This has reduced the collective local knowledge base

and experience. That knowledge base is needed to support the management and assessment of groundwater issues related to the approaching boom in unconventional gas extraction in the NT. This, coupled with the paucity of data and understanding of groundwater systems of the NT means that, at present, the NTG does not have the capacity to make well informed decision on these matters.

Examples from Queensland (Qld) and New South Wales (NSW) show how those jurisdictions have funded data gathering and investigations to develop baseline assessment plans (Qld), compliance plans (Queensland: CSG/LNG Compliance Plan) and strategic water resource management plans (Queensland: CSG Water Management Policy 2012; New South Wales: NSW Aquifer Interference Policy).

Recommendation:

2.5.1 The groundwater data paucity in shale gas basins should be addressed through an investigation program funded through royalties from shale gas production.

2.5.2 The NTG must invest in a skilled labour force and capacity building to be able to adequately manage and review permit applications and data provided by proponents and the on-going environmental risks/ impacts of the fracking industry.

---

3 NT Legislation and the Protection of Groundwater Resources

Under the current legislative framework, the protection and use of water resources in the NT is administered by several agencies through a range of NT legislation. All aspects of water resource protection and use are covered under the Water Act but limitations are placed on its application to mining and petroleum activities. Water resource protection and use directly associated with mining and petroleum activities are covered under the Mining Management Act and the Petroleum Act.

It is well understood that unconventional gas extraction can be a water resource intensive activity. And yet, *petroleum activities are exempt from the need for licensing under the Water Act for extraction and use of surface water and groundwater*.

Pollution of water resources is prohibited under the Water Act unless licensed under this Act, but this conditional prohibition does not apply to wastes that are confined to a mining or petroleum site. Pollution of water resources is prohibited under the Waste Management and Pollution Control Act, but this prohibition does not apply to waste from an authorized petroleum pipeline or within 1km of the pipeline.

Petroleum activities must comply with permits and licences granted under the Petroleum Act. Permits and licences include conditions that the activities cause as little environmental disturbance as possible and the escape or release of petroleum must be approved. As defined in this Act, environment includes water and is not confined to the site of the activity.

Offences and penalties for unlawful pollution or waste disposal into water resources across the other Acts are consistent with the Environmental Offences and Penalties Act. Accordingly, penalties range from $5000 for causing environmental nuisance to up to $1,250,000 for intentionally causing serious harm to the environment. As outlined above, the cost of plugging for a single well could cost $500,000 although this figure is poorly constrained. The costs of remedying other impacts outlined above are also difficult to constrain.

The ability to protect the environment from pollution caused by hydraulic fracking, and to manage the allocation of potentially scant freshwater resources in basins where fracking occurs, is dependent on robust and clear legislation. It is recognised that there are both gaps

and duplication in NT legislation for the protection and use of water resources, and indeed the NTG's Water Directorate is addressing this problem through legislative reform.

Recommendations:

3.1 IAH(NT) recommends that the outcomes of the Inquiry are fed into the ongoing water resources legislative reform to:

- *Ensure that the roles and responsibilities of the regulator and industry under new or revised legislation are clear;*
- *Advise whether the provisions under the Petroleum Act adequately cover the activities associated with the relatively new (for the NT) phenomena of hydraulic fracking;*
- *Review the penalties associated with overuse or pollution of water resources through fracking activities, commensurate with the cost associated with that overuse or pollution;*
- *Provide transparent and effective regulations and companion codes of practise to guide both industry and Government;*
- *Include Dam Safety regulations;*
- *Employ qualified Hydrogeologists in these regulatory fields; and,*
- *Clarify roles and responsibilities in legislation, and precedence of legislation.*

---

4 The NT EPA's Proposed EIS approach to Hydraulic Fracturing Projects

It is understood that the NT EPA is depending on the hydraulic fracking inquiry to evaluate the potential for environmental impact from fracking in different parts of the NT by comparing the geological settings with areas elsewhere in Australia and internationally where shale gas has been explored. Due to basin geology variability and other factors, care should be taken when extrapolating hazard magnitude and frequency from the US experience and applying it to the Australian environment.

To be able to evaluate environmental impact risk, it is necessary to conceptualise the geology and hydrogeology just as is done for a mining application. The level of potential environmental impact may not be commensurate with the footprint of the development; i.e. the impact that a mine might have on ground water and surface water availability and quality is not necessarily always greater than that for an unconventional gas production well. This calls for a rigorous environmental assessment process that can consider the risks associated with individual wells in addition to cumulative impacts of a wellfield, rather than a blanket EIS for an entire basin. Understanding of the cumulative impacts of fracking project operations should be incorporated into the environmental impact assessment process.

The NTG is a signatory to the Intergovernmental Agreement on the Environment and has adopted the National Strategy for Ecologically Sustainable Development (ESD). The NT EPA take a lead role in ensuring the principles of ESD guide policy development and decision making in the development of the NT. The NT relies heavily on groundwater shallow and intermediate aquifers for community, potable water, horticulture, agriculture, industrial, cultural and stock and domestic water supplies. Investment in access to good quality groundwater made by those for these beneficial uses should not be undermined and put at risk.

Consistent with the principles of ESD, the onus and cost to demonstrate the potential level of environmental impact should remain with each proponent and not with the NTG and NT taxpayer.

It should be noted that the scope and effort needed to obtain the background data so that potential ground and surface water impacts of any development can be properly assessed are significant research undertakings in their own right. For instance the compilation and assessment of water data the IESC guidelines (IESC 2014) consider necessary to begin to evaluate coal seam gas developments is extensive and therefore likely to be a major financial outlay by the development proponents.

In recognition of the NT's social and economic dependency on groundwater, the NTG needs to invest in strengthening institutional provisions and building institutional capacity for its improved management, before it is too late and groundwater resources and consumers are adversely impacted.

An agency whose major responsibility is water management should be established by the NTG. This agency must work flexibly with local stakeholders as partners in resource administration, protection and monitoring, whilst also acting on broader water resource planning and management strategy. Such an agency might also be expected to take responsibility of review of development proposals from a water perspective.

For instance, one crucial part of the whole fracking process is the assessment of environmental impacts of proposed developments. The NSW (2012) parliamentary enquiry discussed the potential for perceived bias by the public if environmental impact assessment is conducted and paid for by the proponent gas companies. The committee, however, believed it was not feasible due to a lack of resources for the NSW Government to undertake the research to assess environmental impacts of coal seam gas projects. Instead the NSW parliamentary committee took the view that

> *'6.89 The Committee considers the central issue to be not who does the research, but whether the NSW Government has sufficient officers with the necessary skills to effectively peer review environmental assessments, and therefore supports transparent Government review of environmental assessments of coal seam gas proposals.'*

This consideration illustrates the need for adequate groundwater expertise to be set up within a NT Government Agency.

Other jurisdictions have created and built up specific technical expertise in such agencies, for example the Office of Groundwater Impact Assessment in Queensland, or the Office of Water in New South Wales. It is noted here that the Department of Mines and Energy in the NT, the regulatory body for unconventional gas projects, has no in-house groundwater technical expertise, neither does the NT EPA which is responsible for assessing environmental impacts as described above.

Reform of existing NT legislation and regulations is required to address the lack of a robust framework to assess and manage the potential impacts of unconventional gas development on the NT's water resources. This includes bringing water use for fracking into the water allocation planning framework, in line with the National Water Initiative framework. It may also include aligning the guidelines around shale gas bores and water bores to reduce bureaucracy whilst ensuring robust guidance for the drilling, testing, construction, rehabilitation and decommissioning of all wells that intersect aquifers.

It is noted that, in other jurisdictions where fracking and unconventional gas exploration and production is more developed and there is more data to assess fracking environmental impact, legislation and regulation has become more stringent with time (Hoare and Finn, 2014). This presumably indicates that the impacts of CSG and fracking are greater than expected, whether because of the process or because of the cumulative effect.

The notion of commercial-in-confidence should not apply to any ground and surface water data generated by the petroleum industry in the NT. These data should be reported and made accessible to the public as a matter of course.

Given the more advanced position of other states, this is an opportunity for the NT to develop its own legislation and regulation, with advice from other jurisdictions, whilst also

recognising the NT situation where the variables are shale gas rather than CSG; data paucity; and semi-arid to arid to sub-tropical environments etc. The IESC guidelines which outlines the scope and extent of background surface and groundwater data needed to assess coal seam gas, should serve as a guide to the rigour required by frack gas proponents in the NT.

Furthermore, other relevant data from interstate should also be reviewed for guidance. The NSW Chief Scientist background papers commissioned for CSG review are also relevant to the NT as they deal with most factors that should be considered in fracking hydrocarbons and developing CSG. No doubt other reviews from Australia and overseas are also likely to be relevant to the NT.

Recommendations:

4.1 An agency whose major business is water should be established within the NTG. This agency should be resourced with relevantly skilled experts who can facilitate a coherent legislative framework.

4.2 A comprehensive assessment of local and regional groundwater resources be undertaken prior to use by the fracking industry.

4.3 Pre-fracking groundwater baseline studies should include measurement of natural methane levels in groundwater.

4.4 Drilling and groundwater data from gas fields should be made available to the NT Water Resources division (Department of Land Resource Management) to facilitate better understanding of the groundwater environment of the NT.

4.5 Funds for the NTG to engage resources (internal and external) for the assessment of permit applications, resource assessments and impact assessments should be provided by proponents as part of the application fee and licensing process.

References

Cook, P, Beck, V, Brereton, D, Clark, R, Fisher, B, Kentish, S, Toomey, J and Williams, J., 2013, Engineering energy: unconventional gas production. Report for the Australian Council of Learned Academies, www.acola.org.au.

Council of Canadian Academies, 2014. Environmental Impacts of Shale Gas Extraction in Canada. Ottawa (ON): The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction, Council of Canadian Academies.

Dusseault et al., 2000, 'Why Oilwells Leak: Cement Behaviour and Long-Term Consequences'. Society of Petroleum Engineers.Presented at International Oil and Gas Conference and Exhibition in China, 7-10 Nov 2000, Beijing, China.

Frogtech., 2013, Potential Geological Risks Associated with Shale Gas Production in Australia, Australian Council of Learned Academies

Horvath, R.W., Illgraffea, A., 2011, Should Fracking Stop ? Nature, Vol 477, pp 271-273

Hoare, R. and Finn, W., 2014. 'Regulation of Hydraulic Fracturing in Australia', paper presented at OzWater'14, Brisbane Australia, 29 April-1May 2014

Humphreys, G. and Kunde, B.,2004, Rehabilitation of flowing bores in the Northern Territory portion of the Great Australian Basin, Draft .Department of Infrastructure, Planning and Environment Internal Report 12/2004D.

IESC., 2014, Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals. http://iesc.environment.gov.au/pubs/iesc-information-guidelines.pdf

Ingraffea, A., 2012, Unconventional Development of Natural Gas from Shale Formations: Impacts on Water and Climate. Presentation. http://www.chesapeake.org/stac/presentations/208_Ingraffea%20Part%201.pdf

Mitchell, A L. and Casman, E.A.,2011, Economic incentives and regulatory framework for shale gas well site reclamation in Pennsylvania. Environmental Science & Technology. 45(22): 9506-9514

Myers, T. 2012,.Potential contaminant pathways from hydraulically fractured shale to aquifiers.National Ground Water Association.

Munson, T.J., 2014, Petroleum geology and potential of the onshore Northern Territory, 2014. Northern Territory Geological Survey, Report 22.

NSW 2012 *https://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/318a94f2301a0b2fca2579f1001419e5/$FILE/120501%20Media%20release.pdf*

NSW Chief Scientist background papers *http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/csg-background-papers*

Osborn, S.G., Vengosh, A., Warner, N.R., Jackson, R.B.,2001, Proc. Natl. Acad. Sci. USA 108, 8172-8176.

Watson, T.L. and Bachu, S., 2009, Evaluation of the Potential for Gas and CO_2 Leakage Along Wellbores. SPE Drill & Compl 24 (1): 115-126. SPE-106817-PA: *http://www.spe.org/ejournals/jsp/journalapp.jsp?pageType=Preview&jid=EDC&mid=SPE-106817-PA*

IDENT	Job numbe	Project coc	pH	Df	Ag_T	Al_T	As_T	B_T
UNITS			units	--	µg/L	µg/L	µg/L	µg/L
SCHEME			ALK1	W204	W205M	W205M	W205M	W205M
WATER 17/12/2015	NT44890	WATER S	6.9	5	<10	11000	4	<20

Ba_T	Be_T	Br_T	Cd_T	Cr_T	Cu_T	Fe_T	Hg	I_T
µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
W205M	W205M	W205M	W205M	W205M	W205M	W205M	W205M	W205M
400	<1	736	<0.2	10	10	3740	<0.1	<10

Mn_T	Mo_T	Ni_T	Pb_T	Sb_T	Se_T	Sn_T	U_T	Zn_T
µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
W205M	W205M	W205M	W205M	W205M	W205M	W205M	W205M	W205M
100	20	6	3	0.6	<1	<10	0.34	30

COMMONWEALTH OF AUSTRALIA

Proof Committee Hansard

SENATE

UNCONVENTIONAL GAS MINING

Adequacy of Australia's legislative, regulatory and policy framework for unconventional gas mining

(Public)

TUESDAY, 12 APRIL 2016

DARWIN

CONDITIONS OF DISTRIBUTION

This is an uncorrected proof of evidence taken before the committee.
It is made available under the condition that it is recognised as such.

BY AUTHORITY OF THE SENATE

[PROOF COPY]

INTERNET

Hansard transcripts of public hearings are made available on the internet when authorised by the committee.

To search the parliamentary database, go to:

http://parlinfo.aph.gov.au

SENATE

UNCONVENTIONAL GAS MINING

Tuesday, 12 April 2016

Members in attendance: Senators Lazarus, Ludwig, Peris, Waters.

Terms of Reference for the Inquiry:

To inquire into and report on:

The adequacy of Australia's legislative, regulatory and policy framework for unconventional gas mining including coal seam gas (CSG) and shale gas mining, with reference to:

a. a national approach to the conduct of unconventional gas mining in Australia;

b. the health, social, business, agricultural, environmental, landholder and economic impacts of unconventional gas mining;

c. government and non-Government services and assistance for those affected;

d. compensation and insurance arrangements;

e. compliance and penalty arrangements;

f. harmonisation of federal and state/territory government legislation, regulations and policies;

g. legislative and regulatory frameworks for unconventional gas mining in comparable overseas jurisdictions;

h. the unconventional gas industry in Australia as an energy provider;

i. the current royalty and taxation arrangements associated with unconventional gas mining; and

j. any related matter.

WITNESSES

ANDERSON, Mr Robert, Traditional owner 39

ANKIN, Ms Rosita, Traditional owner 39

ARMSTRONG, Mr David, Managing Director/Owner, Terrabos Consulting 46

BACON, Dr Rachel, Deputy Chief Executive, Department of the Chief Minister 1

BICKNELL, Mr Gregory, Chief Executive Officer, Chamber of Commerce and Industry, Northern Territory 10

CAREY, Dr Marion, Coordinator, Unconventional Gas Special Interest Group, Doctors for the Environment Australia 35

CASS, Miss Pauline, Private capacity 46

COTTEE, Mr Richard, Private capacity 26

DALTON, Mr Robert, Policy and Research Officer, Northern Land Council 14

DOMAN, Mr Matthew, Director, South Australia and Northern Territory, Australian Petroleum Production and Exploration Association 26

DOWADI, Mr Andrew, Traditional owner 39

EARLEY, Mr Braedon, Private capacity 46

FITZPATRICK, Mr Nicholas, Traditional owner 39

FRASER, Mr Mark, Private capacity 46

HARRIS, Mr Ian Mervyn, Director, Environment Centre NT 18

HICKS, Mr Armon, Group Executive Public Affairs, Santos Limited 26

HOGAN, Ms Naomi, Coordinator, Lock the Gate Alliance Northern Territory 18

HOOSAN, Mr Gadrian, Traditional owner 39

KELLY, Mr Ron, Chief Executive, Department of Mines and Energy 1

MASON, Mr Eddie, Traditional owner 39

MORRIS, Mr David, Principal Lawyer, Environmental Defenders Office NT 18

MORRISON, Mr Joe, Chief Executive Officer, Northern Land Council 14

QUINLIVIAN, Ms Belinda, Private capacity 46

ROTH, Ms Charmaine, Vice-Chairperson, Don't Frack Katherine 18

RYAN, Mr Tom, Executive Officer, Northern Territory Cattlemen's Association 46

SILVESTER, Mr Lex, Private capacity 46

SLOAN, Mr Tristan Robert, Amateur Fishermen's Association of the Northern Territory 46

SULLIVAN, Mr Bill, Chief Executive Officer, MS Contracting 46

SULLIVAN, Mr Rohan, Private capacity 46

TAPP, Mr Daniel, Private capacity 18, 46

WILKINSON, Mr Richard (Rick) John, Chief Technical Officer, Australian Petroleum Production and Exploration Association 26

WILLIAMS, Ms Helen, Traditional owner 39

WILLOUGHBY, Emeritus Professor John, Member, Doctors for the Environment Australia 35

WRIGHT, Mr James, Private capacity 46

YARRNGU, Ms Molly, Traditional owner 39

BACON, Dr Rachel, Deputy Chief Executive, Department of the Chief Minister

KELLY, Mr Ron, Chief Executive, Department of Mines and Energy

Committee met at 8:03

CHAIR (Senator Lazarus): I declare open the public hearing of the Senate Select Committee on Unconventional Gas Mining and I welcome you all here today. This is a public hearing and a Hansard transcript of the proceedings is being made.

The committee prefers to hear evidence in public. It may agree to take evidence confidentially, if it is relevant. The committee may publish confidential evidence later but we would try to ask before doing this. It is important that witnesses give the committee notice, if they want to give evidence in private. In addition, if a committee has reason to believe that evidence may reflect badly on a person, the committee may direct that the evidence be heard in private.

I remind all witnesses that, in giving evidence to the committee, they are protected by parliamentary privilege. It is against the law for anyone to threaten or disadvantage a witness, because of evidence given to a committee. If they did, the action may be treated by the Senate as a contempt. It is also a contempt to give false or misleading evidence to the committee. Witnesses should be aware that if, in giving their evidence, they make an adverse comment about another individual or organisation, that individual or organisation will be made aware of the comment and given a reasonable opportunity to respond to the committee. If a witness objects to answering a question, the witness should state the grounds of the objection and the committee will determine whether it will insist on an answer.

On behalf of the committee, I would like to thank witnesses here today for their time and their cooperation. Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. The committee has the department's submission, which the committee has numbered as submission 37. I now invite you to make a short opening statement and after you have spoken I will invite members of the committee to put questions to you.

Mr Kelly: I would first like to thank the committee for allowing us the opportunity to appear today to advise the committee about the work that the Northern Territory government is doing to implement a robust and effective regulatory and policy framework applicable for onshore oil and gas developments. The term 'unconventional gas mining' covers a wide variety of oil and gas deposits and therefore, by extension, a wide variety of extraction processes. Coal seam gas, shale gas and tight gas are all grouped under the 'unconventional' banner. In the Northern Territory our known deposits are deep shale—typically more than a kilometre deep and, in effect, an average of about 2.5 kilometres in depth. That is the type of gas deposit applicable for the NT and the type of deposit that we are working, in a regulatory process, to administer.

The geology in different states and countries is not the same. That means that implementing uniform assessment and extraction processes across Australia is not necessarily desirable from an economic or environmental perspective—or even achievable. These differences explain why shale gas developments have in some regions been carried out with no discernible environmental impacts. In that context, the southern region of the Northern Territory and northern South Australia have been producing oil and gas from unconventional wells for more than 40 years with no significant environmental impacts. In saying that, I acknowledge the necessity of learning from the experience of other jurisdictions, both domestically and internationally, and working together to ensure a continuing improvement and targeted regulatory regime.

The Northern Territory government is aware of community concerns about some of the practices used to extract unconventional gas; hydraulic fracturing, or 'fracking', is one such practice. To that end, the government commissioned Dr Allan Hawke AC to undertake a public inquiry into the regulation of hydraulic fracturing, and after considering public submissions and detailed academic studies, Dr Hawke found that there was no case for a moratorium on hydraulic fracturing provided a robust regulatory regime was put into place. The Northern Territory government has accepted this report and each of Dr Hawke's recommendations contained within it. This is not the only work underway across the Northern Territory government to implement a robust and effective regulatory and policy framework.

When Dr Hawke delivered his first review, the Northern Territory government asked him to stay on and conduct a review into our environmental assessment and approval processes. Dr Hawke's review of our environmental impact assessment and approval framework confirmed that the territory environmental regulatory framework needed reform to meet modern challenges and community expectations. The government embraced the recommendations and are already progressing the development of a contemporary regulatory system with work underway right across the Northern Territory government to ensure that the territory has a robust and

effective environmental regulatory and policy framework—this is for all environmental matters and not just oil and gas. Officers from the Department of Mines and Energy, the Department of Lands, Planning and the Environment, the Department of Land Resource Management and the Department of the Chief Minister are all at various stages of community consultation processes for our respective environmental regulatory responsibilities. When completed it will bring the Northern Territory to the forefront in environmental regulations nationally—and that is our stated and, we believe, achievable goal.

With reference to oil and gas specifically, my department have been running a three-stage process of overhauling our regulatory framework to provide better transparency and clarity for Territorians and for industry. Firstly, we released guiding principles to clearly articulate our expectations of industry, and all activities are currently being assessed against those guiding principles. Second is the environmental regulations themselves, which I will introduce in a moment. Finally, of course, is reform of the Petroleum Act to give it all effect. The new draft petroleum environment regulations are also designed to deliver on the government's objective of improving transparency and accountability in the regulatory system. The draft regulations have been released for public comment and are designed to apply best-practice principles to the regulation of the onshore oil and gas industry. In doing so, we have taken into account the adoption of new regulations by the Commonwealth for offshore waters and by the South Australian and Western Australia governments for their onshore unconventional gas industries.

Specifically, the regulations adopt an objective based approach rather than a prescriptive approach. The regulator will no longer develop a long list of prescriptive measures that a company ticks off when seeking approvals. Instead, the company must demonstrate that they have considered and assessed all risks and have appropriate practices developed. This drives continual best-practice improvement rather than complying with minimum standards which may not always necessarily address the specific risks of an individual site.

They encapsulate the following key points. Interest holders must not conduct petroleum activities unless there is an approved environmental plan in place. The plan must identify all environmental risks associated with the activity and demonstrate that all risks are reduced to a level that is as low as reasonably practicable and acceptable. They incorporate the principles of ecologically sustainable development. Baseline testing and through-life monitoring regimes must be designed and approved by the regulator and, importantly, the plan must involve stakeholder engagement during the development. The approved environmental management plan becomes a public document. If it helps the committee, I am happy to table a copy of the draft regulations, as to where they are at this point.

CHAIR: Thank you.

Mr Kelly: The benefits of objective based regulations are that oil and gas companies will be held accountable for the environmental outcomes and for the compliance of their approved implementation plans. Oil and gas companies are free to choose the best methods to achieve the agreed outcomes but must provide supporting evidence to satisfy the government that the outcomes will be achieved. We believe this stimulates innovation and continuing improvement within the industry.

An example of how this may work is if applied to the protection of surface water and groundwater, which are of paramount importance to all Territorians—in fact, to all Australians. In relation to groundwater, one of the critical risks is the integrity of the well that passes through the aquifer. We require companies to demonstrate that they have designed and implemented construction, testing and monitoring techniques that will ensure aquifers are not placed at risk before any approval to construct is granted. And they will be monitored and audited to ensure that they are complying with these approved plans and stated outcomes.

Water acquisition and the current exemption for mining and petroleum activities for licence and permit obligations under the Water Act has also been raised as a concern. In November last year, the Northern Territory government announced the removal of this exemption. The Department of Land Resource Management and my department officials are currently working together on legislative amendments to give effect to that exemption.

In addition, all approved environmental plans and statements of reason will be made public, including a new level of transparency that will allow Territorians to be appropriately informed about industry activities. The government further acknowledges that there may be instances where the risk of a project may well be managed—as in: brought into as-low-as-reasonably-practicable criteria—but it is simply not acceptable for environmental, social or cultural reasons for that project to proceed in that location. This is what being ALARP-consistent and acceptable means. In this context, the regulations dovetail with both the department's land access policy and its inclusion zone policy. We have effectively ruled out exploration for onshore oil and gas in a range of areas, such as residential and rural-residential areas. This is part of the requirement for the industry to demonstrate that it has achieved a social licence to operate.

The draft regulations have been out for public consultation, and the government is now considering submissions as we finalise these regulations. We have also sought expert, independent analysis and feedback on the draft regulations. One of those experts was a Dr Tina Hunter, who is an expert in energy law and codirector of the Aberdeen University Centre for Energy Law. She has advised governments around the world about environmental protection and the oil and gas industry, and the Western Australian government engaged her as well. If I can give one comment from Dr Hunter's report, I would like to read part of her executive summary in which she says: 'These'—that is, the regulations—'are a solid regulatory tool for future petroleum activity and represent a quantum leap from the Northern Territory regulations of old. They herald in a new era of objective based regulations which have been assessed by the World Bank to be the most suitable form of regulation to foster petroleum development. In addition, these regulations are the first for onshore petroleum to implement the concepts of ecologically sustainable development.' If it aids the committee, I am happy to table a copy of Tina Hunter's report on our draft regulations.

Our road to regulatory and policy reform has involved commissioning independent and internationally recognised experts to apply their knowledge specifically to the territory context. We have investigated many peer reviewed studies into unconventional gas developments and worked with other governments to incorporate their recommendations and experiences to ensure that we design and implement the best possible regulatory regime for any unconventional oil and gas industry in the Northern Territory.

Thank you for the opportunity to outline the process that we are undertaking here and the work involved in the Northern Territory. Dr Hunter and I are very happy to answer any questions and provide further details.

CHAIR: Ms Bacon, do you have any statement you would like to make?

Dr Bacon: I have nothing to add to that.

CHAIR: Okay. Senator Ludwig, did you want to kick off proceedings?

Senator LUDWIG: Originally, Dr Allan Hawke did a report and indicated that ultimately a moratorium should not be used for the exploration of onshore and shale gas. Do you have a name you refer to it as more commonly?

Mr Kelly: No. Onshore and shale gas are how we refer to it here.

Senator LUDWIG: He ultimately also recommended that it should proceed if the regulatory regime is robust. I take it that the work that you are currently doing is to that end. I want to connect the dots there a bit better. The work you are doing about the regulatory regime—the draft regulations and the consultation that is now being proceeded with—is to the end of ensuring that, if there is going to be that type of mining, there will be a robust regulatory regime in place as Dr Allan Hawke recommended. Am I on the right track there?

Mr Kelly: Yes. That is the full intent of conducting the review and changing our environmental regulations for shale gas and onshore gas. We have a regulatory and legislative regime currently in place that has enabled us to approve and develop the gas industry in the Northern Territory to date, but it was, as said earlier, prescriptive based regulations. With modern drilling techniques, modern well completion techniques and just knowing a whole lot more about the environment and oil and gas developments, there was a realisation that we needed to move to a better, more transparent and more robust regime that could accommodate that. That is the work that is underway.

Dr Bacon: To add to that: you are absolutely right that Dr Allan Hawke's inquiry was commissioned under our Inquiries Act, so it was a very formal established inquiry. It ran almost over the whole of 2014. There were over 263 written submissions received as part of that inquiry, and Dr Hawke conducted extensive consultations with the community right across the Northern Territory. He made six recommendations, all of which government accepted. You are entirely correct that one of the recommendations was that there was no need for a moratorium around hydraulic fracturing in the Northern Territory provided there is a robust regulatory regime in place. Government, having accepted all the recommendations from Dr Hawke's inquiry, sought further advice from Dr Hawke, taking advantage of the fact that he had done such extensive consultations with the community as well as a lot of other research into international best practice around regulation for oil and gas activities. In light of that background and the work he had already done, government asked Dr Hawke to provide further recommendations to government about how we could improve our regulatory system to ensure that the way we do environmental assessment and approvals right across all industry sectors is national best practice. The government also accepted those recommendations, which was announced last year, and now there is a whole-of-government implementation effort directed at implementing those recommendations to make sure the Northern Territory's environmental regulation regime is national best practice.

Senator LUDWIG: When you say whole of government, it is not only these regulations we have been talking to Mr Kelly about; there is other work that is being done by other departments?

Dr Bacon: There are half a dozen agencies working in the environment and natural resource space that have recommendations that need to be implemented, particularly out of Dr Hawke's second review of the environmental assessment and approvals processes. There is strong coordination around that whole-of-government effort. The CEOs of the relevant agencies involved meet on a regular basis to ensure that we are proceeding with that implementation exercise in a coordinated manner.

Senator LUDWIG: Sorry for being a little bit more specific, but does that also include access to land—particularly that which is freehold or pastorally held and that which has a bundle of Indigenous rights that might be attached to it?

Mr Kelly: Yes, that does. The government has announced a number of policies with respect to land access and potential land release for oil and gas activities. Firstly, no activities for drilling or exploration activities have occurred on any land in the Northern Territory without a written land access agreement between the parties. We have recently worked with the Northern Territory Cattlemen's Association, the mining industry and the oil and gas industry to develop a process where we can help facilitate those access arrangements so that all parties can have a reasonable and a fair opportunity to put their interests forward.

In relation to Aboriginal-owned land: the legislation, the Aboriginal Land Rights Act, has certainly not been changed in any way through this process, and Aboriginal landholders—the traditional owners—still enjoy all their rights about who has access to their land. The changes that we have also implemented in our land release program for potential oil and gas activities were changed recently to what we now call an 'inclusive zone'. Historically, the Northern Territory could be best described as a blank canvas, where any company could come and apply for an exploration permit over any part of the Northern Territory. That resulted in almost 98 per cent of the Northern Territory being subject to a claim in one way or another.

The government has changed the philosophy and the policies now to go down an inclusion zone area where we essentially pre-vet areas of land. There is a process that we have implemented for that, which involves all other government agencies, to decide what areas of land would be consistent with our land release policy. That is that it is not rural residential land, highly intensive agricultural land or land of strategic importance that may, in future planning, be allocated for some other potential use, or there are cultural imperatives. We will assess that and decide what areas of land could be potentially released, so the government now proactively releases land rather than waiting for applications to come in. We are slowly going through all of the existing licence applications that are in place and adjudicating or ruling on them under those new criteria. We have actually cancelled or refused to issue a number of licences as a result of that process.

Senator LUDWIG: In my state and in other places, one of the key issues for landholders particularly is the right of access. In short, many submitters that I have heard from in both this inquiry and others do want to have some say, rather than having what was described in Queensland—which happened very early in the piece—where there were geological exploration teams that would go out, explore, demand access and claim that they had a right to access and that, if you did not give them access to the particular land, they would see you in court. That is a shorthand explanation of how it was described. It was significantly objected to by the landholders themselves who wanted to have a little bit more say. Is what you are describing a shorthand way of saying how you have been addressing this issue? It is very critical to landholders—particularly people with stock—as to how the survey teams and the mining might actually be on that land.

Mr Kelly: It was probably a more longhand version of describing that, but that is exactly the process that we are trying to put in place. Here there is a process of consultation and mutual agreement on land access processes and regimes. The laws of the country over mineral ownership and the like are not something that we can contemplate or change here. That is for another time and another place. But, from a Northern Territory perspective, what we are endeavouring to put in place is a process where the parties will come together, and if they will not come together voluntarily then we have some leverage to force companies to engage with landholders. We have changed the process of when they have to consult and the format for when that consultation takes place. We encourage any mining company or any oil and gas company to engage early and thoroughly with other interested landholders so that we do not have the animosity that has bubbled to the surface in some other areas.

Of course, the biggest leverage we would have—and both the landholders and the oil and gas companies, in this case, will attest to this—is that we do not approve any activities on a granted-lease area. We might grant the lease, but you still cannot do anything unless you get approval from the Northern Territory government, the Department of Mines and Energy. We will not approve any activities until we are satisfied that that consultation

has taken place and an access agreement has been provided to us. We have no visibility into what the terms of that access agreement might be, but it has to be shown to us that both parties have come to that agreement.

Senator LUDWIG: Ultimately, the reason for the work that you are doing—I will call it whole-of-government work—around the regulatory schema is designed to ensure that there is safe, accessible mining activity and a monitoring and regulatory regime that supports it. Is that a shorthand way of describing what you are currently doing?

Mr Kelly: Absolutely; that is what we are trying to achieve. We understand that any mining—any oil and gas activities—has an impact. Our regulatory regime is designed to assess that, to keep the impact as low as reasonably practicable and to have any monitoring and remediation proposals already preapproved in case something does go awry. That is the objective. But, importantly, built into that approvals process is significantly more transparency and stakeholder engagement that ever before. We believe that everyone has a greater level of transparency and, therefore, hopefully confidence in the processes that we are implementing.

Senator LUDWIG: You raise one issue: if there are land access agreements in place which have payments attached to them for landholders for access, will they be made public, too, as to what the payments are?

Mr Kelly: No, they will not. The government has no visibility into what is in those land access arrangements and processes. We just need to ensure that they are in place.

CHAIR: Just getting back to Dr Hawke: are you aware of any informal role that Dr Hawke had in the resource sector or in an organisation that supplies services to the resource sector?

Mr Kelly: I have read media reports that talk about Dr Hawke's past professional engagements, yes.

CHAIR: So, are you aware?

Mr Kelly: Yes.

CHAIR: You do not think that is a conflict of interest?

Mr Kelly: No, I do not. I believe that Dr Hawke dealt with that issue when it was raised with him as well as any involvement he had directly or vicariously in his previous appointments.

Dr Bacon: If I could just add that Dr Hawke is a highly respected eminent Australian with relevant expertise, most notably in relation to his work on the Commonwealth Environment Protection and Biodiversity Conservation Act. Dr Hawke has publicly demonstrated that assertions that I understand you are referring to have no basis.

CHAIR: Okay. There have been many calls for more independence from the resource sector in these matters. Do you support this?

Mr Kelly: Sorry, I am not quite sure of the—

CHAIR: Rather than having people that have had a role within the mining sector, do you think that we should have people that have had no previous connections?

Mr Kelly: We have sought and engaged people that we deem are independent from government or the resource sector; however, we still need to ensure that the people that are engaged to provide the government with advice on our approvals and regulatory process do have an in-depth knowledge of the industry and, on the other side, an in-depth knowledge of the environmental considerations. It is a balance in finding those people.

We have relied on a number of national and international academic investigations into oil and gas. Certainly the Australian Council of Learned Academies and Australia's current Chief Scientist have done some work in this space. The British academy of scientists in the UK have done some work in this space. Yale University, Stanford University and the University of Cincinnati have done longitudinal studies in this space, and we believe that their independence is established and their qualifications are certainly acceptable for us to take their recommendations forward.

CHAIR: The Hawke report calls for baseline testing. Will this be implemented?

Mr Kelly: Absolutely. It is one of the first things that we put in place with our guiding principles and with our regulatory process. Basically, the first drill that goes into the ground at any site will be a water bore, and testing will be conducted on both surface water and groundwater both on-site and surrounding any site so we can build up or add to our current knowledge database of water in the Northern Territory. We have also commissioned some joint work between Geoscience Australia, CSIRO, the Bureau of Meteorology, the Northern Territory Department of Land Resource Management and the Department of Mines and Energy to look at what knowledge and data we have on water and environmental matters in the areas where activity is taking place. Collaboratively, we will work on what we need to do to improve on that and plug any gaps that may be there.

CHAIR: Does an independent body do this?

Mr Kelly: The analysis is done by various government agencies. Most of the collection is done by our own environmental science people or companies engaged by oil and gas companies to collect samples. We crosscheck and cross-reference all of that and we believe it is building up the knowledge database that we have.

CHAIR: So the answer is no?

Mr Kelly: Independent bodies? The Northern Territory Environment Protection Authority, which is an independent entity here, has oversight of all wastewater discharge licences and the Water Act legislation. It is involved as well.

CHAIR: That is a government agency—is that right?

Mr Kelly: It is appointed by the government. It is independent, yes.

Dr Bacon: It is an independent statutory agency.

CHAIR: What about companies? Do they self-report?

Mr Kelly: Companies have to provide their water monitoring data to us, and we then compare that data with data that we currently have, or that our environmental monitoring people have collected, to ensure that we have a reliable, valuable database being built up for that baseline testing.

CHAIR: Do you think we would be better off with the government collating the data rather than the mining companies?

Mr Kelly: There is a combination of both. If the mining companies are out there spending money on doing the drilling and the like, having them collect the information that is provided to us means a greater volume of data is collected and the cost of that is not totally borne by the taxpayer.

CHAIR: Have you consulted with the landowners or the people who are going to have to live around these gas fields about the impact that this industry is going to have on them?

Mr Kelly: Absolutely. We have and continue to do so. I note that some of the witnesses who are down to provide evidence to the committee today are landholders or companies involved in that process. They may have a view on the value or the effect of that, but the Department of Mines and Energy does regularly visit community groups and landholders. To that end, I am travelling to Borroloola tomorrow to do another round of consultation on just that matter.

CHAIR: What are their major objections?

Mr Kelly: Their major concerns are certainty about water acquisition and potential water contamination, because it is very important that we have proper processes in place to protect that. Another issue is having good access arrangements so that they can coexist with mining companies and not have interference with mustering, fence lines being put up in silly places or the like. There is no one single issue that affects people, but I would rather yield to those people who are giving evidence who are directly involved to provide you that information.

CHAIR: Have you kept an eye on or looked at Queensland and New South Wales and the issues that they are facing?

Mr Kelly: Absolutely. We have looked at all of those issues. As I said, we have scouted quite widely. On the actual resource and the extraction method used there is really nothing to compare it with because it is a completely different type of resource and therefore extraction method. The similarities and things that we do keep an eye on and make sure that we put in good processes are about that landholder, mining company or gas company relationship and how that moves forward. The sort of information that stakeholders in New South Wales or Queensland—your home state—are claiming or are desirous of having, we are making sure that we capture that data so that we can provide it to people.

Senator PERIS: Mr Kelly, in your submission you talk quite a bit about the fracking process that has taken place in the Territory for decades. However, we are talking about unconventional shale gas here. On page 26 of your submission you say that the exploration of unconventional gas has occurred since 2011. Is it true that there are no commercially operating shale gas fields at the moment?

Mr Kelly: There are no commercially operating fields or wells in that more recent exploration activity that was referred to here from 2011 onwards. There are of course, though, commercially producing unconventional wells in the central Australian region of the Northern Territory. Some of them are shale, some of them are what we call 'tight gas', but they are still unconventional players in that sense. They have been using the process of fracking in those unconventional wells in Central Australia for some 30 to 40 years.

Senator PERIS: Are you able to explain, as briefly as you can, the key differences between conventional versus shale?

Mr Kelly: A conventional gas well is probably best described as a cavern or a void in the earth where gas has been released from where it was formed and captured in the earth. A drill can go down and access that gas, and it naturally flows to surface or is pumped to surface if it is a liquid. That is probably the simplest description of conventional. Unconventional covers gas deposits that could be termed 'tight gas', so it is in sandstone formations and cannot flow to surface naturally, or it could be still captured in shale rock, which is a prominent formation in the Northern Territory where oil and gas is captured in the rock but again it cannot flow or cannot be released from that sediment. That is where in the unconventional sense there needs to be some well-completion technique deployed whereby once the drill well has been drilled into that formation that something needs to happen to allow that gas to flow freely. That is the technique of fracking, which is to break apart or open up a path for that gas or oil to flow.

Senator PERIS: We have heard in a number of the submissions that shale gas fields require thousands of wells to be drilled and then fracked in order to get commercial quantities of gas. Is that correct?

Mr Kelly: That is correct. But with the introduction of modern drilling techniques, which is the horizontal drilling that we hear of now, it means that there needs to be considerably fewer wells drilled than what used to be the case when you only had vertical wells drilled. You will see examples in other parts of the world where there will be a wellhead every 300 metres, maybe even closer, and they all joined up together to access that shale gas. With the modern techniques of horizontal drilling, whereby you can drill a well down vertically into the shale and then horizontally for somewhere up to 1½ kilometres. This means that your separation between drill pads or wellheads can be upwards of three kilometres or more between wells and you can have multiple wells on a single pad. Yes, there do need to be multiple wells drilled into the deposit to free up commercial quantities of gas, but with modern drilling techniques that we are investigating here or that are under exploration here, the impact or the number of wells required is considerably less that what it was in the past.

Senator PERIS: Do you know if you have had shale gas drilling ponds overflowing already in the Territory, from the gas wells that have been drilled?

Mr Kelly: No, Senator.

Senator PERIS: Are the ponds that have been drilled lined to avoid seepage into the groundwater underneath?

Mr Kelly: In the current regime of drilling—because there have not been any wells drilled in the southern part of Australia for some time—in all the new work that is being done, any ponds that may have been or are constructed are certainly lined, but they are only temporary. With regard to the wastewater, or the processed water, that resulted from exploration wells that were drilled last year, we required that all of that processed water be captured, sealed into appropriate containers and trucked away to an approved water treatment processing facility. The reason for that is that, until we have the actual chemical constitution of that water—as it has come back out of the ground, if it has picked up any other elements—and we know exactly what that water looks like, we are unable to approve an appropriate treatment process on-place. So we take the precautionary principle in that regard, and we are not going to let it sit there in an evaporation pond, if you like, while we figure out the best way of treating it. We make sure that it is treated appropriately from the start.

Senator PERIS: Okay. Has the Department of Mines and Energy done water samples of what pollution is present in the shale gas drilling ponds across the Sturt Plateau and the Daly Waters?

Mr Kelly: We have water samples from any of those operations, but I think you would have to tell me which ponds you are looking at, because I am not aware of anything other than what may be there as temporary, protective, storage type measures. There are no long-term dams that are unlined or untested in the Northern Territory.

Senator PERIS: If the wells are not being used, are they continuously monitored or are they just abandoned?

Mr Kelly: If the wells that are not being used are in the exploration phase, then we are monitoring those wells on-site as work is occurring, and that is regularly happening. If a well is suspended while testing is being undertaken on the gas or the oil that has come out of it, or while analysing the results of the exploration, then we have to approve the method of suspending that well and ensure that that has taken place, and then the company will revisit that or come back when they continue their exploration work.

Senator PERIS: And how often is that?

Mr Kelly: Our inspection regime? It depends a bit on where that well is and what state of construction or development it is at in order to determine when we need to visit that site.

Senator PERIS: The chair asked just before about underground water quality. So you do have baseline studies prior to any exploration?

Mr Kelly: We do. I am not saying that we have long-term longitudinal studies on water monitoring of bores in the particular area where the drilling is taking place—because other landholders there have not conducted that regular testing because there probably has not been a need to—but we require that all water bores in the vicinity of a proposed well be identified and tested. For any new water bore that is put down, whether it is a monitoring bore or it is water for the people in the camp that are doing the construction, all of that information must be captured and then fed back into the Department of Mines and Energy, and then we work with the Department of Land Resource Management, Geoscience Australia and other people of interest in that space. With any testing that you do, of course, the first one is just a point-in-time test. It tells you maybe what the chemical constitution and the water level are at that time, but, until you can build up a long record, it is only a point-in-time test. So we ensure that we do that baseline testing before any activity takes place; and then, through the entire life cycle of that operation, we will require the same testing.

Senator PERIS: Are those baseline results made public before the drilling?

Mr Kelly: They will be made public. A lot of wells have not been done, to date. One of the reasons why all of that information is not currently available on our website is that we need to compile it into a format that includes the historical testing and the regime going forward, so that it actually means something. Otherwise, it is just a point-in-time test and it is not that meaningful to anybody.

Senator PERIS: The Northern Territory government, and it is publicly known, has issued extensive groundwater extraction licences from some of the territory's major aquifers. Can you explain how the gas industry's water usage is regulated and what impact current entitlements have on potential gas developments?

Mr Kelly: Currently, the oil and gas industry water extraction is regulated through departmental lines. We need to know where that water is coming from and part of our analysis on that aquafer is to what would be appropriate or sustainable yields. But, as I mentioned I my opening statement, to have accumulative impacts correctly monitored or accounted for, we are removing the exemption from the Water Act for mining and oil and gas operations so that all extractive licences for underground water will be administered through the one piece of legislation. That way, the full accumulative impacts of all water users will be better recorded.

We will have meters on bores for extraction, for commercial and oil, gas and mining operations. Understanding the draw-down from other users is a work that other departments are working through, as to how we can capture all of that and will talk to pastoralists and agriculture users.

CHAIR: What will you do if people do not want their land to be mined? What rights do landholders have in this state?

Mr Kelly: The same rights they have in any other state or territory in Australia.

CHAIR: Is that, pretty much, it?

Mr Kelly: No. If you talk absolutes, you are probably correct. But the process we are putting in place, here, is endeavouring to have coexistence between various—'competing' is, probably, not a term most people like to use—interests in that land. We are trying to implement—and I believe it is working; there is success in a number of areas of landholders and mining and oil and gas companies being able to work together for mutual benefit. I am not saying it is an easy road for all concerned, but it is the process we are embarking on to ensure that we will not approve operations until there is an access agreement in place. And we are working with the various stakeholders to develop a way to facilitate those agreements to resolve issues that people have.

CHAIR: So if I am a landholder and I say, 'No,' what is the process?

Mr Kelly: Essentially, the process is there will be an opportunity for consultation between all parties and, hopefully, they can resolve those differences. In the Northern Territory we have found that to be the case in most cases—in fact, in all cases to date. If either party in that discussion cannot reach agreement or will not reach agreement, for whatever reason—maybe unrealistic demands on either side—the process is that we form, here, in the Northern Territory, a mediation or arbitration panel. That involves representatives of government agents, at CEO level, and representatives from the different interests—whether it be the mining companies or peak body, or the cattlemen's association or peak body, or delegates they have agreed to—to form that arbitration panel. The quorum is four people and must be equal representation between industry and government, so it is not stacked one way or the other.

Hopefully, that group can work through each person's issues or grievances and find a way forward. There are always, of course, natural justice processes and people's rights to seek a legal outcome going through the courts. As we all know, the issues of Australia's land rights—

CHAIR: So I would be right in saying the landholder does not have any rights to refuse mining companies, and the arbitration is only going to try to nut out some sort of compensation for the landowner. If the landowner does not want mining companies to come on to their property and mine their property, they just do not have any rights to say no.

Mr Kelly: They have a right to contest that and—

CHAIR: [inaudible] they do that?

Mr Kelly: No, Senator. It is the same right across Australia.

CHAIR: Thank you very much. We have run out of time. Thanks, guys, for coming along.

Senator LUDWIG: If there are other matters that you would like to raise, you are welcome to provide a further submission to the committee.

Senator WATERS: Can you both hear me?

CHAIR: Yes.

Senator WATERS: I was hoping to ask a couple of questions of the witnesses.

CHAIR: We have run out of time, sorry, Senator.

Senator WATERS: I am here to give quorum to this committee, so I would like to ask some questions. I will not be very long.

CHAIR: I am sorry, we have run out of time, Senator Waters.

Senator WATERS: Do you need me on the call or not, Chair? My understanding is that if I am not participating quorum cannot proceed.

CHAIR: You can certainly participate all day, if you like, but we have run out of time. We are 20 minutes over time.

Senator WATERS: Thanks very much.

CHAIR: Senator Waters, we were led to believe that you were busy, but I am happy for you to start the next line of questioning. That is fine.

Senator WATERS: Great. Sorry. I misunderstood. I thought you dismissed the current witnesses. Do we still have Mr Kelly and Dr Bacon there?

CHAIR: No, we do not. Sorry, Senator. If you would like to put questions on notice, we are happy for you to do that. We are way behind. We are nearly half an hour behind now.

BICKNELL, Mr Gregory, Chief Executive Officer, Chamber of Commerce and Industry, Northern Territory

[08:52]

CHAIR: Welcome. Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. I now invite you to make a short opening statement and then, after you have spoken, I will invite members of the committee to put questions to you.

Mr Bicknell: I shall be brief to help you catch up on a bit of time.

CHAIR: That would be helpful, Mr Bicknell.

Mr Bicknell: No problem. I am here on behalf of the members of our organisation, which number 1,250. We are a chamber of commerce and part of the international chambers of commerce around the world. We are slightly different here. Our membership is spread right across the Northern Territory. Our members are mainly here in the Top End, but 30 per cent of our membership is from the regional areas of the Northern Territory. We have no great scientific expertise. Our concerns around the unconventional shale gas issue is related to economics and the importance of the industry to the economy of the Northern Territory going forward over the next 20 years. Also, for the top of Australia, we have been very strong proponents of the northern Australia development plan. We see some key issues around economic development for northern Australia over the next few decades unless this industry goes ahead. That is a view that is supported by our members. Like most residents of the Northern Territory, they have some concerns, but those concerns can be met through a regulatory process, which I believe took a little bit of extra time to talk about earlier.

We regularly survey our members across the Northern Territory. Our most recent survey on the unconventional gas issue showed that the majority of businesses in the Northern Territory were in support of that. Most of our members are small to micro businesses; they are not the big end of town. We do not have a big end of town really in the Northern Territory. The majority of businesses, some 96 per cent of businesses in the Northern Territory, employ less than 20 people, so small businesses are very close to what is happening in their neighbourhoods. They can see that the economy of regional Northern Territory is often reliant on either government spending or the mining industry, and we have seen a downturn in both of those over the last couple of years. The mining sector is nowhere near as strong with commodity prices, and we are also seeing that some major government programs have come to an end in some of the regional areas, so that is having some real economic impacts.

The bright light on the horizon for those small businesses was exploration and development of the onshore gas industry. They are very keen to see that industry proceed but with the proper regulations surrounding it, particularly in terms of land access and water security. They are the two key issues that are raised by the business community, as they are by the wider community. But our members are satisfied that there is due process being undertaken by the Northern Territory government that will set a regulatory framework in place that will address the issues from the business community.

In terms of the economics of the Northern Territory, we have been reliant on the resource sector for many years. We are seeing a change in the dynamics and we really need to move with the times and make sure that, if these sorts of developments are taking place, we have the regulatory framework in place. The economy in the Northern Territory has always borne the brunt of issues surrounding the tyranny of distance. The cost of supply of raw materials and the cost of energy are all things that make it very difficult for businesses to operate here. We need the economies of scale to be able to continue economic development in the north and prevent some of the population drain that we are seeing, affecting the whole of the Northern Territory economy. That has been fairly constant over the last few years. We are seeing a range of people coming into the Northern Territory for short-term economic opportunities and not settling long term. For any economy to remain strong it needs a good strong population base.

We certainly welcome the estimates on the impacts of this industry in terms of 4,000 to 6,000 jobs. It will have some major impacts on the gross state product for the Northern Territory and also lessen our reliance on Canberra for funding, with the royalties from this industry coming direct to the Northern Territory government, rather than to the Commonwealth government, as the offshore gas royalties do. That is something that any jurisdiction should be looking at—achieving a better degree of self-sufficiency and having some control over that ourselves rather than relying on the machinations of Canberra.

I will leave it at that, at this stage. We are a bit unfortunate in that LNG18, the major LNG conference, is on in Perth today and tomorrow, so a couple of people who would have been here with me are not.

CHAIR: Thank you, Mr Bicknell.

Senator WATERS: Thanks very much for your time. You mentioned that you conducted a survey and you found a majority of businesses were in support of unconventional gas and the fracking that goes along with it. I am wondering what sort of investigation you have done into, say, the experience in Queensland—whether you have spoken with your counterparts about the real, on-ground impacts of what this industry has done to small business, to communities and to other industries.

Mr Bicknell: I have spoken to Queenslanders—nothing formal. The structure of the chambers of commerce is slightly different in other parts of the country, so the chambers in Queensland generally look after companies in Brisbane rather than in the regional areas. We are part of the northern alliance with Advance Cairns, Broome Future and the Karratha chamber. Anecdotally, they are quite supportive, but we have not done any sort of rigorous study around it.

Senator WATERS: Obviously there is not that much unconventional gas in the north, so I am not aware that Advance Cairns has any actual experience with the industry. What sort of information base did you provide to your members, or, indeed, what have you looked at yourselves in the course of conducting that survey?

Mr Bicknell: We have referred our members to—we have used the Hawke report as a basis for people to have a look at in terms of background. As you say, things are a bit different around the country. That was something done specifically for the Northern Territory, and from our perspective it offered a reasonably diverse report on what was happening and what the situation is in the Northern Territory.

Senator WATERS: I am not familiar with that report myself—I am a Queensland senator—so I will have a look at that in due course. I am just reflecting on the experience in Queensland. There was obviously an awful lot of promise about local jobs. That, in our experience, did not eventuate. Many of the jobs were fly-in fly-out or drive-in drive-out, and many local businesses and certainly the community members in those smaller towns then found that they were not able to attract workers or keep workers in those smaller businesses. I am just wondering: were the respondents to your survey able to say why they were in support of this industry? What do they actually think is going to be good for them?

Mr Bicknell: They were able to add some commentary to their responses. It is quite early at this stage. It has been mainly people's experience with opportunities out of the exploration phase. In some smaller centres such as Katherine, which is quite a small town in the bigger scheme of things, there have been some very good economic opportunities out of that exploration phase, which have been very noticeable. But even those businesses have welcomed the fact that that has occurred some distance from Katherine.

Senator WATERS: I am interested, if you can outline what those economic opportunities were in the exploration phase for those folk at Katherine.

Mr Bicknell: They were things like supplying transportable buildings, supplying food and supplies to the camp, doing repairs on equipment that they are using, some fabrication work on various parts of the exploration camps, some assistance and some opportunities for bores—just the general sorts of opportunities. I believe there were some labour supply opportunities. That is probably about all I can recall at the moment.

Senator WATERS: Thanks for that. Mr Bicknell, do you have any tourism representatives that are members of your chamber?

Mr Bicknell: We have some. There are not a huge number of tourism operators who are members of the chamber. There are a couple of other tourism associations that operate, one in the Top End, one in Katherine and one in Central Australia, and they generally join those associations.

Senator WATERS: We might have some questions for them at a later date. I am just interested in the potential conflict between the two industries, which is of course what we have experienced in Queensland.

I have one final question, Mr Bicknell, and probably the department would know more about this but please share your knowledge if you have some. I recall reading some coverage—it must be a year ago now—about proposed fracking near or even under Uluru. Are you across that at all? Can you shed any light on that?

Mr Bicknell: No.

Senator WATERS: Unfortunately, it seems that I will have to put some questions on notice for the department to get to the bottom of that one. Thank you for your time, Mr Bicknell. There are no further questions from me.

Senator LUDWIG: The only question that I have is: in terms of your membership, does that include most of the oil and gas companies that exist in Northern Territory? Are there some that are not members of your association?

Mr Bicknell: There are some that are not.

Senator LUDWIG: Who are they? Are they large or small? In short, are the big companies members of your chamber?

Mr Bicknell: Those that are currently producing are members. Those in the exploration phase do not tend to be.

Senator LUDWIG: So, as a general rule, the smaller exploratory companies are not members?

Mr Bicknell: Yes. It is not a size related issue; it is more about what stage of development they are at. If they have permanent operational staff they tend to be members of the chamber. In the exploration phase they do not.

Senator LUDWIG: Of the larger ones, what companies are members?

Mr Bicknell: I do not think that I am in a position to give you their names, but it is pretty easy to guess from what I have just told you.

Senator LUDWIG: I am entitled to ask, but you do not have to answer if you do not wish to. Do they pay according to their size? In other words, how are your membership fees structured?

Mr Bicknell: It is based on the number of employees. They are certainly not our top-paying members.

Senator LUDWIG: We do not know who 'they' are yet anyway. Thank you.

Senator PERIS: I have a couple of questions. Mr Bicknell, you were saying in your presentation that members of the Katherine region were potentially for this. Recently there was an article where Willem Westra van Holthe publically came out and denounced his support for onshore fracking and said 'not on his watch or anyone's watch'. He is the member for Katherine. He is totally against it and his constituents are against it. What do you say to that?

Mr Bicknell: He is not a member of the Chamber of Commerce. I read what is in the media as well as anyone. People have responded to a survey to our membership—it was not to a wider audience. As with any of our surveys, we get a diverse range of opinions. There are members right across the Territory who are not supportive of it, but the majority of them were. That is what I am commenting on.

Senator PERIS: Did you say to Senator Ludwig how many members you have?

Mr Bicknell: We have 1,250.

Senator PERIS: And you said 30 per cent of those are regional.

Mr Bicknell: Yes.

Senator PERIS: Is that below the Berrimah line regional or is it just—

Mr Bicknell: It is outside of the Top End—basically Katherine and Alice Springs.

Senator PERIS: Are you able to take on notice, if it is publically available, whether your members are business owners and whether the Chamber of Commerce is representative of the agricultural or the farming industry?

Mr Bicknell: Our constitution requires that a business be operating in the Northern Territory to be a member. It is broad. We do not cover the pastoral sector very much and we do not cover the tourism sector very much. Retail, manufacturing and international traders are all members. We have members basically right across the spectrum but no real core group where you could say that one group is better represented than any others amongst our membership.

Senator PERIS: Would it be fair to say that it is not just public perception or commentary; that mining can provide a false economy?

Mr Bicknell: This is only a belief rather than something I have actually proven, but it is more the cyclical trends in the industry that tend to be more of a worry to members than perhaps a false economy.

Senator PERIS: I guess FIFOs or people coming in to work on that are bumping up the economy and then leaving and deflating it.

Mr Bicknell: FIFO is a problem right across northern Australia. You are damned if you do and you are damned if you don't. If you don't use FIFOs on a project such as Blaydin Point here, at the end of the project you suddenly have a really severe impact on the local economy. So I think there needs to be a mixture of both.

Senator PERIS: Being a Territorian myself, born here, would it be fair to say that the Northern Territory offers more than the minerals sector? When you look at our fishing, our tourism and the agriculture, there is so much potential beyond the mining sector.

Mr Bicknell: Yes, it has always been a place that offers a lot of potential. It is bringing that potential to reality that has remained a little bit of an issue for a long time, and often for the reasons that I mentioned before. The cost

of transportation and the cost of energy are things that make running a business here fairly difficult. Everyone talks about international competitiveness now, but the cost of getting a container from here to Singapore is three times the cost of one from Sydney. We just do not have the economies of scale. There are barriers to operating businesses here, and we do not have the population to sustain a wide range of businesses within the Northern Territory either.

CHAIR: Thank you, Mr Bicknell, for your time.

DALTON, Mr Robert, Policy and Research Officer, Northern Land Council

MORRISON, Mr Joe, Chief Executive Officer, Northern Land Council

[9:18]

Evidence was taken via teleconference—

CHAIR: Welcome. Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. I now invite you to make a short opening statement. Then, after you have spoken, I will invite the members of the committee to put questions to you. Do either of you have an opening statement?

Mr Morrison: Yes, I have one. Thank you for the opportunity today to provide the Northern Land Council's perspective on unconventional gas extraction. Under the authority of the Aboriginal Land Rights (Northern Territory) Act 1976 and the Native Title Act 1996, the Northern Land Council has statutory responsibility for half of the land mass of the Northern Territory, including 87 per cent of the Northern Territory coastline held by traditional Aboriginal owners.

Between 2012 and 2015, the Northern Land Council negotiated 30 exploration agreements between traditional Aboriginal owners and oil and gas proponents. One of the key tenants of the negotiation process is to ensure that traditional Aboriginal owners affected by oil and gas exploration are fully informed prior to making a decision. We know this process as the principle of free, prior and informed consent and it is the basis for much of our work at the Northern Land Council.

The Northern Land Council's expertise in the consultation process in understanding of the science of hydraulic fracturing and its potential for impacts on the physical, social and cultural environment has proven invaluable in making sure that this principle is upheld. We are always seeking new information to avail traditional owners and the broader Aboriginal community of any new knowledge and technology to that end. To reiterate: it is vital that Aboriginal people in the Northern Land Council region are properly informed when making decisions about onshore petroleum exploration and development proposals.

I now seek leave to table the following document: the Northern Land Council submission to this inquiry. In summary, the submission makes the following key points. Regulatory mechanisms at a national or state level must not impinge on Aboriginal people's right to make decisions about their land with free, prior and informed consent. Such mechanisms must at all times be evidence based and oriented towards best practice examples derived from domestic and overseas modelling. Innovation and technological advancement and refinement should be encouraged as a means of minimising environmental impacts of extraction. On the basis of any potential environmental impact, a robust and comprehensive environmental bond should be applied to any and all unconventional gas mining practices on a similar basis to the Northern Territory's legacy mine management policy, and it should be transparent to the broader community of the Northern Territory as well. All regulatory and policy frameworks should be open and accountable to the public for information accessibility, including internet notification and publishing of monitoring data. A national regulatory and compliance regime for unconventional extraction should set minimum industry standards but also be flexible enough to match local conditions. Finally, a national approach should provide the requisite level of oversight to achieve balance between sustainability and economic returns.

The last comment I really want to make today in my opening statement is in relation to the need for a national level policy debate that concerns Aboriginal people, their land and their future to be intrinsically refocused around seeking the views of Aboriginal people in the decisions. As I alluded to earlier, Aboriginal people in the Northern Territory own half the land mass and have rights and interests in the remainder and are also a significant portion of the population and should be taken seriously when it comes to regulations and environmental and other approvals associated with oil and gas extraction.

CHAIR: Thank you, Mr Morrison. Mr Dalton, do you have anything to add?

Mr Dalton: No, nothing further.

Senator PERIS: My opening question is to either Mr Morrison or Mr Dalton. Mr Morrison, you said in your opening statement that, between 2012 and 2015 the Northern Land Council has negotiated 30 exploration agreements between traditional owners and their oil and gas proponents. That opening statement alone suggests that Aboriginal people are not against development and the oil and gas industry. Would you say that is a fair call?

Mr Morrison: Obviously it is a complex matter. I think it is foolish to suggest that all Aboriginal people have a particular view in relation to any particular activity on their land. However, through the land council's processes, Aboriginal people consider many third-party proposals on Aboriginal land, and oil and gas is obviously one of those. As I have alluded to, there are a number of third parties interested in activity on Aboriginal land and also

lands where native title exists. So it is fair to say that Aboriginal people are open to the idea of discussing oil and gas.

Senator PERIS: I know you speak quite a bit about the principle of free, prior and informed consent, but there have been media reports of some traditional owner groups around the Mataranka and Roper River areas being concerned that they were not consulted widely in relation to a shale gas exploration licence being granted. Is that your understanding? Could you elaborate more on that?

Mr Morrison: I understand that there is a view out there in the community held by some people who purport to speak on behalf of traditional owners. However, we have had many extensive consultations that led to the two permits being issued. Obviously there is a level of complexity in the fact that not all of those permits are on Aboriginal land. Some of them are also on native title land. So there is, I think, an outside level of confusion in relation to consent provisions, as they do not necessarily apply under the Native Title Act as they do under the Land Rights Act. But I am fully confident that the NLC has consulted widely and talked to the traditional owners and the traditional owners group have given consent for those permits.

Senator PERIS: Mr Morrison, are there any current legal options available to the Northern Land Council to request a gas drilling company that allows for the consultation?

Mr Morrison: I am not exactly sure of your question. Can you elaborate on that further?

Senator PERIS: We have heard earlier from the chair that Aboriginal landowners do not always feel they have the right to say 'no'. Are there any legal options open to the Northern Land Council to say 'no' to further exploration?

Mr Morrison: Obviously, there is a process through the Native Title Act involving the Native Title Tribunal through mediation. That does not necessarily say that people have the power to refuse consent; it is just a mediation mechanism that is available to people. However, I have no cause for concern that that should have been taken into consideration in the work that the land council has done so far. The Northern Land Council has called for greater improvements in the Northern Territory regulatory framework and that was put forward in our submission here and in our previous submission to the Northern Territory government's Hall inquiry about the importance of the regulatory framework and about the importance of communication with people who speak English as a second or third language.

Senator PERIS: You have mentioned Aboriginal people who speak two or three languages. Are interpreters always available in consultations?

Mr Morrison: Where interpreters are required, interpreters are provided.

Senator WATERS: You said that you have concluded 30 agreements. Are your clients, the so-called traditional owners, able to refuse to enter into those agreements, if that is their wish?

Mr Morrison: As I alluded to previously, if it is on land that is subject to the Aboriginal Land Rights Act, there is a provision in that that allows people to refuse consent and therefore the tenement goes into moratorium for a five-year period. If it is native title land, there is process of mediation that obviously involves the Native Title Tribunal.

Senator WATERS: My understanding is that under the Native Title Act there is no right to say 'no'. Is that correct?

Mr Morrison: That is right. There is a right to negotiate but, if people want to refuse a development, then there is a long and protracted process of going through that refusal and that involves the tribunal.

Senator WATERS: Can you just elaborate on the provisions of the Aboriginal Land Rights Act and the moratorium? I am not across that and I would like a little more detail on that.

Mr Morrison: I might just refer that to my colleague, Mr Dalton, in the Darwin office. He has some of those provisions; I do not have them in front of me unfortunately.

Senator WATERS: I do not need section numbers, but just the effect of those laws in relation to people's rights to say yea or nay.

Mr Dalton: To cut a bit of a long and complicated story short about how we consult, traditional owners do have the right to provide direction to us not to enter into an agreement. That will place the application for exploration into moratorium, as Mr Morrison suggested. That moratorium period lasts for about five years, upon which it is open for applications to explore once again. What is critical to understand in terms of the exploration application is that, it is implicit that if a traditional owner group on Aboriginal land agrees to that exploration, then they implicitly provide consent for actual extraction activity to occur as well.

Senator WATERS: Is that taken to mean 'yes' for all time?

Mr Dalton: For the length of the agreement in question.

Senator WATERS: Has that moratorium for exploration for five years been used at all?

Mr Dalton: It is often the case where traditional owners do not agree to a particular exploration proposal. There is an important piece of context that should be offered up as well: traditional owner groups on Aboriginal land are also able to make decisions about what is called 'areas of nonconsent'. That means traditional owners are able to agree to any and all parts of an area that an exploration company puts forward. In some of the exploration permits granted—this information is commercial-in-confidence but if ever you were to see the map—you will see large swathes have been removed from exploration activity. In some instances that might be on account of sacred site matters. It also could be due to local pressures that may not necessarily be obvious. But traditional owners do have the right, even when they agree to exploration, about where that should occur.

Senator WATERS: Are there any instances where your Territory government has not respected that moratorium?

Mr Dalton: The provisions around making decisions about activity on Aboriginal land fall under the Aboriginal Land Rights Act, which is Commonwealth legislation. Given that it is federal legislation, the Northern Territory government cannot get involved in the five-year moratorium process that arises from traditional owners' decisions.

Senator WATERS: Has the federal government ever reneged on that five-year moratorium?

Mr Dalton: Not to the best of my knowledge. My understanding is that that would require amendment of the Aboriginal Land Rights Act, which is a pretty rare occurrence.

Senator WATERS: How many times has that moratorium provision being used?

Mr Dalton: That would be a reasonably substantial number. I would probably have to take that on notice.

Senator WATERS: Yes, I am interested in that, because one of the reasons I am concerned about this industry is that it is not respectful of landholders' wishes. Having looked around the country there are very few land tenures where landholders can actually refuse. So it is very interesting that there is at least an ability for a moratorium on particular Aboriginal land. That gives me some encouragement.

Have you had any involvement in the private member's bill that I put forward to the federal parliament to expand on that and to give all landholders the right to actually refuse—to say no, rather than just having a moratorium? Is either of you aware of that bill?

Mr Morrison: No, I am not.

Mr Dalton: Not from my end.

Senator WATERS: I will send you a copy and seek your input into it. I recall a media article from about a year or so ago that speculated on fracking being proposed in or near or under Uluru. Are you aware of that? Can you tell me anything about that situation?

Mr Morrison: I am aware of it, but I think you might be referring to another area called Kings Canyon, which is in Central Australia—I am not sure if it is Uluru. But even if it is Uluru it is a different land council. That is the jurisdiction of the Central Land Council.

Senator WATERS: So there is nothing as pertains to Uluru that you are aware of?

Mr Morrison: Not that I am aware of.

Senator WATERS: Can you tell me about the Kings Canyon situation to the best your ability, noting that it is not in your area?

Mr Morrison: I just understand that there have been some views expressed by some Aboriginal people and some external proponents, or interested parties, in relation to petroleum activities within that area, but I am not sure of the exact outcomes. I would be reluctant to express that any further.

Senator WATERS: Perhaps Chair and Secretary we can pop some questions on notice to the Central Land Council. They are not a witness and I am not sure if they have made a submission, but it would be good to get some more information about that.

Senator LUDWIG: Welcome to the committee. I am pleased to have both of you as witnesses. I am looking at a submission from the Northern Land Council pertaining to the inquiry of the Senate Select Committee on Unconventional Gas Mining, in April 2016—I know, Mr Morrison, that you cannot see what I am looking at. Regarding the key messages ultimately that you provide as part of the executive summary, are those the

conditions upon which you agree or do not agree that unconventional gas mining should be proceeded with in the Northern Territory?

Mr Morrison: Yes. Those key messages—I think there are seven key messages—relating to a range of matters associated with requirements of tighter regulatory frameworks, bonds and those sorts of things should be taken as, I guess, recommendations from the Northern Land Council's submission.

Senator LUDWIG: Ultimately, from the work that the Territory government has done, including the work of the chamber and the various mining companies or extractive industries, are you confident that those key points will be met?

Mr Morrison: I don't think at this point in time that all of those are being met. I think there is still some way to go. One of the matters that I raised earlier, albeit briefly, is the interaction between state and federal legislation. I think that that could in fact be further work to ensure that perhaps the federal government could set some minimum standards for state based regulatory frameworks and legislation to meet. Obviously, in the Northern Territory there is considerable concern in relation to the interaction with ground and surface water. Some of those areas remain grey and require additional work.

Senator LUDWIG: Mr Dalton, did you want to add to that answer?

Mr Dalton: Getting back to the first point you made there, which is that, were certain conditions that we outlined in our submission to be met, the land council would support this industry to be enabled to proceed—that there is a certain national perspective that the government takes. The NLC is not a regulatory body. We do not have any power us. We have statutory functions under the land rights act. We have not had a role in terms of native title legislation. It is not necessarily our job to support or not support a particular industry. We simply facilitate decision making by traditional owners about any proposal that comes forward for Aboriginal lands. On that basis, we obviously have a duty of care to our clients to make sure that they understand the decision they are making and that the implications of the decision are clear. But it would not be quite correct to suggest that there is a threshold by which we would or would not support an industry.

Senator LUDWIG: To put it another way, you are not opposed to it if it meets those conditions for your members?

Mr Dalton: I would still say that it would not be a matter of us opposing it or not. What we do is facilitate whether or not traditional owners are disposed to it, or otherwise.

Senator LUDWIG: Are you satisfied that the work to date has facilitated the traditional owners' interaction with the industry?

Mr Dalton: We put exploration applications to traditional owners on the regulatory environment in place at the time.

Senator LUDWIG: Has that been successful to date?

Mr Dalton: Two exploration permits have been granted towards unconventional extraction of gas.

Senator LUDWIG: How have you found that experience? Has it been an easy experience dealing with both the regulatory regime and the companies involved, and ultimately reaching agreement? Or, have you found it—these are my words—difficult, protracted and troublesome?

Mr Dalton: It is a reasonably contentious environment, from my perspective—and I am not sure if my chief executive would agree. But as a new and emerging industry in our region, in terms of the actual horizontal fracking, it is not necessarily something that people have a lot of exposure to. The fact is that there is a range of public views about the merits or otherwise of the science, which is difficult for us because we have a job to do in which we have to understand the science but not necessarily make a decision about whether or not it is supported.

CHAIR: Are there independent scientists whom you negotiate with or use?

Mr Dalton: We draw fairly extensively from academic sources. We maintain a pretty well qualified regime of internal staff, as well, in terms of interpreting the environment.

CHAIR: That is all we have time for today, I am sorry. Thank you very much for your time.

HARRIS, Mr Ian Mervyn, Director, Environment Centre NT

HOGAN, Ms Naomi, Coordinator, Lock the Gate Alliance Northern Territory

MORRIS, Mr David, Principal Lawyer, Environmental Defenders Office NT

ROTH, Ms Charmaine, Vice-Chairperson, Don't Frack Katherine

TAPP, Mr Daniel, Private capacity

[09:41]

CHAIR: Welcome. Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. I invite you to make a short opening statement, after which I will invite members of the committee to put questions to you.

Ms Hogan: The Lock the Gate Alliance in the Northern Territory has made a clear submission in regard to some of the regulatory reforms that we feel would be improved upon if the federal government were to assist the state and territory governments in protecting land and water resources. We have also attached many peer reviewed scientific articles pertaining to the water contamination issues that have been measured by the industry and governments around the world, particularly in the United States, where shale gas fracking in particular has taken place.

I wanted to make some short statements that are not in the submission in order to help with any questions that might come forward. One is in relation to the way in which the industry promotes the need for onshore gas in order to facilitate gas to the eastern states of Australia, in particular in New South Wales. Something that has happened since we made our submission is that the *Gas statement of opportunities* has been released by the Australian Energy Market Operator, AEMO. I have copies here of a page from their recent report. It states:

Despite the projected rising demand and limited local production, no supply shortfalls are forecast for New South Wales under the medium scenario.

AEMO's medium scenario does not include gas from the Northern Territory. They are saying there that we do not need any onshore gas development of shale in order to meet the demands for New South Wales. I wanted to put that out, and we can discuss that later if you wish.

The other point I wanted to raise that has also come up recently is that, in just the last few weeks, we have seen a new peer reviewed report come out of Stanford University. I have the abstract of that here for you as well. Basically, it shows that there is a clear link between the fracturing fluids and the process of fracturing for shale that has led to contamination of underground drinking water resources. That is in stark contrast to a press release put out last month by APPEA, the gas industry body, which states clearly on 11 March 2016:

But the reality is there have been no proven cases of groundwater contamination directly linked to hydraulic fracturing anywhere.

I bring that up because it is a concern to community members and advocacy groups on their behalf when the government is listening to APPEA, the oil and gas industry, and relying on them for factual information when in fact they are making comments that have been found to be untrue. I will leave it there for now. I am happy to answer any questions.

CHAIR: Thank you, Ms Hogan. Mr Harris.

Mr Harris: Senators, I come here today as somebody who has worked in the oil and gas industry. I have worked in Canada, the North Sea, Norway and shortly Australia. Some of the concerns that I have, and thus the centre has, are at what the scale of this industry will be, if it gets a head. Currently, I liken it to a bull at the gate. The bull can kick the gate open or we can lead it through. We can put a halter on it and lead it through. At present, the regulatory system in the Northern Territory is way too inferior to look after this type and scale of activity. I do not think a lot of our government people understand the scale of the operations involved if large fields of gas are discovered. I will leave it at that, and we can move on to questions.

CHAIR: Thank you, Mr Harris. Mr Tapp, just give us a brief outline of the experiences you are having as a pastoralist.

Mr Tapp: My first concern, obviously, and major concern is water security. As we all know, every industry relies heavily on water. My experience makes me very doubtful of the shale gas industry. For instance, I had a government geologist come down to my property a few years ago. He was studying old rocks for the government. I just happened to ask him what his thoughts were on fracking, and he said to me: 'You won't have to worry about it here. The landscape is too fragile and it would be very, very risky for fracking as there are too many fault lines

in the area.' A couple of weeks after that I went to a meeting in Katherine held at the Cinema Cafe, and lo and behold I find that I am in the middle of one of the hot spots. I have just had a geologist tell me that it is too risky to be fracking in this area.

I am just basically very concerned about water issues and regulatory issues. Just going on what I have witnessed of people living in the industry—living in the gas fields, if you want to call them that—down south and overseas is that no-one is happy about it. If it is safe and there is money to be made, why are these people not happy? Why have they got serious water problems?

CHAIR: Thank you, Mr Tapp. Why would you support a moratorium? Anyone?

Mr Morris: I am happy to kick off. All of the scientific reports, which are referred to by the Northern Territory government and various other state and territory governments around Australia, have said that this industry is only safe if there is a robust regulatory regime in place, and we are not there yet. There has been a lot of talk by the Northern Territory department and there has been some action, but we are not there yet. The Hawke report came out, I think, in late 2014 and since then there has not been a single piece of regulatory reform in this area in the Territory. There have been guiding principles. There have been some draft regulations, but that is very different, vastly different, to actual legislative reform in this area. I do support a moratorium and I support it because of the very facts that these reports have come to find, which is that you must have a robust regulatory regime, and we are not there yet.

The other thing that I have significant concerns about is the capacity of the regulator in an environment where what we continue to have is a huge amount of onus placed on the operator doing the right thing. I am not sure that history tells us that we should have a great deal of confidence in oil and gas operators doing the right thing, unless they are required to, or they see an incentive in doing so.

CHAIR: The Hawke report comments on baseline testing. Why do you consider this the best practice?

Mr Morris: I have a list of litigation cases in America if anyone wants to see them. The Columbia Law School did a digest of hydraulic fracturing cases. There is a huge amount of litigation in this area. And we know that one of the big issues with litigation in this area is establishing the cause of contamination. If you do not have proper and transparent baseline data, it is very difficult to later hold someone to account for the damage they have done. One way of addressing that through legislation in some parts of the world has been to simply say that, if there is water contamination in an area, it is assumed it is the gas operator who has caused it—and the onus is shifted on to them to prove that they did not cause the contamination. That is one way of dealing with it. And if it is as safe as the industry says it is, I would assume they would welcome that kind of reverse onus provision in our legislation.

CHAIR: What do you think could be achieved if we had third-party appeal rights implemented in relation to permits or licences granted?

Mr Morris: Third party appeal rights do an enormous amount for the integrity of process. A merits appeal allows a community group to assess whether a decision made by a minister is good or bad. All of us who have spent much time in the Territory have probably come across decisions made by ministers that may be lawful but we do not think they are good decisions; they do not really stack up. I believe that having third party review rights creates an extra layer of rigour in the process. It provides better decision making and it provides more community support for the decisions that are ultimately made; they have a greater level of confidence in those decisions.

CHAIR: You say you do not want in the Northern Territory evaporation pits such as those in New South Wales. Do you want to elaborate on that.

Ms Hogan: We have major concerns that there is currently no prescribed minimum standard on what we would need from ponds. The areas that have been identified as the hot spots for shale gas in the Territory are subject to seasonal variation; there is a wet season and a dry season. It should be remembered that a commercial gas field requires thousands of wells; in fact, there will be tens of thousands of wells if we see shale gas like they are talking about and the volumes we have seen in the United States. That means thousands of ponds. The issue with these waste ponds, through the scientific literature, is that they are one of the leading causes of contamination to surface water, to underground water—these ponds leak into underground aquifers—and also to soil and land, which can be devastated when these ponds overflow and pollute neighbouring areas. We have seen that in Australia already and it is well documented in the United States. If we had those ponds here, they would be overflowing in the wet season. The cumulative impact of thousands of ponds across the landscape could have a huge impact on areas that are reliant on tourism, fishing and good, clean cattle country. That is a concern to many of the community members we work with here in the Territory.

CHAIR: The EDO Queensland, in its submission, talked about projected royalties of $411 million in Queensland in the 2015-16 budget papers and then revealed the almost $7 billion in subsidies to industry from 2007 to 2012 had a further $25.5 billion for rail, port and water infrastructure. Are you aware of whether subsidies exceed the projected royalties for the government in Queensland over the same period of time? What is your opinion of the government's policy to subsidise the industry beyond the expected royalties and are you concerned about the same thing in the NT?

Mr Morris: Sorry, but I do not have the answer to your question. I am concerned about the inadequacy of security bonds and environmental bonds that apply to oil and gas activities in the Northern Territory. As to the economics of the industry as a whole, and the subsidies provided by government, it is not within my area of expertise to add to that.

CHAIR: Senator Waters, do you have some questions?

Senator WATERS: Forgive me, I am just trying to bring up the submission. Is there something that I am missing? Do we have any submissions made by these witnesses?

CHAIR: I do not think so.

Senator WATERS: Can I get clarification on that?

Mr Morris: If it assists, I can indicate that the EDO of the Northern Territory did not provide a submission to this inquiry, but I believe that the EDOs of Australia did. I could be wrong about that. It was guided by the EDO New South Wales policy team.

Senator WATERS: Okay, great. I did not think I had seen one, but then I thought I heard a reference to a submission. Anyway, I will push on. Thank you for your outline. Firstly to you, Mr Morris. You mentioned that you do not think that there is a robust regulatory regime, and then I think it was Ms Hogan who went into the inadequacy of the evaporation ponds and the lack of standards for them. Given we do not have the benefit of a written submission from you, could you just outline for us here what the deficiencies in the regulatory system are, which fail to ensure that environmental and community rights can be protected?

Mr Morris: I will certainly try, although I am not sure we are going to have sufficient time for me to go into great detail about all of the deficiencies of the current regulatory regime. I suppose the first thing that is critical to note at the outset is that the Petroleum Act, which is the governing legislation, places economic interests—and I should say short-term economic interests, I believe—above environmental protection. There is no legislated objective under the Petroleum Act that these operations be undertaken with ESD or ecological sustainable development principles at their core. If you drill further down into the legislation, there are no environmental protection regulations in existence at the moment. We have draft discussion environmental regulations which are out for public comment at the moment. As I said before, I do not think they are there yet in terms of enshrining and embedding ESD principles into the regime.

As I understand it, at the moment there is also an approach by the government to basically set out the means, which is to have only gas operations with acceptable environmental impacts, but they are going to leave it to operators to work out what the means are to justify those ends—namely acceptable environmental impacts. I do not believe that that is an appropriate way to deal with this particular industry and we do need to set minimum standards. Those minimum standards would go to things like how pits are to be appropriately lined and the minimum requirements for well integrity—particularly testing or ongoing monitoring and testing of decommissioned wells where we know there can be potential problems into the future.

As I said, we need to be very careful about outlining in the legislation exactly what the minimum standards are for this industry. If your concern is that industry might be able to innovate and do a better job, you should be able to include in your legislation some mechanism by which they could come to the government with an alternative approach that would result in better environmental outcomes. I believe that there should be some form of independent body that could then assess whether or not that proposed departure from the minimum standards in legislation was going to result in better environmental outcomes or just cost savings. But I might leave it there because I am taking up a great deal of time. I should note that the EDO of the Northern Territory did a 45-page report which looked at the Northern Territory's regulatory regime for this industry and, given there has been no legislative amendments since then, all of the recommendations and things we identified in that 2014 report remain valid and current.

Senator WATERS: Great. Could you email us a copy of that once you are able to?

Mr Morris: Certainly.

Senator WATERS: Thank you. In relation to the precautionary principle, is that required anywhere in either the current laws or in the draft discussion regulations that you referred to?

Mr Morris: I believe it is referred to in the draft petroleum environment regulations. It is not in the current Petroleum Act.

Senator WATERS: Can you expand a bit further on that? Have they done so adequately? Is there a requisite information base on which to then use the precautionary principle? Have they done it well enough?

Mr Morris: We are in the process of making our comments on the environment regulations. My overall comment would be that there remains a reliance on the minister making a good decision and that is not a process that, in and of itself, gives me great confidence. I believe there should be some independent assistance to the minister to ensure that they do make a good decision and that the principles of ESD, and the precautionary principle essential to that, are taken into account when making decisions about this industry.

Senator WATERS: Perhaps once you have finished preparing the submission on the draft regs you could slip that to our committee, assuming we are still underway at that stage. That would be great. I have one last question and I do not mind who on the panel answers it. Part of the problem in Queensland has been not only our woefully inadequate regulations but the pitiful enforcement of those regulations. I am wondering whether or not your environment department and the departments with responsibility for regulating this industry are well resourced. Do they have a history of good enforcement and compliance, or are they like most other environment departments around the country, which are under-resourced and not given a lot of teeth to do their jobs properly?

Mr Morris: I think your question raises two points. The first is whether or not the Department of Mines and Energy is a body that is sufficiently independent to regulate this industry, and I do not believe it is. It is, through both legislation and government policy, the body that is created to promote the industry and regulate it. They singlehandedly have to be the people who try to tell industry to come here and why it is such a great place to come to but also the ones who hold them to account. In my opinion, that does not lead to good outcomes. I think, however, it is best not to take my word for it but potentially to look at the recent report by the Northern Territory Environment Protection Authority. I might be slightly misquoting them, but essentially they found that there was an ongoing tension within government departments which are forced to both promote and regulate industry. They said that in the case of Redbank mine, which is a copper mine in the Gulf of Carpentaria, the regulator had failed.

Also, if you look further, the Department of Mines and Energy, I understand, was also the regulator in charge of the Montara debacle. So we do need to ensure that government departments are adequately resourced. It is a big problem in the Northern Territory to both retain and recruit staff who stay around for long periods of time. That is a challenge. It is also a challenge, given the vast geographic size of the Northern Territory, to ensure that industry operations have adequate oversight. We do need to be very certain—and I am not—that the department that regulates this industry is both sufficiently independent and sufficiently resourced.

Senator WATERS: Thank you for that; it has been great. Can I just check something? The Northern Territory EPA does not have any formal role at all in the regulation of this industry; is that right?

Mr Morris: The Northern Territory EPA would have a role if an operation by this industry triggered some form of environmental assessment under our Environmental Assessment Act. They may also be involved through offsite pollution type issues or through the need to obtain a wastewater discharge licence to discharge some kind of waste to a water body.

Senator WATERS: With the first instance, are there any of those environmental requirements that need the Northern Territory EPA to issue that permit?

Mr Morris: I think it would depend on the magnitude of the operation that was proposed. I do not understand that exploration activities have thus far triggered the need for an environmental impact assessment.

I do not have information before me as to whether or not this industry has required the issuing of a wastewater discharge licence, but I think someone mentioned earlier that they potentially had. I can try and find out as a question on notice, but I cannot guarantee that I will be able to find out.

Senator WATERS: We might put that to the department to answer, because I know your resources are stretched as they are, doing the excellent work you do.

CHAIR: Ms Hogan, you were going to add to that?

Ms Hogan: I just wanted to jump in to back up some of those points. With the proposed revised regulation here in the Territory, there still isn't the need for environmental management plans to go through an assessment process by the EPA. There are also grounds in their proposed assessment to split the assessment into parts, where parts of proposals can be approved in segments. There are large concerns there about the cumulative impacts of

the gas field. If you were to propose a thousand wells, but have them approved 100 at a time, you can often slip things through that do not look at the full impact on a landscape, on pollution that comes out through the air, water pollution et cetera.

The other point I wanted to make is in regard to the Department of Mines and Energy being both the regulator and the promoter of the industry. From having done detailed work to look through the proposed regulation and from reading the newspaper—which comes out with an advertisement every day from the Northern Territory government promoting shale gas and groundwater safety—I think it is safe to say that their advertising, which is just half a page, actually contains more stringent regulatory proposals than their actual regulation. Their actual regulation does not legally require any of the things that they are talking about in here around cement casing and the like. In fact, their regulation just talks to the mining company itself—the gas fracking company—being able to put forward what they think is best practice, and then the minister has the discretion to sign off on whether that is appropriate and whether it has an acceptable level of risk. There are concerns that the promotion of the industry does not stack up against the proposed regulation and that the minister has far too much power and potentially not enough information to make these critical decisions on behalf of Territorians.

Senator PERIS: Mr Morris, do you think there are sufficient independent sources of expertise available to the Northern Territory to oversee gas operations?

Mr Morris: I do not believe there currently are. Under our legislation there is no creation of an independent body of information that the minister could go to to seek some independent advice before making a decision. I also note, importantly, the difference between operations occurring on the east coast with CSG, where there is a trigger under the Commonwealth Environment Protection and Biodiversity Conservation Act. One of the results of that trigger, which looks at the impact of large coal operations and coal seam gas operations, is the creation of an independent body. That independent body is able to provide advice to the Commonwealth environment minister and also to the ministers involved in the relevant states—Victoria, New South Wales, Queensland—that have CSG operations. We do not have that same independent option to seek advice; our minister does not have the benefit of that. I would support both an inclusion of a trigger under the EPBC Act for shale gas and the creation of independent bodies to provide assistance to our decision makers in the Northern Territory, who, as we have heard before, often suffer through the inability to hire and retain good staff who have good understanding and knowledge of the area. Having that independent body would be a major improvement on the current scheme we have here.

Senator PERIS: The Northern Territory government has issued extensive groundwater extraction licences from some of the Territory's major aquifers. Can you explain how the gas industry's water use is currently regulated and what impact the current entitlements will have on the potential gas developments?

Mr Morris: Ron Kelly, who I heard earlier, indicated that the current exemption for mining and oil and gas operations will be removed from the Water Act. Like other industries, they will have to apply for groundwater extraction licences in the same way other operators do, such as the large sandalwood plantations that we have seen arising down in Katherine and the Mataranka area. That is a definite improvement that they will be required to obtain licences under that same regulatory regime.

I understand that, for the moment, the water use is regulated by the Department of Mines and Energy and there is an memorandum of understanding between them and the Department of Land Resource Management. We need to understand that in some areas of the Northern Territory, and this is my understanding, some of the aquifers are already at capacity. The government has already issued groundwater extraction licences that take those aquifers to their limits and in some places take them past those limits.

One of the other things we know is that the gas industry requires water to go ahead. We need to understand that the government—by abandoning the National Water Initiative approach, and issuing major groundwater extraction licences in areas such as the Oolloo Aquifer, which is near Katherine, and the Tindall Limestone Aquifer, which runs down to Mataranka—has placed significant constraints on what the gas industry can do. What they have done is already allocated all of that water. If you are going to extract more water from those aquifers, common sense tells you that the only way that can occur is by putting environmental health at risk.

I think that one of the things government fails to understand in the Northern Territory is we cannot have everything. We cannot have the food bowl; we cannot have the perfumery—which is the sandalwood plantations; we cannot have a big tourism industry with healthy Mataranka hot springs; and we cannot have a gas industry and a healthy environment. We cannot have it all. When you make decisions about water extraction licences for one industry, you necessarily place restraints on another. I cannot help but feel like our current regulatory environment does not adequately assess the cumulative impacts of all of those things.

Senator PERIS: Hearing Mr Morris speak about that—that a lot of the aquifers are at capacity and the water licences go beyond that—how does that make you feel within your industry?

Mr Tapp: This is exactly my concern: aquifers in our area are at maximum and over-applied for in some areas. The baseline study that they have used on this 80 per cent/20 per cent for use thing has been done on a 40-year rainfall average. The last 40-year average rainfall is almost double the hundred-year average rainfall. If you take that into consideration, it puts extra strain not only with the mining companies—I am a pastoralist. This central area of the Sturt plateau and Beetaloo Basin, where a lot of this activity is most likely to take place, basically waters the central half of the Northern Territory. All these cattle need water—there are hundreds and hundreds of thousands of cattle there. None of that water is being monitored at all. Basically, water has already been allocated to the farmers, but the pastoralists and the mining companies are unmonitored. There is only a certain amount of water that we can use.

Ms Hogan: I think this gets back to the point around the moratorium as well. We have major concerns that the appropriate mapping of aquifers and understanding of how much water is available and that there are proper regulations in place to protect water, and protect other water users, are not currently in place. We feel that potentially a national standard approach for a Water Act would be beneficial to Territorians and other community members across Australia, who are grappling with this. It is certainly time to put those baseline studies in place so that we can measure water quantity and quality before we start putting in hundreds and then thousands of gas wells through these aquifers that risk water contamination through well failure and other things that have been measured and through the large quantities of water that the gas industry will use. We need to know exactly which aquifers that water will come from, because it can have very adverse local impacts, which I am sure you will have heard about in Queensland.

Senator PERIS: Are the wells they intend to use public knowledge?

Ms Hogan: It is not public knowledge at this point and that certainly needs to be put in regulation—that they need to be up-front with that and they need to be able to show the independent modelling of that aquifer to be able to know that there is water available. Currently, that information is not being discussed or adequately mapped. We absolutely feel that we need a pause to gather this sort of information so that people are not left guessing. To date, the industry has not even needed to report how much water they are using, let alone where they are getting it from.

Senator PERIS: According to your submission, the Northern Territory government reports a further 25 wells are anticipated to be drilled, with many of them likely to be hydraulically fracked. Do we know where these are?

Ms Hogan: They are around the Beetaloo Basin, as Mr Tapp has mentioned, which is in the northern central part of the Northern Territory. Since that submission was written, we have had word from Ron Kelly from the Department of Mines and Energy that only five wells are likely to go ahead this year, predominantly because of the low international oil and gas price. It means that the companies operating do not have a lot of cash flow at the moment to do new operations. Those international and economic considerations are important because, if companies have limited financial resources or if they are subject to boom-bust economic realities, which we have seen, there is a large concern that they may go in with best intentions but, if the cash flow dries up then, we are concerned that the long-term health of communities and other industries will be put at risk by a mining company that runs out of money and does a runner. We have seen that time and time again in the Territory.

Senator PERIS: You also say in your submission that the drilling ponds around the Daly Waters region overflowed during the recent flooding events of late 2015 and that the contamination was released into the surrounding environment. Earlier I asked Mr Kelly whether he was aware that any gas drilling ponds had overflowed and he said, 'No.' Is he not correct?

Ms Hogan: It does not surprise me. It gets back to the issue of funding and having officers on the ground to look at this. Those ponds were there after the Saxon drillers for the Origin site left. The whole area was reported by the ABC to be underwater and so we can presume that those ponds would have overflowed. If that is the case, the fact that the Department of Mines and Energy did not know about that is a concern—the Territory is a vast area and there are not enough people on the ground to go out there to have a look before and after and measure what is going on. That is a No. 1 concern for many people.

Mr Harris: We have just been talking about the changes that need to occur with regulation within the Territory, but at the same time that DME is issuing licences to go ahead and frack. Wells are still being drilled and are going ahead, even though the legislative framework has not changed. It is quite concerning that this is happening. As Ms Hogan said, initially it was going to be 25 for the current year and now it has dropped down to

five. We still do not know if those five will go ahead or not, but it is quite concerning that this is all happening prior to regulation change.

Senator PERIS: This goes back to what you were saying, Ms Hogan: you have a department that is the regulator as well as the promoter of the industry, and there is a huge conflict of interest in that.

Ms Hogan: Absolutely. What we would hope to see is an independent, expert scientific committee to oversee those decisions here in the Territory. We also appreciate the Senate taking the time to do this inquiry because we feel there needs to be federal oversight to ensure that our state and territory governments can properly regulate. To reiterate the point that Mr Morris made around shale gas and tight gas needing to come under that EPBC water trigger: it is crucial so that we can have that oversight and the benefit of the scientists and experts to provide advice here. According to the gas companies, shale gas is the next big boom for Australia. They want to see huge gas fields developed, for a large resource, with thousands and then, likely, tens of thousands of wells, if what happens in the shale gas fields of the United States happens here. So we need as much oversight as we can before that takes place.

Senator PERIS: Mr Harris, you did not go into detail in your opening statement, but is the Northern Territory prepared for a big boom in this area?

Mr Harris: My experience, particularly in Alberta and Saskatchewan, in Canada—when I was working there in 1988 and 1989, where there are hundreds of thousands of wells being drilled—is that there is a huge problem. With methane leakage, from both wells that were in production and wells that were abandoned, integrity of the well itself is a very difficult thing to achieve, to get full integrity. Not only is it the methane emissions that will be of large concern, depending on whether the wells sour, which means whether they have a hydrogen sulphide content—I worked in fields where people have died because of the lack of integrity on wells—but also we heard Mr Kelly from DME say that there will not be the need for so many wells. What he did not mention was the need for infrastructure to support those wells.

If wells are going to be approximately three kilometres apart, I think he said, and you have 1,000 wells, pretty soon the kilometres of road for access add up. When you extrapolate that across tens of thousands of wells, over time, that is a huge proportion of the landscape getting impacted on. Not only that, it opens up that area of the landscape for weed contamination and problems for pastoralists, with people accessing their land without their consent. Emissions from the wells, whether it be through leakage or flaring off of unwanted gases or controlling pressures in the wells, it is really big. With the exception of maybe one person in DME, I do not think our regulators have enough experience, in this area, to unleash this type of industry on the scale that will be required to make it profitable.

There has been a bit of talk about moratorium. That is the chance to get it right. We have seen from numerous government departments, over the past couple of years, activities occurring within the environment without proper approvals. We have seen simple things, like clearing undertaken without a clearing permit and departments posting comments for the clearing permit online. It is crazy to think that we can run ahead with this project, at such short notice, without the proper legislation being in place. As for DME and the conflict of interest, it is a huge conflict of interest. They are actively promoting this industry and they are going to be regulating it without the expertise that is required. I do not think the territory is ready for it at all.

CHAIR: Mr Morris, I want to talk about the expenses to landowners. I know that they ultimately, from what I gather, will not be able to refuse. They can go to court over compensation and things, but what problems do you see that farmers or families will have in this sort of negotiation?

Mr Morris: The first thing to note is that approximately 50 per cent of the territory is Aboriginal land, under Aboriginal land rights, and they do have a veto right at the exploration stage. That is a process that Mr Morrison and Mr Dalton outlined earlier. I do know, from experience with my clients, that many of them find that a heavy burden, to have to give up that veto right at the earliest stage, the exploration stage, where they are unable to have a complete picture of what a full-scale operation may look like. That is my experience with my clients.

In terms of the access agreements required, I appreciate that Mr Kelly has said that the Department of Mines and Energy will not look at those agreements. I have some level of concern that, potentially, an agreement could be arrived at with a great disparity, in terms of the particular party's legal expertise or the people who are able to assist them in negotiating that agreement. That is a concern to me.

It also should be pointed out that we were told recently that, if a matter were to go to arbitration, a party that, say, was not represented by the Northern Territory Cattlemen's Association would be able to choose a representative of their own. It is important—Mr Kelly spoke about not having the panel stacked at that arbitration and having equal representatives from government and industry. We have a government that supports this

industry, so, in effect, you are stacking the panel if it only contains representatives of industry and government, because this government is pro this industry. That is fine, but, if you want to have a balanced panel, you have to have someone with independence—someone with an evidence based, scientific understanding of this industry who is able to provide some balance to that arbitration panel if there is disagreement. But, as you have outlined, if it is not on Aboriginal land, the landowner, whatever the land status, will not have a right, ultimately, to say no to this operation on their land.

CHAIR: Mr Tapp, have you any consultation with or approaches from mining companies? What were those dealings?

Mr Tapp: None at all. My property is under an exploration licence, but I have not had any interaction with them at all. It is probably because of my stance and they know they are not welcome. They have been next door and talking access agreements. I do not know the finer details of that.

I have a couple of points. On the flooding of waste-water dams, I was actually an eyewitness to the ones down at Daly Waters. I flew over in a helicopter and you could not see a waste-water dam; it was just literally two or three metres underwater. I have seen them in the dry, with the little ponds they have had there. I had witnesses with me. They are not lined; they are just dug out of the dirt and basically bodgie. We have been conducting frack-free surveys around the Territory over the last six or 12 months. We have had four signed up frack-free communities. There is Mataranka, which is just about to be done, the Katherine area, the Adelaide River and the Coomalie region, all with in excess of 95 per cent opposed to fracking. That says to me that this government ain't got a social licence to be fracking up here.

Ms Hogan: I think the gas field-free survey really demonstrates that community members, because they are not given the right to say no, are having to go to other means to try and have some sort of say in this process. They are feeling very disempowered, which is why people are talking amongst themselves, talking to their neighbours and wanting to declare their own communities gas field free. Astoundingly, what we have seen in the Territory, in relation to both the traditional owners of the Watarrka-Kings Canyon national park area who made that stand and also the Coomalie region, was that the government then came out and said, 'Oh, don't worry, we'll get rid of those applications, and that area, in my political part of the world, can be gas field free.'

So we are seeing an ad hoc approach from a government who are responding in a knee-jerk way to people when they do stand up. Good on them for listening to their constituents, but, at the end of the day, we are calling for a pause so that we can map out where the really important community values, cultural values and tourism values are. Where are the rivers that fishos need to be able to conduct the tourism businesses that should not have overflowing frack ponds next door? That sort of work has not been done to really map that out in a consistent way, so we are seeing community members throw their hands in the air and have to do their own work to talk to one another and try to get their own declarations through, because they have no right to say no to this industry. As we have heard from Mr Tapp, I find it astounding that there is a granted application for gas field fracking over his property, and yet he has not had any discussions with the company that has been granted that licence.

CHAIR: We have run out of time, so I thank you all for coming here today and talking with us.

Proceedings suspended from 10:29 to 10:42

COTTEE, Mr Richard, Private capacity

DOMAN, Mr Matthew, Director, South Australia and Northern Territory, Australian Petroleum Production and Exploration Association

HICKS, Mr Armon, Group Executive Public Affairs, Santos Limited

WILKINSON, Mr Richard (Rick) John, Chief Technical Officer, Australian Petroleum Production and Exploration Association

CHAIR: Welcome. Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. The committee has received submissions from APPEA and Santos, which the committee has numbered 121 and 57. I now invite you to make a short opening statement. After you have spoken I will invite members of the committee to put questions to you.

Mr Doman: APPEA thanks the committee for the invitation to appear before you today. The Australian Petroleum Production and Exploration Association is the peak national body representing Australia's oil and gas industry. APPEA seeks to increase community and government understanding of the upstream petroleum industry by providing and promoting information about the sector's activities, impacts and benefits. There are, unfortunately, a number of myths pedalled about our industry that have no basis in fact. Our submission addresses a number of those myths directly and also provides extensive reference to the findings of leading scientists and institutions that are independent of the industry.

I draw specific attention to the following key points in our submission. Firstly, it is vital that there is a genuine, fact based examination into how onshore unconventional gas production operates. The findings of multiple Australian and international reviews by eminent individuals and institutions are clear. The risks associated with unconventional gas can be managed effectively through the creation of a robust regulatory regime underpinned by effective monitoring and compliance. A balanced inquiry should give due weight to the views of these groups.

The industry and governments actively promote coexistence. In all states and territories where we operate we support fair and transparent land access arrangements that ensure benefits flow to landholders and any impact on their existing land use is minimised. The Queensland natural gas industry has negotiated more than 5,000 landholder agreements. This would not have been possible without the constructive engagement between industry, landowners, agricultural representatives and government. Compensation paid under these agreements is estimated by Gasfields Commission Queensland to have totalled $238 million as of June last year. From 2015 to 2020, it is estimated, a further $189 million will be paid in compensation to these landholders.

The science of hydraulic fracturing is well understood and, as Australia's Chief Scientist, Dr Alan Finkel, has stated, is completely safe if properly regulated. As the recent report by Dr Allan Hawke into fracking in the Northern Territory stated, this technique has been used here since 1967, mainly in the Amadeus basin, west of Alice Springs. Over 30 wells have been fracked since then, with no negative impact on the region's precious groundwater resources. All activities undertaken by the natural gas industry are subject to comprehensive regulatory processes. An onshore gas company operating nationally needs to comply with over 70 pieces of state and federal legislation, numerous additional regulations, associated operational policies and local council regulations.

There has been considerable discussion around water and the impact on farmers. In Queensland, 97 per cent of the water produced by CSG activity is put to beneficial use. Treated CSG water provided to farmers is reducing dependence on shallow groundwater resources and reducing the overall demand on critical aquifers. Farmers throughout Queensland have emphasised the importance of natural gas operations in providing passive income and treated water at no cost. Treated CSG water is aiding drought proofing and substantially boosting productivity on farms right across the state. The Queensland industry is a success story that shows what can be achieved when people work together on the basis of mutual respect. The benefit to that state and regional communities will be seen for decades to come.

The industry continues to work closely with landholders and a range of other stakeholders. Pleasingly, research from CSIRO confirms that there is growing community acceptance and support for coal-seam gas in the regions where the activity is actually occurring. The economic and social benefits have been welcomed. Many communities right across Australia have felt the full force of the global financial crisis, drought, the decline in Australian manufacturing and the downturn in employment. In contrast the CSG industry at its peak in Queensland employed over 40,000 people and paid royalties which have supported programs which have invested more than $495 million over the last four years in new community infrastructure, roads and flood mitigation. Here in the Territory, a study by Deloitte Access Economics found that a successful shale industry has the potential to

deliver up to 6,300 new jobs and increase Northern Territory government revenues by almost $1 billion by 2040. That is a lot of money for roads, schools, hospitals and other community benefits. This is an industry that is committed to continuous improvement, a long-term industry that is focused on stability and public benefit. We think the committee for the opportunity to appear today and look forward to your questions.

Mr Hicks: I will just take questions. I am not proposing to use the committee's time for a statement.

Mr Cottee: My submission is No. 124. I am actually making this in my private capacity because this committee originally started talking about CSG and shale gas but has now moved across to unconventional. As a result, Central Petroleum is not actively involved presently in any CSG extraction. Nonetheless, I am a person who bought a company called Queensland Gas Company, out of financial difficulties to become a company that within six years was taken over by BG for the CSG, so I have a long history in it.

Central owns and operates the three onshore producing gas fields in Central Australia—namely, Mereenie, in which we are joint ventured with Santos; Palm Valley; and Dingo. Since we took over that operatorship we have increased local employment there by 450 per cent and traditional owners' employment by 250 per cent. In fact, 25 per cent of our workforce are traditional owners.

Arguably, Central is commercially advantaged by a shale gas moratorium given the natural gas pipeline, junkiyi, going ahead and the resultant shortage and increase in price. As we have existing reserves, my shareholders will be somewhat advantaged, at least in the short term. I make that as a disclosure at the beginning, but the prime reason that I wish to make a submission to this inquiry is that I am really quite concerned about the health of my nation's economy and, in particular, the number of manufacturing jobs at risk—the collateral damage—if the natural gas shortage that the ACCC has identified after a long inquiry comes about. In fact, I have a copy of a speech by Rod Sims on 9 March, in which he states that the critical period is 2016 to 2018, and:

> Second, without new gas supply from a range of basins and producers there will be significant implications for gas prices and possibly gas availability.

The New South Wales government has indicated that there are 300,000 direct jobs in manufacturing at risk if there is an insufficient gas supply.

The prime issue is that six new LNG export terminals are being built and one LNG train equals the whole of New South Wales's consumption. To go to the last normalised year, 2012, the New South Wales government is on public record to say only 26 per cent of the New South Wales gas consumption goes into electricity generation. So, 26 per cent can be replaced, possibly by renewables but that is another issue, but 48 per cent is consumed by 300 companies employing 300,000 people, in which electricity is no substitute. That ranges from fertiliser, building materials, such as coated steel et cetera—and that is pretty important when we are talking about Arrium at the present time—glass manufacturing and, indeed, the only known present way to dispose safely of highly infectious hospital waste. Electricity is no substitute for those particular processes. If you extrapolate across Australia, one million jobs are dependent on a stable gas supply, which obviously, according to AEMO in its recent announcement and the ACCC, in 2019 all developed gas resources will have been committed and there is no further developed gas resources coming through the pipeline. So fighting for manufacturing jobs for a million, out of our 12 million Australians employed, I think is a fight worth going for.

There is a radical departure in this debate from the age of reason, in which I grew up, to a degree of McCarthyist emotional unsubstantiated assertions which, if unchecked, will vest a known risk to the Australian economy of the number of manufacturing jobs that would really affect the weak, the unskilled, the infirmed. They are the collateral damage in this argument. They are the ones who need to be protected and they need natural gas as a stable energy and input source. Whether it is for tractors, whether it is fertiliser, whether it is for explosives, whether it is for glass manufacturing, whether it is for brickmaking or whether it is for coated steel for roofing, Australia should not be importing those when the science has been settled by the Australian Council of Learned Academies, the Royal Academy of Science, the National Academy of Science in America, the Chief Scientist of Australia, the Chief Scientist of New South Wales, the Hawke inquiry and many more. This is a time when we should not be scared of unsubstantiated risks to take on substantiated risks.

CHAIR: Thank you, Mr Cottee. Mr Wilkinson, do you have anything?

Mr Wilkinson: No, I am fine.

CHAIR: Senator Waters, do you have any questions?

Senator WATERS: No, not at this stage but I am happy for you to come back to me at the end.

CHAIR: Santos, your submission states that a distinction between 'conventional' and 'unconventional' gas is largely irrelevant, as all of the gas is predominately methane, which is natural gas, and the activities undertaken are fundamentally the same. Do you accept, though, that the new way of unconventional gas drilling across

Australia is requiring thousands of more wells? For example, Santos was recently approved by the Queensland government to drill 6,100 new CSG wells, which is more wells than are typical of a conventional gas field. Is this correct?

Mr Hicks: That is correct. It is the case that you drill more wells to produce CSG. You do not drill them as deeply—they are a much shallower depth than you do with conventional gas. Conventional gas wells can be up to four to five kilometres deep. Yes, that is a correct statement.

CHAIR: Have you experienced issues with the integrity of waste drilling ponds?

Mr Hicks: Sorry, I am not sure I understand what the question is. What do you mean by 'waste drilling ponds'?

CHAIR: Have you experienced issues with the integrity of the holding dams and ponds of the water that you have used?

Mr Hicks: I understand what you are referring to, yes. You are referring to the leak that we reported to the New South Wales EPA in regard to the Bibblewindi Pond 3, which had a small leak that saw some produced water leak from the pond. That was reported, we then emptied the pond, in compliance with an agreement we had with the EPA and New South Wales government, and we were fined, I think, $1,500.

CHAIR: You were fined $1,500.

Mr Hicks: Yes, the New South Wales government said and the EPA said, at the time, and I am quoting from February 2014:

The fine imposed on Santos reflected the small environmental impact of the incident, the fact that the company self-reported the incident, cooperated in the investigation and is implementing measures to minimise the impact.

It is important to note, for example, the water that leaked was many kilometres from either the aquifers that are used by agriculture or for human consumption. As they said, it was small, localised and contained. It was found to be no risk to livestock or drinking water sources.

CHAIR: You state in your submission:

NSW is facing a significant gas supply challenge.

Is that right?

Mr Hicks: Yes; that is, indeed, the case. It has been supported by the ACCC, as Mr Cottee has just explained, and also by the New South Wales government. The New South Wales Minister for Industry, Resources and Energy is, I believe, on the public record stating the importance of a domestic gas supply to be developed, for New South Wales, to protect jobs and manufacturing businesses.

CHAIR: The 2016 *Gas Statement of Opportunities* report, by the Australian Energy Market Operator, states:

Despite the projected rising demand and limited local production, no supply shortfalls are forecast for New South Wales under the medium scenario.

The medium scenario does not include gas being required from the Northern Territory. If there are no shortages expected, why does Santos mention a supply challenge for New South Wales?

Mr Hicks: Can I say, for the record, it is important to note that that assumption is based on a destruction of demand. The AEMO, in their *Gas Statement of Opportunities*, the last report they published, made it very clear that that scenario is based on large, manufacturing users of gas going out of business, taking their business offshore and putting Australians out of work.

CHAIR: I note in Queensland media, last week, it was said:

Santos has been embroiled in a $6 million dispute over allegedly unpaid work on its central Queensland LNG pipeline.

Liquidators claim that Santos owes the pipeline contractor an estimated $6.3 million. What is the economic impact on contractors and subcontractors caught up in the boom-bust nature of the unconventional gas industry?

Mr Hicks: Can I say for the record that we have made very clear to the administrators that reported that we dispute their claim that we owe any money for any unpaid work that has occurred. There is a legal process underway at the moment, and I fundamentally dispute that claim that was reported in the media last week. I would also state that the impact of the industry has been entirely beneficial for the communities in which we operate and for the state governments that take royalties from the industry. Santos Development pays royalties. So I dispute fundamentally the basis of the argument.

CHAIR: I would like to know how you deal with landholders who approach you about issues with CSG mining on their properties in Queensland.

Mr Hicks: I am not sure I understand the basis of your question. We have a great relationship with our landholders. It is based on mutual benefit and a transparent and open process so that people can understand the compensation that they get paid.

CHAIR: So what is your reaction to the hundreds, if not thousands, of people who have come to me and said that they do not want it, that their bores have dried up and that they are experiencing health issues?

Mr Hicks: I will first go back to the first principle that we said have said many times and have put on the public record: Santos does not go onto landholders' properties where we are not invited. We have always taken the position that it is a long-term relationship that has to work to the mutual benefit of everybody—and that, I think, is reflected by the very high scores that our independent surveys find of landholders' attitudes towards us.

As to the claims about health impacts and so forth, those claims are made about operators many kilometres from where we operate. I am not aware of any such claims being made about Santos. In reference to that, I would also say that we have been operating and producing natural gas for some 60 years and we are very conscious of our workforce and our workforces over those decades have never shown any of the symptoms to which you might be referring. I think that is more of a question for APIA to address.

CHAIR: We will get to APIA in a minute. In Narrabri in New South Wales, Santos decided to write down the value of the operations around the Narrabri area to zero. Is that right?

Mr Hicks: Yes, you are correct: the value has been written down to zero. That reflects the engineer accounting rules with regard to reserves. Because we have been focused on getting all the necessary approvals rather than proceeding to drill holes or do further exploration appraisal work, under the ASX rules and the engineer rules around that stuff, we had to write the value down. That does not mean that we are not committed to the project and we do not believe there is a valuable resource of gas that should be developed for the benefit of New South Wales and Australia.

CHAIR: Do you take notice of all those landholders who have been protesting in that area who do not want it?

Mr Hicks: We are always concerned to know what the community are saying about our activities. In Narrabri or Roma or Fairview or even in the Cooper Basin, we are confident that we have local community support. We believe that is justified by the number of land access agreements that we have been able to sign over the years across Australia. In Queensland, we have over 900 with about 320 landholders and in New South Wales we have all the access agreements required to proceed to the next phase of appraisal and development. With respect to the landholders who have expressed concerns or opposition to our projects, the vast majority of those are not locals and are not within the project area.

CHAIR: Senator Waters, do you have any questions?

Senator WATERS: No. I think as previously canvassed with APIA and a number of the other CSG operators we are on radically different perspectives and I have not found it particularly useful in the past. So I am actually happy to leave it.

CHAIR: Mr Hicks, how many jobs are going to be created if the project at Narrabri goes ahead?

Mr Hicks: We believe that between 200 and 300 jobs will be created during the construction phase and that somewhere between 16 and 20 operators will be required in production.

CHAIR: Will those jobs be local?

Mr Hicks: Yes, they will. We have a very firm policy of supporting local employment and working with the communities in which we operate. That is certainly the case today. The team based in Narrabri who operate the fields, conduct the current appraisal work and operate the pilot and so forth are all locals.

CHAIR: And all these employees are going to be trained and ready to go once the project is up and running?

Mr Hicks: Yes, they will. But I would point out that we have indicated that we expect it to be a number of years before the project is complete, as we comply with all the planning and approval requirements of the extensive and stringent regulatory regime we have in New South Wales and then we proceed to further appraisal work.

CHAIR: Is it true that, when this goes ahead, no royalties will be paid in the first five years of production?

Mr Hicks: No. I think you are misinformed. That used to be the case. Certainly Nick Greiner, as I understand it—it was well before my time—instituted a royalties holiday to enable the development of a gas industry in New South Wales. But former Deputy Premier Andrew Stoner abolished the royalties holiday to create a fund, a form of royalties for the regions, to help pay for and support the communities that host the gas industry so that not only

do the landholders get a benefit but also the communities get a benefit and compensation for hosting the gas industry.

CHAIR: What is the process when a landholder does not want you to come onto their property? Do you just abide by their rights or do you take it to another level?

Mr Hicks: As far as I am aware, no means no. As I have said, Santos has had many land access agreements; for example, over 900 in Queensland. We have never been to the Land Court; it is not our intention to go to the Land Court. We want to build a relationship based on mutual respect. But I would also state, for the record: if no means no, then yes should definitely mean yes. I think it is appalling the way that some landholders—who have considered all the risks and benefits for them, their families and their farms—have been targeted by activists.

CHAIR: Does Santos have a full understanding of the environmental implications from drilling and fracking?

Mr Hicks: As an organisation which has been producing gas in Australia onshore since the 1960s, I would argue that we have a very strong history of knowledge and expertise on how to drill, explore, develop and produce gas safely without harm to environments or to water resources.

Senator LUDWIG: My question is more of a broader one, I guess, that anyone from the panel may wish to comment on. From this hearing and others that I have participated in around coal seam gas and shale gas, there is an extraordinary amount of community angst about it, which you face continuously. In Queensland, it first began around the land use agreements and then migrated when AgForce and the like came on board, if I can use that phrase—correct me if I am wrong—and, ultimately, has reached Narrabri and the Northern Territory. What do you think you can do more of to try to mitigate some of the community concerns that exist around this industry? The literature that you produce, the literature that is produced worldwide and the independent research all point to, more broadly, the idea that this can be managed safely for the community benefit and for the broader economic benefits that flow from it.

It seems that the jury is not out. The jury has already come in with a verdict world wide about the industry, more broadly, on the proviso that you manage the resource in an environmentally sensitive way, which, from all intents and purposes, you appear to be doing. But why do we still continue to have this? Is it the mistakes you make? Is it the approach you have taken? I am happy for you to provide your own comment about why.

Mr Doman: In the first instance, it is important to note that the perception of community opposition to our industry is a false perception. One piece of work I can refer to, mentioned in our APPEA submission to this inquiry, is the work that the CSIRO did on community attitudes towards coal seam gas in Queensland. It found that only 10 per cent—only one in 10—of people in those communities opposed the industry. Ninety per cent of the community either tolerated, accepted, supported or embraced it. That is borne out also by the record of land-access agreements that the industry has been able to negotiate and agree. There are landholders who do not want our industry on their land, but they are in a very small minority.

That is not to say that there are not genuine questions and concerns held throughout the community, particularly when we move into new areas—as we are proposing to do in the Northern Territory—and to areas unfamiliar with our industry's practices and its track record. Those people are entitled to raise their concerns, to ask questions and to expect frank and immediate answers from our industry and from the government that regulates our activity.

I would say we do need to do more, in terms of informing the public discussion, but it would be greatly assisted if some of the extreme, false, exaggerated claims that are repeatedly made are not made and that all comments made, in relation to our industry, are based on fact and verified by science. At the end of the day—

Senator LUDWIG: Sorry to interrupt you, but you are a realist. I am a politician. You are always going to have that.

Mr Cottee: I am an old man, and I have seen a lot in my long tenure on this earth. The prime issue we have is to show, overtly, the economic benefit that we are contributing to the community. The advent of FIFO, for example, has disconnected, to a large extent, the benefits for that community. When I was in Chinchilla, in the early days, they complained, primarily, of what they called the doughnutting of their community. Their children, when they turned 20, had to leave for Brisbane to get a job, because there were no jobs in that local community.

I sincerely and honestly believe that Australia, America or wherever has always been able to decentralise and create regional development through the agriculture and resources sector. That is a historical fact: 'Go west, young man,'—goldmining, gold rushes et cetera. The advent of FIFO has blunted that obvious economic benefit. I also note that absolutely everyone, including my children, is always change resistant, so any change is always hard to manage. When I look back and see that the Chinchilla region was worried, when I first went there, about the

closing of the last bank to, now, worrying about whether McDonald's come in, I think it is a job well done. You have given people an economic choice as to their future.

I would say in the areas where we operate, with the traditional owners—on whose land I wish to acknowledge I am presently speaking and I apologise for not making it at the outset—we need to ensure that both the direct and indirect economic benefits are seen for regional development in Australia. In the resources sector, since about the eighties, FIFO has not been able to see that. We need to make sure that this impact is felt so that parents have a chance of allowing their children to stay in the region in which they were born.

Senator LUDWIG: Mr Doman, I did cut you off, so I do apologise. Did you want to finish?

Mr Doman: The point is that we always have to be responsive to community concerns, and that includes here in the Northern Territory or wherever else we operate. The perception gleaned from media coverage of overt hostility between communities and our industry is not the reality that we face every day. Richard would vouch for that in Central Australia. I joined APPEA recently, after eight years at Santos. I believe that in the areas in which the company operates, and where the industry operates, we enjoy strong support. Not unanimous support—quite clearly there are people who have concerns that they are not satisfied about or who oppose our industry for a range of reasons. We will never achieve 100 per cent support, but we are very comfortable with the relationships we do have with the communities who host our activities, and we are determined to maintain it in that manner.

Senator LUDWIG: In the Australian Petroleum Production and Exploration Association submission, you also talk about a range of ancillary benefits that you say you bring, such as additional medical support and the like. Is it only confined to that? Or is it broader in terms of the contribution made by, for argument's sake, Santos—from Mr Hicks's organisation—and the others that you represent to those regional communities, contributions that otherwise would not be there?

Mr Doman: Again, Queensland is a good example. It is not my role to speak for the companies who have operated in that region, including Santos and Origin, who are closest to the community of Roma. We have seen the industry contribute to improvements to the airport and the hospital, and develop new housing stock in those communities. There is a wide range of initiatives that have been supported by our industry. We believe that is an important part of contributing back to the communities that support our activities. Of course, our industry, when it does bring significant workforces into a community, does place a demand upon that community's social infrastructure. We have accepted and demonstrably exhibited in Queensland a willingness to contribute to that social infrastructure, to enable that process to be a smooth and satisfactory one for those communities.

Senator LUDWIG: Are there a couple of concrete examples you can give?

Mr Doman: Several of them are detailed here in APPEA's submission, but the Roma airport is one example that comes immediately to mind. There is the Roma hospital. Santos has contributed to initiatives in New South Wales that Mr Hicks could speak more authoritatively to. In South Australia, the industry has supported—

Senator LUDWIG: [Inaudible] Mr Hicks, if you want to.

Mr Hicks: I will speak specifically about our GLNG project. It was first sanctioned in 2011; we have been through the construction phase; we are now up to final commissioning. During that time we purchased about $15 billion worth of services and materials from Australian businesses. We also spent about $1 billion in regional areas through that process. So that is the direct payment of cash, influx of cash and investment into businesses and jobs. At the same time, we paid across the company last year, in 2015, about $183 million in taxes and royalties. That is on top of another $18.5 million in community investments. Last year, Santos alone spent $12 million on roads in the Maranoa and Gladstone shires.

CHAIR: I have been to Chinchilla, Mr Doman, and they have not received any benefit from having CSG mining around their area. Why would you suggest that CSG mining is really good for all of these country towns?

Mr Wilkinson: CSIRO looked specifically at Chinchilla. I am not talking about the people you have interviewed, Senator, but CSIRO looked specifically at Chinchilla and over the recent period, during this build-up for the CSG, the proportion of families living below the poverty line has decreased from 23.4 per cent to 8.3 per cent.

CHAIR: That is because they have left; there is no work there.

Mr Wilkinson: No, that is not true, because the number of young people—and that is very important to local communities—has increased by 46 per cent in that area. If you look at unemployment, it is down to three per cent. These are very low figures. They have got jobs, young people are moving back to the regions and the poverty line has gone down.

CHAIR: I do not know where you are getting those stats from.

Mr Wilkinson: The CSIRO.

CHAIR: How many thousands of gas wells would need to be drilled and hydraulically fractured in order to extract the 200 trillion cubic feet of gas that is outlined by the Northern Territory government and APPEA commissioned report by Deloitte—the ballpark figure for 200 trillion cubic feet? How many fractured gas wells did it take for other shoal areas to get that much gas out?

Mr Doman: That potential resource is a very large number, as we referred to. It is very, very unlikely that level of resource will be totally developed. The scenario in the report that Deloitte Access Economics has completed on the economic analysis of the potential of the shale gas industry in the Northern Territory identifies, as I said in my opening remarks, an industry that could create 6,000 jobs and deliver up to $1 billion in revenue to the Northern Territory government over the next 20 years. That is based on a scenario of a maximum of 2,300 wells, but on multi-well pads, so you would have between 200 and 300 well sites. The pace at which this industry will be developed will be gradual. We heard earlier on that five wells are likely to be drilled this year. Somewhere around 15 wells, I believe, were drilled last year. As the industry continues to explore the resource and identify the potential, there will be a gradual increase in the amount of drilling that occurs. But a large-scale development of our shale gas resources, as portrayed by Deloitte Access Economics, would see around 2,300 wells drilled.

CHAIR: APPEA put out a press release last month that states:

… there have been no proven cases of groundwater contamination directly linked to hydraulic [fracking] anywhere.

Is that still your position?

Mr Doman: That is correct.

CHAIR: So despite all of the fracking that has been going on, there has been no contamination?

Mr Doman: There has been no proven groundwater contamination from hydraulic fracturing anywhere. That is not to say there have not been environmental impacts from our industry more broadly, but opponents of this industry very specifically target the fracking process. We hear phrases such as 'Don't frack the Territory', 'Frack off', 'What the frack' et cetera. It is wordplay that might be effective in rallying emotion against the industry, but it specifically targets a practice that has a very strongly established track record of safe operations with no systemic impacts. That has been confirmed by repeated scientific studies. The US environmental planning authority, the Australian Council of Learned Academies—a long list of organisations that have looked into our industry and found that there are no direct linkages between the fracking process and groundwater contamination.

Senator PERIS: In your submission, with the Santos submission, you said you have signed close to 50 voluntary land agreements with traditional owners that are over and above the compliance requirements. Is that here in the Northern Territory?

Mr Hicks: It is my understanding that is nationally.

Senator PERIS: Do you have any in the Northern Territory?

Mr Hicks: I do not know the answer to that question. I will need to take it on notice and come back to you with an answer on that.

Senator PERIS: Okay. With the compliance requirements, who develops them? Is that an independent body, or is it Santos that develops it?

Mr Hicks: Once again, I am not aware of that level of detail about our agreements, so I would need to take that on notice and come back to you on that.

Senator PERIS: Okay. Are the voluntary land agreements with traditional owners being made in consultation with the land councils, with their assistance? Or are these agreements being made independently by the traditional owner groups themselves?

Mr Hicks: It varies according to the various areas in which we are operating. It is certainly in compliance with the Mabo legislation.

Mr Doman: Here in the Northern Territory activity can only occur on Aboriginal land with the express support and endorsement and informed consent of the traditional owners. The industry works with the land councils, who in turn represent the traditional owners in that negotiating process. There is, relatively speaking, a small area of operations in the Northern Territory at the moment. We are talking about the potential for a significant increase in that, and so going forward you will see more discussions with the land councils and traditional owners about the potential for this activity in their areas, on their land, but that activity will only go ahead with their informed consent.

Mr Cottee: If I may answer on behalf of Santos, because we are the operator of Mereenie: the answer is definitely they do have those agreements through the Central Land Council and certainly exploration agreements through the Central Land Council to the south of Mereenie. They have been entered into. It is traditional owner freehold title. Under the act, you negotiate through the CLC, with community consultations organised by the CLC, and there are terms and conditions upon which you agree. In addition to and above that, we do make additional payments to the landowners for such matters as netball uniforms or sorry leave or whatever. Where a traditional owner has a particular request, we have made and continue to make some other payments above and beyond those that are legally required under the CLC brokered agreements.

Senator PERIS: Mr Doman, I think you said that there were 15 wells last year.

Mr Doman: That is about right. It is somewhere between 15 and 20.

Senator PERIS: They are here in the Northern Territory?

Mr Doman: Yes.

Senator PERIS: Have any of those wells become abandoned?

Mr Doman: No. In the stages of exploration, a well is drilled and an analysis is taken of the results from that well. But if we are heading into a more technical question here, I might ask Mr Wilkinson to explain the processes in relation to exploration.

Mr Wilkinson: Senator, if the basis of your question is what is the technology used when a well is abandoned, it is a common term used but the well is far from abandoned. There is a full remediation process that goes on. When a well is drilled it is designed for its entire life, and that includes how it is going to be maintained through to its final remediation and rehabilitation. Typically, while it is an active well, you would be revisiting that well every two or three years with a rig, testing the well to make sure that it still has integrity and that it is operating in a way that you had planned. Often this involves changing out seals in glands and testing for gas that might be building up that you did not expect. When it comes to the end of the life of the well there is a process of abandonment which typically involves mechanical plugs that are lowered down on the ends of cables and used to jam off or close off the wells themselves. You also fill the voids, or a good part of them, with cement. When you have deep wells like you have in the Northern Territory, you probably do not fill the entire well with cement. That is expensive. What you would use instead would be a heavy clay, like bentonite. The advantage of a heavy clay like bentonite is: firstly, it is natural; and, secondly, if any movement or corrosion occurs, the bentonite swells and tends to self-heal any holes that you might have in those processes.

Just to summarise: mechanical plugs cement across the sensitive zones, and bentonite comes onto the top. All of that has to be signed off, generally by government auditors who come and inspect that that completion is correct. And then generally it is cut off beneath the ground so that you can take a plough over it and resume agricultural and other activities that might be there.

Senator PERIS: Has any of that happened over the last two to three years?

Mr Wilkinson: Most of the CSG wells are still fairly new. Typically, when you have a plug and abandonment you are looking at 20-plus years for that to go through, but it is a fairly standard process. For example, if you drill an exploration well and it looks like there will be a long period of time or it will be an unsuccessful well then certainly that well must be plugged and abandoned. It is not like you are filling a large mine area. It is basically filling a tube with cement and bentonite and putting the plugs in place. So it is fairly straightforward, and it saves you costs to finish it because you do not have to monitor it and continue to report on it.

Mr Doman: Senator Peris, a company called Statoil drilled, I think, five wells in an area called the Georgina Basin in the south-east of the Territory. Those wells were unsuccessful in terms of proving up a commercial gas discovery, so those wells were decommissioned by that company following the procedures Mr Wilkinson has described. That is one case that comes to mind of a company that decided not to continue with the exploration activity. But in all other cases, to my knowledge, the wells that have been drilled are still being assessed and developed for future near-term activity.

Senator PERIS: Have the ones that have been decommissioned, for which there is no longer a use, been filled in?

Mr Doman: They would have to follow the procedures that Mr Wilkinson outlined in terms of decommissioning a well. To my knowledge, they certainly did that.

Senator PERIS: Earlier on there was a question that I did not get around to asking the department. It was about the abandoned wells legacy fund. Have you heard of that? It was something that they were looking at establishing.

Mr Doman: There are a wide range of policy initiatives that the Northern Territory government has put forward in the last four or five months. That is one of the proposals that they outlined in November last year. In broad terms, yes, I am aware of that.

Senator PERIS: Do you think something like that should be in place before they start exploration?

Mr Doman: There are similar arrangements in place in terms of financial securities that must be lodged with our activity, and I think it is very important that the companies that undertake this activity have the experience, the expertise and also the financial wherewithal to see their commitments through. There are various ways in which jurisdictions around the country reassure the community of that, and the measures you are referring to are something that is being considered in the Northern Territory.

Mr Wilkinson: As a Queensland example, the amount of money that is held in either bank guarantees or company guarantees with regard to the oil and gas industry in Queensland is about $800 million, and there are no examples where the government has needed to tap into those funds because it could not locate the responsible company or person. Our track record—at least that which I can point to in Queensland—shows high commitment to financial insurance and very low utilisation of those funds.

Senator PERIS: Thank you, Chair. I do not have any more questions.

CHAIR: Thank you, gentlemen. Thank you for your time.

CAREY, Dr Marion, Coordinator, Unconventional Gas Special Interest Group, Doctors for the Environment Australia

WILLOUGHBY, Emeritus Professor John, Member, Doctors for the Environment Australia

[11:34]

Evidence was taken via teleconference—

CHAIR: I now welcome representatives from Doctors for the Environment Australia. Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. The committee has received your submission, which the committee has numbered as submission 116. I now invite you to make a short opening statement and then after you have spoken I will invite members of the committee to put questions to you.

Dr Carey: Doctors for the Environment Australia is an organisation of medical doctors and students who advocate to address the impacts on people's health from damage to the natural environment. We would like to thank the committee for the opportunity to present our views by teleconference. Firstly, we would like to pay tribute to George Bender and his family for their courage in speaking out against considerable odds, and we would like to express our sorrow at his loss and commend the government for proceeding with this inquiry. We hope that the outcome of this inquiry will result in important protections for the health of people like George and many other Australians.

In 2011, DEA presented to a former Senate inquiry relating to unconventional gas activity. At that time, we argued that water and air pollution, water shortages, permanent degradation of productive agricultural land and loss of livelihood and landscape all have mental health consequences in the communities living in a gas field. At the time, health was not even on the agenda for a government inquiry, so in almost five years there has been, thankfully, some progress in that regard. We also said, in the following years New South Wales government inquiry on CSG, that we consider the current level of assessment, monitoring and regulation of unconventional gas activity to be inadequate to protect [inaudible] generations of Australians and the potential for public health to be affected directly and indirectly through contamination of water, air and soil, and for mental health impacts on communities who have had environmental changes imposed upon them. This is still our position.

Since then we have made submissions to inquiries in Western Australia, the Northern Territory, Tasmania, South Australia and Victoria, and now another Senate inquiry. Our question is, 'What real progress has been made by Australian government in protecting the health of Australians from this ever-expanding industry?' We recommend to this inquiry that there be much stronger national oversight and protection from processes which, at a state level, are often inconsistent, inadequate and lack transparency. We argue that real progress is needed to address the information gaps required for the proper assessment of the risks to human health in this industry. Until we have better evidence of safety, new unconventional gas operations should not be approved and better monitoring and assessment should be required for existing projects. Our national chemical regulator should have the power to require full disclosure of all chemicals used in fracking operations, and these should be available for comprehensive risk assessments of human and environmental harm. Human populations, prime agricultural land and water supplies must be protected from the impacts of the industry.

We understand that governments are custodians of the minerals below our soils for all Australians. The way governments have transferred these rights to corporations without proper oversight and restriction has the potential to counteract economic gains with social and individual damage, such as that seen in the tragic case of George Bender. Governments are also custodians of sustainable agriculture and water supplies, which will impact on the health and wellbeing of all of us into the future, and our communities expect them to be managed wisely. Allowing mining companies, effectively, a blank cheque when it comes to water utilisation and not requiring safe solutions for the disposal of salt waste in the driest continent on earth does not seem consistent with guardianship.

Aquifers are a resource for all Australians and do not stop at state borders; their pollution does not either. With the relatively short life of a gas well, an ever-increasing number of wells will be needed to meet the needs of export facilities, with industrialisation of the countryside spreading like a rash and an increasing number of people being affected. There are no definitive long-term health studies in Australia which assess the health impacts of this industry on people's health. There is currently no significant independent resourcing of such research that we are aware of. However, there are more and more scientific papers being published to give us great cause for concern as doctors and which add to the jigsaw puzzle of preliminary studies and documented impacts on the social and environmental determinants of health.

The interim report of the 2011 Senate inquiry recommended a comprehensive review of chemicals used in fracking completed within the next few years. We have yet to see an outcome. The report also noted that it is vital that the interests of a relatively short lived industry are not allowed to put at risk vital food-producing industries, and the land, water and communities on which they depend.

The concerns that George Bender had were legitimate and were recognised by an Australian government inquiry years ago. We call upon the current government to now act to protect the health of all Australians. Thank you.

CHAIR: Thank you, Dr Carey. Senator Waters, do you have questions?

Senator WATERS: Yes, I do, Chair. Thank you so much, Professor Willoughby and Dr Carey, for coming along today. I recall your evidence to that inquiry five years ago. I, too, share your disappointment that progress has not been made in relation to the regulatory environment, particularly that there has been little done about health. Given that you now have another opportunity, for the benefit of everyone listening can you run as through what your concerns are with the human health impacts of coal seam gas, shale gas and tight gas, and how you think the issue should be addressed.

Dr Carey: As we have outlined in our submission, we believe that there are actual and potential threats to health to the public from this activity. The evidence around the actual health impacts is currently fairly minimal. Most of it is related to a fairly small number of studies from the United States. But, as we have mentioned in our submission, year by year there is an increasing amount of scientific literature that is coming out that, put together, is cause for concern.

Also, there is quite a burgeoning amount of information both from Australia and from overseas in terms of the impacts on the environmental determinants of health. By that I mean: for good health, we need clean air, clean water, safe food, safe climate. We know that there is good evidence to date that there are impacts on air quality. Health can be affected particularly by air pollution. This is a problem because, rather than being a point source of air pollution which is regulated and [inaudible] a system, it is a widespread network of smaller sources of pollution. From these sources of pollution, we can get volatile organic chemicals, we can get particular matter—benzene is included in that, but there are others, as well. Also, we can get precursors that come together to form ozone. Ozone is a respiratory irritant for humans, and worst in asthma and other conditions. We also know that considerable leaks in terms of methane have implications for the climate and for global climate change, which has impacts for human health.

In terms of water security, there are a range of threats which are well documented. For instance, the most recent report came from the US EPA in 2015. It talked about the way water can be effected by chemicals that are put down into the fracking fluid, are mobilised from beneath the surface and produce water that comes to the surface. That can affect surface and groundwater. For this range of chemicals, we have very little knowledge about what is actually happening with them. There is a lack of disclosure about the toxicity. In order to assess human health impacts, we really need to know the toxicity, the sorts of doses, duration and exposure that people would have in relation to these.

I think the US EPA study has estimated that something like between one and 12 per cent of wells that they studied had accidental spills and about eight per cent of those spills ended up in waterways. They found literally hundreds of chemicals in produced water. Even when this produced water is used for what is called 'beneficial use', where it is put on agriculture and pastures, we cannot be 100 per cent sure that this water is always safe because not all contaminants are used by this purification process. Currently. there is very little testing to see if any of these chemicals are actually migrating out through the food chain. So we have concerns about food security and water security apart from the climate impacts, which I am sure are well known, but I can enlarge on this if you like. There is a range of community impacts in terms of what happens when the industry comes into a community; what authorities commonly call the 'boom town effect'. People are differentially affected—some people might be affected financially, some people might just experience anxiety and disempowerment, with an inability to control their lives. It is evident that mental health problems can ensue and pre-existing mental health problems can be exacerbated.

There is a whole range of ways in which health is affected actually and potentially. We do not have a lot of information and data because we have not been putting the resources into the long-term studies that will give us the answers. The two major institutions within Australia that are doing some work related to health and social impacts are both at least partially funded by coal seam gas companies. I am not saying that their research is not legitimate, but we are not putting in resources such as NHMRC funding, which has recently been allocated in relation to wind farms. We are not seeing that sort of resourcing in relation to the health impacts of unconventional gas. What we need to do is to be certain that, before we proceed any further, we are not going to

cause long-term harm to people and communities, and we really need to exercise caution in that. I am happy to answer further, but I will stop there.

Senator WATERS: Thank you. That is a fantastic, comprehensive answer. Why do you think the industry has been allowed to get as far ahead as it has without those long-term studies on community health impacts being done beforehand?

Dr Carey: The obvious answer is that there are considerable economic incentives for the industry to go ahead. One could argue that governments are conflicted in that on the one hand they are wanting to accrue economic benefits for people of their state and on the other hand they have a duty of care to those same people. Very often government departments might have conflicting priorities, and I think that what probably happens is that, with a new threat to health, it does take a long time before it is officially recognised. If you look at what happens with communicable diseases, even with Ebola or now the Zika virus, you can see that with institutions such as WHO or with governments it does take a while for people to wake up and really realise the importance of that and to put resources and energy into dealing with that threat.

On a much lower key basis, the threat from unconventional gas perhaps has not been recognised. As I said, the evidence has been accruing over recent years and the institutions which are there to look after it perhaps have not quite caught up with that. There are some encouraging signs there that I have seen. As far as I am aware, until recently there has been no health department input into these inquiries—the exception being just lately in Victoria, where the Acting Chief Health Officer gave evidence. I am very encouraged by that, but I feel that it is unfortunate that health has been left out of the conversation until now. And as long as the conversation is only about water or only about money, then part of that equation that the community is demanding from their governments has not been met. I think governments have been very slow to catch up after these effects with the sort of rapid expansion of the industry that we have seen.

Senator WATERS: Would you recommend that no further approvals be issued until those independent long-term health studies have been done?

Dr Carey: Yes, we would, as we say in our submission. We also would hope that even the existing approved projects have better monitoring and compliance than they have had to date.

Senator WATERS: Thank you. Given the time, I will hand over to some of the other senators. Thanks so much.

CHAIR: What medical testing should be undertaken in regard to individuals who are impacted health wise when it comes to unconventional gas mining? Is there any possibility of testing them for large metal deposits in their bodies? Who should be doing the testing there? For some reason, in my state of Queensland it is very difficult to get help sometimes. I am not sure why. Who do you think should be testing those people?

Dr Carey: That is quite a difficult question to answer. It depends on individual circumstances, so it would not be appropriate to generalise. Just as when you go to the doctor and say you want to be tested for everything to make sure you are okay, the doctor needs to have some sort of background, some sort of history, some sort of assessment in order to do the appropriate tests. Some chemical exposures can be tested for but some are much more difficult to test for. As we know, there are numerous problems with chemicals. There are different chemicals used in different places, in different wells and at different times. One of the big problems is the transparency around the chemicals. If we do not even have any information about what chemicals are used in a particular well, it is very difficult for a doctor to order appropriate testing, even if that testing is available, without knowing what people have been exposed to. Some chemicals require very specialised testing that may not be routinely available through a person's local doctor. And sometimes there can be a range of other things that can impact upon the test result. So it is quite a complicated thing.

I have been involved with the health department, which is looking at doing risk assessments for people's health problems. In order to be able to do a risk assessment, you need to know about the hazard—the thing you are being exposed to and that you are worried about. In this case, it is a chemical or a range of chemicals. So you need the toxicity information about that. As we have said in our submission, the vast majority of chemicals that are used have not been assessed for safety. So there is very little information and, for some of them, we do not even know what they are because they are commercial in confidence. On the other hand, we need to know about people's exposure. We need to know the dose they might be receiving. We need to know the way they might have been exposed to something—whether it is through their skin or through breathing it or drinking it. And we need to know how long they have been exposed to it. When a doctor looks at someone who thinks they have had a chemical exposure, they would need to have the majority of that information on hand to make a rational assessment before anything could go further.

I will relate your question to a specific example. I go back to the Queensland investigation that occurred and the report that came out in 2012. What happened there was that no clear link was found between CSG symptoms and exposure. But we know that there were big gaps in holes and that study. It was retrospectively; there was not monitoring put in prospectively. We know that the government relied very heavily on industry data which was incomplete. But we do know that they reported at the time that there were already psychological impacts among people in that area and there was a recommendation for services to those people. We know that very few of the people who were complaining were actually physically assessed. And we know that there have been complaints from people in that area that they have not been receiving the sorts of services that they need.

So the approach to people who have been complaining of symptoms has been quite problematic. As far as I am aware, none of the recommendations of that report from the Queensland government have yet been instituted. As far as I know, there has not been comprehensive air quality monitoring, nor have increased services been given to those people who are clearly having problems. I am afraid that does not completely answer your question. It is a very complex issue, but I am happy to try and explain further.

CHAIR: That is okay. You can answer the question in any way you like. What would you like to see implemented in terms of baseline testing, and what would this achieve?

Dr Carey: It is very important to have that environmental monitoring because, from that, we can start to see whether things are bio-indicated in humans. Sometimes when people are exposed to something it does not necessarily cause a harmful effect. But sometimes it does. And sometimes there can be something in their blood or urine that can be measured, depending on what the chemical is. But the early starting point is really to get that environmental information, which in many cases has not been required. We absolutely have to have information about what chemicals are going to be used. We find it extraordinary that our national regulator does not have the power to require this information of companies, and even years down the track we still cannot access this information. So that is essential.

In terms of monitoring the water quality, we need to know what goes into watercourses. They need to be tested. We need to have independent verification of what is going on there. In terms of air pollution, the United States has moved to put limits on the amount of volatile organic chemicals that are coming off these sorts of operations. There is nothing that I am aware of in Australia, but there have been no impact studies done. So we need much better monitoring of the air quality around coal seam gas wells and shale gas wells wherever people are exposed. Those sorts of techniques are available. It is a question of resourcing and having a requirement to have appropriate monitoring.

We need to monitor water. We need to test the water before people go in, and we need to test it during and after the process. Otherwise what happens is that, when there is a problem, the companies can turn around and say, 'It wasn't us; that could have been there before.' It is a very difficult thing to prove. As you are aware—and I think it happened in the case of George Bender and his water supplies and his bores—because of technology that can go kilometres underground there can be impacts very far distant. And trying to prove after the fact that there are impacts is very difficult, so it is very important to put baseline monitoring into place before the industry comes in.

CHAIR: I thank you for taking the time to talk to us today.

Proceedings suspended from 11:58 to 12:31

ANDERSON, Mr Robert, Traditional owner

ANKIN, Ms Rosita, Traditional owner

DOWADI, Mr Andrew, Traditional owner

FITZPATRICK, Mr Nicholas, Traditional owner

HOOSAN, Mr Gadrian, Traditional owner

MASON, Mr Eddie, Traditional owner

WILLIAMS, Ms Helen, Traditional owner

YARRNGU, Ms Molly, Traditional owner

CHAIR: I welcome the Mataranka traditional owners, traditional owners of Arnhem Land and Protect Arnhem Land.

Information on parliamentary privilege and the protection of witnesses and evidence has been provided to you. The committee has a submission from Protect Arnhem Land, which the committee has numbered submission 115. If anybody has any questions about parliamentary privilege and the protection of witnesses make yourselves know and the secretariat will be more than happy to answer any of those questions for you. I invite you to make a short opening statement, and after you have spoken I will invite the commttee to put questions to you.

Mr Anderson: I am also a pastoralist, at Manangoora station, pastoral lease 685, portion 0408. Besides being a traditional owner I am the chairman of a committee we made in Boroloola through the Northern Land Council. Through that we work in the Commonwealth structure. What we are doing at the moment is finding some funding we hope to get some things worked out. The case may be about this certain thing that we may have to talk about, but as I introduced myself, as we go along I will be happy to answer any questions. If anybody likes to ask me any questions you are welcome to do it.

CHAIR: Does anyone else want to make an opening statement?

Ms Williams: I am from Maningrida, in Arnhem Land. The population of Maningrida is 3,000. I am a mother, grandmother and great-grandmother. I am here to talk about the children's future as well as having a healthy and happy environment and having beautiful water like we are having here now with us. I would like to talk about a few good things that we want to talk about, that you want to listen to from us and be able to take a message from us. I am quite happy to give you some of the stories. Thank you.

Mr Mason: I am the founder of Protect Arnhem Land. I am here to talk about why this mob want to come and destroy my country when I have got everything there that I need. That is the reason I come here to talk about that—no poison or nothing on my land. That is the reason I come with my other colleagues here. We want to try to get to you guys to tell them that we are not for sale, my people are not for sale and the land is not for sale. We want to keep our culture as it has been going for generations. We are teaching our children the same thing. We would like to hear the government tell us a good story about how we can work together and maintain and look after our country. That is all.

Mr Fitzpatrick: I am a junkiyi for my country. Junkiyi means carer and protector of the land. I am here because I am genuinely concerned about what is going on in the country with all of this mining activity. There is a huge problem there. We could pollute our country. It will all happened so fast you will not even realise it.

Mr Hoosan: I am a Garawa man from Borroloola. Nicholas is my cousin brother. We are both junkiyi for our mother country. It is our job to look after our mother country. We are seeing a lot of things that happen in our country. We sit right into the Garawa Land Trust. We have got licences, exploration permits, all around the land trust on the pastoral area and native title.

Uncle Jonsie is also my uncle. We came here today to make sure that you know we do not want this thing to happen. We want to let everyone know in parliament that we are here to talk for the country and make sure the country is safe because we need our waters. We have the McArthur River already contaminated. With fracking were going to face double trouble. We need to stop that now before it is too late. It is not just for us. This mob here talked about our future generation. That is the main thing. Our future generation is important. They have to live in this country in the future when we are gone. We want to make sure that they live in a clean environment in the future. This country is for them.

Mr Anderson: I would like to add about being a junkiyi. These two fellas on my left are my gaathus. Gaathu means that they belong to my sister's kids. Junkiyi is not only the protector of the land. I am junkiyi for them and

we are junkiyi for each other. We also look after each other and not our own backs. Junkiyi is a form of a very cultural structure. Junkiyi actually means manager and, if it was used in the old court, judge, jury and executioner. That is the true meaning of what junkiyi is.

As I have noticed through the political ways, the traditional owner owns the land and that is from your father, but when you are junkiyi that is from your mother. When you are junkiyi you can paint and talk stories about your mother's country but you cannot do it for your father because it is taboo. If we did that, we would be breaking the law. Our law and culture is there for everyone. It does not matter who you are. All we would like to do is explain. We know two laws.

We are not supposed to mention these old people's names. When we say moranji, someone who has passed on, we cannot mention it. Just to explain it to you I will have to name these people. There was Leo Finlay in that video, Don Miller and old Splinter Woody. That was taken on North Island. This was many years ago.

There is a follow on of the two laws. My gaathu Adrian is in that as well. What the two laws is all about—because we know ours and we also know yours—we would like to share with you. Because we know two laws and you do not know ours—you do, but—I would like to put in the technical details so that way everyone can have a good understanding. There will also be another one done with that. What we would like to do is share it out to everyone. Pass those copies out so at least everyone gets a good understanding.

CHAIR: Thank you, Mr Anderson. Have you had any consultation with gas and mining companies? If you have, are you happy with the process so far?

Mr Anderson: Sorry, I forgot to tell you this. As a pastoralist, what happened on Maningrida station is that the gas company came through our property without any formal written letter to get permission. They have made roads, and the worst thing they have done is driven and smashed our fences down. We have cattle and horses and our calves and foals in there. I am trying to explain that they did not ask us permission for what they did, and we did not know that because we were busy working in other areas, because we were having a bad drought. What happened was that our foals and calves were getting that weak, and there were dingoes. But we did not know that, because we were looking after here and there, because we breed our own stock horses as well for working purposes and for gymkhanas, rodeos and the pony club for kids. Then we came back and saw our fences gone and all our cattle scattered all over the place. We had to remuster them and redo our fences. There was not even a thankyou. That is reality. Our animals are outside getting eaten by dingoes, but the dingoes are not doing anything wrong; they are just looking for a feed. What hurt us is that they should have asked us first, and they did not have permission.

CHAIR: Thank you, Mr Anderson. In your dealings with these gas and mining companies, do you feel they have got your best interests at heart? Are they dealing with you in an appropriate manner?

Mr Mason: They are not dealing with us in an appropriate manner. We started this Protect Arnhem Land—for five years. They never told us what the problems are going to be after they have gone—where they are going to put all their rubbish, where they are going to put all the poison. We are worrying about that. Who is going to end up cleaning it up at the end of the day when they are all gone? We had reports from the United States that there is leaking and that everything is going to go wrong in the steams and everything, that it would even pollute our waters.

I go back to the brother who was talking about the cattle and everything there. We all eat meat here. We love our meat. If that goes down the well and the horses and cows want to drink the water, it will start killing the cattle. We eat the meat from the cattle mob, the pastoralists. Think about that now. If you put poison in our streams then you feed that to the horses or the cow, what does that mean you are going to eat after that? You want to think about that—it is very important—before you put the poison down in our ground. It is not only our ground; it is everybody's ground—white and black.

Ms Williams: It is two areas, all fracking, but we talk about the pastoralists and the saltwater country—the beaches, the shoreline, everything. We do not want any oil or gas running along the sea line, because it will ruin our hunting ground. It will ruin everything—the beautiful water. Just like all the animals of the pastoralists—it will ruin their drinking water and even the mussels we collect, or the crabs or the fish. Maningrida is a beautiful place. We do not want to see this big thing standing there, with a machine. We just want a really clear and clean environment in the Northern Territory. Here we are all together talking about one thing: please, we do not want fracking. We do understand about this gas. With this mob, we need more consultation to make other people understand. Sometimes it is very hard for people who do not understand. They say 'yes'—and, click, dollars, money on my land. If one says yes, it will affect the whole of the country. We are trying to educate the people about the environment. Maningrida has 10 different language groups. It is a huge place, not like Borroloola. And

we are talking about not only Manangoora but also along the coast of Arnhem Land and in the Arnhem Land and inside the pastoralist area, around the Katherine are, wherever. That is the story now, from me.

CHAIR: Thank you, Ms Williams. Mr Dowadi?

Mr Dowadi: I just want to say: respect the peoples who live in the land, respect the peoples who own the place, because of the animals that live in there, because the water has to be good for drinking, and respect those people who have lived there long enough. But we did not know those things that you were going to do, these things that are damaging all the stuff. There are things that are living on from the old generations so we can pass them over to our children, to educate our children, to live alongside—instead of living in towns, or with poison things leaking everywhere. We have to teach them how to look after themselves when they go hunting, especially at the seaside and inland. That is the meat that we eat, that is the water that we drink out of, on the land. That is why we have to be respectful. But we did not know these things were going to be happening in these years. If I die, those kids will not understand. You have to respect those people who are living there. What do you call it when you have an accident, when you get sick and there is a financial thing that pays you—if you are doing your job and you break your arm and everything, they pay for it?

Mr Mason: Insurance.

Mr Dowadi: Insurance, I am talking about. The animals do not have any insurance. They live free, like us. We live with them. They feed with us, and we drink with them at the stream and at the seaside. The things that live there are good things like crabs, oysters, turtles, anything—you name it. And inland we have turtles, emus, buffalos and everything. We eat those things.

If you put those things in there, how are we going to go hunting? Who is going to pay for us in our sickness? Who is going to pay us for our coffins? All those things, we do not understand. Those things that you are digging out there—we do not know anything about it; only you know. We know nothing about it. We are a free people who live there, the longest to have lived there, to look after our land.

CHAIR: Thank you. I just want to ask, and anyone can answer: do you think the land trust is accurately representing your people?

Mr Mason: The land council?

CHAIR: Yes, the land council, sorry.

Mr Anderson: I am the chairman of a committee and we have just finished working on a native title claim. May the old fella rest in peace: Mr Mabo—sorry to mention his name. It went to the Queensland border, and that is also up to Blue Mud Bay. The only gap was Borroloola. So what we did from the Queensland border we added it on to Blue Mud Bay. So we joined that up. Also, next door to Manangoora station is Greenbank Station—like us again pastoral activities—and Seven Emu and Spring Creek; they are also under native title. Now, with this committee, we talked with our people about King Ash Bay, which is like Manangoora: we have a tourist industry running as well and we have crabbers working there. Because there are so many tourists going to King Ash Bay, it is getting overcrowded. Native title is all about protecting the land. I said at the meeting, 'We cannot have too many people there. What we have to do with the tourists is spread them out, because, if you are all in the one spot, you are going to take fish, crab, whatever, and it will be gone. Then you move to the next spot and the same process happens.' An old fella down there who is a good old mate of mine from King Ash Bay agreed, because I said, 'You go to King Ash but you can't even put your trailer in, there's so much.' So what we agreed upon was we were going to spread all the tourists around. Also, the sea rangers are working very well and we are going to actually have a sea ranger base also at Vanderlin Island, because the tourists go out there as well, also to North Island, West Island and South West Island.

If you look on Google at the map, by jingo, that is beautiful, pristine country—untouched. But what it is ALL about is that everybody in this room, all of us, share it. Anybody is welcome.

It is beautiful country. Besides fishing, there are feral pigs—which do damage, and the sea rangers down there are doing nothing—and we on the committee are making industries so that we can take tourists out pig hunting. A lot of people enjoy that. I was down in Newcastle four months ago visiting my daughter. Most of them come from there. A lot of them are our mates. Besides taking them out pigging, we show them bush tucker and tell the stories of our sacred sites. We have got dingo dreaming, bulgur dreaming and all those kinds of things. We explain all this to them and they are so amazed, and I say, 'Mate, you are welcome here any time; this country belongs to you.'

CHAIR: Senator Peris, I will hand over to you but I think Mr Mason would like to say something.

Mr Mason: Yes. Like brother Anderson said, we are starting up a business at Maningrida to do pig and buffalo hunting and barramundi fishing and we are starting up a fishing industry and we can provide work for our people in that area. Instead of the oil and gas company coming in and drilling and offering us money to start working on that land, we can make our own money and our own living. We have a lot of things there that we can trade with you. That is the plan for us back at home. We can sell things that we have over there and we can give it to you guys and you can export it and sell it somewhere—oysters and crabbing and industries like that.

We do not want this gas and oil company coming there and digging and destroying everything. If we destroy it we cannot sell anything. That is the difference between you and I. We are starting up a business over there. We can start a business with you guys in the government. There are a lot of things there that we can offer you, but we cannot give over our land for them to destroy it.

Mr Fitzpatrick: Can I say something?

CHAIR: Sure.

Mr Fitzpatrick: I used to work for the Sea Ranger unit in Borroloola. I came straight out of high school. I have always been very passionate for country, so I was always in these NLC meetings when it came to mining people coming in and being interested in our country. I was young. I was 17 when I started in ranger unit. When you are young like that, you cannot really stand up; you have let the elders have the say. So I was just sitting back and soaking in everything that was happening and I saw the way the NLC work with mining companies. The meetings that they organise are not organised properly. They tell people the day before or just two days before the meeting, and they send out word that everybody is going to get this royalty. There is no information about what is really going on; it is all about the royalties. Everyone is interested in the royalty and they turn up and they will pretty much sign anything just to get to the end of that meeting where they get to talk about money, and they just get jammed. I have seen that happen lots of times. So the NLC is not for the people. What we really need is our own land council, where we can stand up and come to real deals for our country, instead of just being tricked and deceived.

Ms Williams: I have been on the board for 15 years and I am still on the board for the Northern Land Council. I have seen it; I have witnessed it. I wanted to give up and I thought, 'No; I will still fight on.' A month ago we had a meeting at Katherine and we were talking about this fracking. But when they started talking about mining, I said, 'I don't want to hear about mining; here we go again—mining, mining. Aren't you guys going to ever support us by saying no to fracking? You represent the land and the sea. You say, 'This is our land; our life. Where is it? Where is our land and life?'

Some of the members do understand and some do not. I think it comes from the higher position. That is what I really want to know. It is like that young fellow said. I am still on the board and I am still fighting them. I feel like giving up but I do not want to because of what the people said. All they are interested in on their land is traditional owners. They do not understand what that man said earlier—the junkiyi. I am the junkiyi of [inaudible] to my mother country. They do not recognise [inaudible]. They recognise only TOs. So they go head to head with the NLC talking to TOs. They asked, 'What about us? You have to respect us, too, and listen to us. The other people are the TOs of their own country—from their homeland—so can you also talk to them, because they are human? We are all human.' That is a story I wanted to tell you. I am still on the NLC board I will keep on fighting.

Senator PERIS: Mr Hoosan, you visited me recently in Canberra. For the committee's interest, would you like to share your experience of what is going on in Borroloola at the moment and the experience you have had with mining there and what is happening now on the McArthur River?

Mr Hoosan: The McArthur River is not our country. It is on Gudanji country. What is happening on the McArthur River right now is that all of the poison coming out from the McArthur mines is running into the river and has already contaminated it. They had no right to contaminate that river. All of that poison should stay in the mining lease. We used to fish on that river from the top to the bottom. That was our livelihood, and they took that away from us. We cannot even eat the fish any more. We have strangers coming down there and telling us, 'You can eat only a little bit of that fish. Don't eat too much of it.' We used to cook and eat a whole lot of that fish. We have strangers telling us this. They are people who don't even live in Borroloola or even have a house in Borroloola.

This is the sort of thing we are facing and now we have to face fracking. That is going to make it worse. They are going to damage the whole McArthur Basin. All the poison is going to migrate underground and come up in the river beds underneath and then come up into our tap, and what is going to happen? Our tap is going to be poison. You can turn it on and have a flame coming out of the tap. We have seen all of that happen. We have

already experienced all of that around the country. We have seen that happen in America and in Queensland. We know of all the bad things that will happen from fracking. That is the whole reason why we are here. The whole reason I am here is for fracking. It is not to bring up any other issues. That is the only issue I am here to talk about, because we already have the McArthur River mine damaging the country. They cannot even stop the waste rock from burning. They stacked all the clay up to stop it, but they cannot. If they cannot take control of that, they cannot take control of fracking.

That country is important. It is important for our food generation and for our sacred sites and for our dreaming sites. If you hang a book in front of you and read your stories and you have a missing story in there, what has happened? If you have a ripped page you have a missing story. If you rip a dreaming site out of our country you are ripping our story off the land, and our story is bigger than the book you are holding in front of you. It is in the land. Our land is important to us. People do not understand it, but we understand it. All of this mob here understand it, because we all look after the land. That is what we are here for. We are here to stand up for the rights of our country and future generations.

Senator PERIS: Thank you. I appreciated your visit to Canberra recently. Would you like to elaborate on those points, Mr Anderson.

Mr Anderson: Going back to the spillage of the mine, what happened was that the contamination went further than they thought. I was born on the beach on Vanderlin Island, in 1967. The McArthur River Mine has got lead, zinc, copper, a little bit of gold and arsenic. Fair enough, arsenic dilutes, but there is all that lead. Around all those islands is the sea, and when it comes in it acts like a washing machine. Vanderlin Island is 30 kilometres long and 15 kilometres across. When my uncle was alive, he said to me that there were fish from one end of the island right up to the top. He said to me, 'You know what, son? There are even fish in the deep blue sea that you don't see.' So what he did was grab some samples. Old Mr Garrett—Midnight Oil—was the environment minister at that time. So I gave him the sample, but that sample never came back. The old fella tried to explain about the fish, but it seems that nobody wanted to believe him. The truth is: why didn't they investigate it? It is covering up.

We mention tourists going fishing. Fish is our livelihood; it is a healthy food. Besides that, what was on the news? Back in those days we could hear the trawlers out the back. They would get prawns from there and take them over to Japan. Do you know what? We do not hear any more trawlers out there, because those prawns were contaminated. Nobody knows about that. I forgot, because I was busy looking after my horses and cattle and so forth. That is the sad truth. I do not think there are any trawlers out there anymore. The country is coming back now, because, like I said, the sea is a washing machine, so it actually cleans itself out. We had a big flood and we tried to tell them what happened to us who work at that mine. The tailings dam broke. And what was there before the tailings dam, before they put in that diversion, was a little creek called Barney Creek, which flows into the McArthur River. So it all went out there. Going back to Senator Lazarus: the gas company is Armour Energy. I just remembered.

CHAIR: Thank you.

Mr Anderson: You're welcome.

Senator PERIS: Mr Mason, I know you are the founder of the Protect Arnhem Land. Could you tell the committee where things are at now. I know your resilience continues with the fight for country.

Mr Mason: It always continues with us. There has never been a moratorium or anything like that. Every time we start up a moratorium for five years, it is on again straight after Christmas: the government is down our throats. They do not give us a break for five years—no. After Christmas has gone they are there at my front door; they are there. They want it badly. When all my workers are on holidays or I am away from there, they come down, banging on the door, talking to other people who do not understand about this problem. They talk to them. But before they do that, they ought to say, 'I will talk to Mr Mason; he knows all about this issue here,' so the people will call me. Then I would tell them, 'Whoever that government person is down there, tell them don't talk to him until we get it sorted out again.' They always come down and sneak in behind my back—every time. When we start up a moratorium for five years, the next year they down our throats. We give them a fair go. Let's have a break for five years, and then we will talk about it after—but no. After Christmas, they are down there in our backyard.

How can we stop this? I can't stop them because they are the government. They keep coming and forcing, forcing. I told all my old people, all my elders and the seven or 12 or so tribes that I respect down there, that represent Arnhem: 'Whoever goes down there or whoever the government person or oil company is who goes down there, before he talks to you tell him to call me.' I represent those seven or eight tribes people over there. There are really 12 tribes that I have there. I am representing them because they are the ones who have put me in

this position. I have got to take the story back to them, whether it is a good story or a bad story. On the moratorium, I told them, 'Come on. Give us a break.' No. Every year they are down our throats—every year. It happens all the time.

When I talked to the oil company, they said, 'We'll give you five years break and then after five years we'll have a talk.' Nothing. Then after Christmas they are down there. When all my people are not there, they come behind and talk to the old people who do not understand English and everything, bribe them with rrupiya, bribe them with money—everything they want. [Indigenous language not transcribed] But I told them already—all my people. I said to them, 'Whatever government comes round there or any person who wants to come trying to sell your country or anything, tell them to call me or talk to the environment group over here, and we will sort it out.' I will tell them.

It took them five years to understand what we are dealing with here now. It took us three years, when we went to Canberra. They did not understand about this oil and gas thing—what is going to happen. Then we met Naomi Klein. She wrote that book called *This Changes Everything*. We met her in Melbourne. She told us about what is going to happen and what has been happening over in the USA and all that. It gave us a full insight of the story, of what is going to really happen if this goes ahead. We have seen the pictures and we have seen what the story is.

I showed that to my people. They looked at it and they said: 'No, we don't want this. We want our way, the way we are living. Think about your ancestors. Think about your dreaming. Think about all the culture over there.' That is what they told me. I got the story here for them, to tell to our tribe back at home there, representing them.

It has been going on and on. It has been about six years now, and we are still fighting over this. Maningrida is a last frontier. There is no damage, nothing done to it. It is a peaceful country. It is a beautiful country. Nothing has been damaged here. It is just as it has been for the last century. And we want to keep it that way for the next generation. We do not want this poison coming to our boundary—not only me but everybody too, whoever owns the land. They do not want it and we do not want it, all this—what do you call it?—industrial disease coming to our area.

Senator PERIS: Ms Yarrngu, do you want to say anything?

Ms Yarrngu: Yes, because this is part of our life—our life. We are looking at our life. My life is dirt; your life is book. What we are fighting for is a very important part of our life and our surviving. We own the land, and we are fighting for our future generations to stay like that. But, in the other hand of law, it is coming in, coming in: 'I just want you to break your promise.' That is here. To me, in my heart, I do not want to break my promise. I have to follow that promise that was given to me—the nature. Nature gave me that knowledge and the life, the way I can survive and grow and make life and home. But on this other hand it comes and pushes me to make me break my promise. Well, what are you begging for? The water is life for you to survive. With no water, how are you going to survive? So this is what we are fighting for—the book of knowledge and the native knowledge.

That is where I was born. No light. I saw the sun, the stars and the moon. After, I was taken to be educated. We are in a mix—cultural life, destroying our life. I experienced that. You have that judge law; I have that judge law. Understand who I am because my land is my life—and your life. We are not going to live in the indoors. So what is the danger that is coming behind our back?

CHAIR: We are running out of time. Senator Waters, do you have any questions?

Senator WATERS: No, but I have been listening intently, and I want to say thanks to everyone for speaking up. I am deeply grateful that you are able to speak with us and give us your views directly, so thank you.

CHAIR: We have run out of time, but I know there are a couple more people—

Mr Dowadi: Are we allowed to ask you questions?

CHAIR: No, that is what we are here for—to ask you questions.

Mr Dowadi: No, we should know you. We should know your background too, you know. It is a part of—

Witnesses then spoke in language—

Mr Dowadi: making sure.

Mr Hoosan: Just one more before we leave. We are not only doing this for ourselves, for our future generations. We are doing this for both future generations, non-Indigenous and Indigenous people together, because we all have to live in this country. It is for us both.

Mr Fitzpatrick: Can I just say one more thing.

CHAIR: Yes.

Mr Fitzpatrick: See this country. We do not own that country. The country owns us. The mob here now is the part of the small group that is still that country—when you give your mind and soul and heart to your country, it talks to you. It is talking to every one of us. It is very worried. We have to do something—Australia, global warming; it is all happening now within these next 10 years. Our country is talking to us, and if you listen hard enough it will talk to anybody.

Mr Anderson: Right.

Mr Fitzpatrick: We have to do something to protect Australia from collapsing.

Ms Yarrngu: Mother Nature.

CHAIR: Mr Fitzpatrick, you appear to me to be a very knowledgeable young man. What future do you see yourself having and your children having if this continues?

Mr Fitzpatrick: I see a future of pain and suffering and loss—yes, lost connection. It is just really sad. It would be living a really sad life—that the human race in our country here could not come to the terms and see all the reality that is happening everywhere and decide we need to change now before it is too late.

Mr Mason: For you, I would say: leave me alone and let me run my own business and look after the land myself.

CHAIR: Mr Mason, if I were the Prime Minister, you would not have anything to worry about, let me tell you.

Mr Anderson interjecting—

CHAIR: I am not in the government, but I wish I was sometimes!

Ms Williams interjecting—

Mr Mason: You stay on your side of the fence; I will stay on my side of the fence.

CHAIR: That is it. That is exactly right.

Mr Anderson: Can I say something to everyone in this room?

CHAIR: Yes.

Mr Anderson: We are all spiritual people, and, when you go out bush, you hear that quiet. You hear the old people. They are singing. You can hear them cry. It does not matter if the wind is blowing. You hear them crying. We are all spiritual people. And, if that happens, there is a heaven, and it is right here.

CHAIR: All right. We have to wrap it up there. I am sorry. Thank you very much for coming. Thank you.

ARMSTRONG, Mr David, Managing Director/Owner, Terrabos Consulting

CASS, Miss Pauline, Private capacity

EARLEY, Mr Braedon, Private capacity

FRASER, Mr Mark, Private capacity

QUINLIVIAN, Ms Belinda, Private capacity

RYAN, Mr Tom, Executive Officer, Northern Territory Cattlemen's Association

SILVESTER, Mr Lex, Private capacity

SLOAN, Mr Tristan Robert, Amateur Fishermen's Association of the Northern Territory

SULLIVAN, Mr Bill, Chief Executive Officer, MS Contracting

SULLIVAN, Mr Rohan, Private capacity

TAPP, Mr Daniel, Private capacity

WRIGHT, Mr James, Private capacity

[13:15]

CHAIR: We will start the community roundtable, which we will do in blocks of three. Each person will be given five minutes to make an opening statement to tell us their story or their concerns, then if the committee has any questions, we will ask questions after. Mr Sullivan, you can start.

Mr R Sullivan: I would just like to acknowledge Senator Ludwig; we have had previous dealings. I thought the committee might like to hear an alternative point of view from a cocky. I would like to relate how my experience over the past two or three years as a pastoral lessee in Northern Territory has been impacted by petroleum exploration activities. Our pastoral lease, Birdum Creek near Larrimah, is approximately 180 kays south of Katherine. The property was purchased in 2002 and is owned jointly by myself and my wife and our neighbours to the south. The property is 67,000 hectares and run in two halves.

My submission refers to dealings with exploration activities on the northern half. The exploration company Pangaea was granted exploration permits over the Sturt Plateau district, including Birdum Creek, in January 2013 and started making contact with property owners to formalise access arrangements. Problems developed fairly quickly as pastoralists objected to the lack of input into the proposed access arrangements and a perception of being rushed. These problems were only resolved when the pastoralists negotiated with the company as a group to address the issues of concerns.

Ultimately, there was an agreement with Pangaea. Legal advice was provided by a lawyer of the group's choice but paid for by Pangaea. The agreement reached between Pangaea and the group has formed the basis for a strong, functional working relationship. My assessment of the relationship now is that the majority of pastoralists in the district are either neutral or supportive of the exploration program and, ultimately, development of an oil or gas field should the program prove successful. There is no-one who is actively opposed.

In general, the local pastoralists see the activities with the exploration and potential development as a means of fast-tracking public infrastructure development in the district which would not occur otherwise. Pastoralists do not have rights over minerals or petroleum but do see potential benefits from the building of access roads and water supplies on properties which can revert to the pastoral lessee on completion of the exploration or development program. This may help to compensate for the inevitable disruption to normal pastoral activities.

Water has always been a critical issue on the Sturt Plateau. There are no permanent streams and very few natural waterholes. Underground water is present but not easy to find and there have been many unsuccessful bores drilled. Pastoralists are understandably protective of their underground water supplies and any activity which potentially threatens these is regarded with suspicion. However, during the course of the drilling program on the Sturt Plateau most of the local pastoralists have become familiar with the techniques used to isolate the water-bearing strata from the drill holes to prevent leakage and contamination. The main concern is about the amounts of water potentially used for hydraulic fracturing and the effect of this on stock water supplies.

Pangaea have installed monitoring equipment in bore holes; however, their water usage to date has mainly been for domestic purposes. During the course of their seismic and drilling program, Pangaea have identified and mapped a deeper aquifer, which was previously only poorly known. Water quality in this aquifer is lower than needed for stock or domestic usage but is suitable for use in hydraulic fracturing with treatment. It is now highly

likely that no water will be required from the aquifers we draw stock water from. In fact, there may be opportunity for us to source treated water from property use.

Pangaea have also had extensive LIDAR coverage of the area done to assist with the design of the Western Creek Road. An added benefit of this coverage is that Pangaea can now produce a map of ground elevation to plus or minus five centimetres over extensive areas of the Sturt Plateau, including Birdum Creek. This will enable the most efficient placement of dams and excavated tanks to capture run-off water for use in either the drilling or fracking operations or for pastoralists to use for development of dams for stock water.

From my point of view, the main problems in having exploration activity on my property are associated with planning. The placement of planned seismic lines can change, depending on drilling results and vice versa. Having a major seismic program means lots of new gateways need to be installed in fence lines, which is really just another job to do, even though we are compensated for the time and expense. At present, our half of Birdum Creek is relatively undeveloped and requires more fencing of water points. It would be far better from my point of view for Pangaea to get in and conduct their exploration and development activities before we construct more of our own infrastructure. Even with the best will in the world, there will be misunderstandings and communication problems. Rather than deal with this inevitable disruption and drama, it would be far better to get it over and done with. To date we have had over 100 kilometres of seismic lines, one exploration well and three kilometres of gravel road put in on Birdum Creek North. The only issue to arise was when Pangaea's contractors watered the Western Creek road to stop dust and were stopped by the department of infrastructure because they did not have a permit to work in the road corridor.

There is much made about the impact of multiple well pads and other gas infrastructure on pastoral land. My understanding is that horizontal drilling techniques now allow multiple holes to be drilled from one drill pad. These holes can radiate in all directions from the vertical, for up to or exceeding 1.5 kilometres. So potentially a 200 by 200 metre or four hectare drill pad could extract gas from under an area of eight square kilometres, or 800 hectares. Extracted to the rest of Birdum Creek North, which is 360 square kilometres, the whole property could be developed for production with just 45 wells, covering an area of 180 hectares total or 0.5 per cent of the property area. Other infrastructure would include pipelines to connect the wells to a central point and a compression station. But, even if this doubled the area, it would still only be one per cent of the property, and cattle can still graze where the pipelines are laid underground. If the property were to host a conventional oil and gas field then the number of wells required would be vastly increased.

The Kern River oilfield in California has 8,000 wells in an area of 10,000 acres. There is no way that any other land use could coexist with that. This may be an extreme example, but many of the images shown by anti-fracking activists of closely developed gas or oil fields are actually conventional fields. Horizontal drilling and hydraulic fracturing allow a much lower density of well pads. From my point of view, if there is to be any sort of mining or patrolling activity on Birdum Creek, I would prefer an unconventional oil or gas field over a conventional field or an open cut mine any day. Thank you.

CHAIR: Thank you, Mr Sullivan. Do you support the right of refusal on people's land?

Mr R Sullivan: If you have a tenure that allows the right of refusal, yes, I would support that, but we do not have that form of tenure. We have a pastoral lease. The Crown owns the rights to the minerals and timber and things like that, so we do not control that. Similarly, native title also exists on that country. So there are multiple interests in that land.

CHAIR: Do you think it should be implemented though? Do you think that, at the end of the day, a farmer or a landholder should have the right to say no?

Senator LUDWIG: If I could put it this way before you answer that: Santos has stated that they will not enter an agreement unless the landholder agrees. In other words, they have provided that imposition on themselves as a reasonable way of dealing with access, because they recognise, as I understand it, that access can be difficult for some. So, would you agree with the companies providing that imposition on themselves to ensure that, if there were parties who found it too burdensome to have shale gas on their property, they would then not have it?

Mr R Sullivan: I do not think I can speak for a company. My understanding is that, in the United States, that form of tenure does exist in places. If you own a piece of land, you own the mineral rights and the water rights basically to the centre of the earth. There were actually areas of land around Batchelor that were held under that form of title many years ago, and the Commonwealth government compulsorily acquired them. It is nearly that form of tenure that is enjoyed under the Aboriginal Land Rights Act, but I could not see that any other privately owned land would ever be offered that. I could not see it happening.

CHAIR: You could not see it, but do you think it is something that we should consider?

Mr R Sullivan: If you like, Mr Chairman, maybe you could get it through the Senate.

CHAIR: Maybe I could. I doubt it, but maybe I could. We will go to the Amateur Fishermen's Association of the Northern Territory. Over to you, Mr Sloan.

Mr Sloan: In terms of the unconventional gas industry, AFANT has serious concerns over the potential risks to the aquifers and also to the associated stream flows of some of the iconic Top End rivers. While we understand that the unconventional gas industry has the potential to greatly benefit the economy of the Northern Territory, we believe it is extremely important to acknowledge that there are significant international and domestic examples of unintended environmental consequences as result of the unconventional gas industry. AFANT believes that there is the potential for the contamination of aquifers and surface water should the integrity of these gas wells be compromised. This includes failures in the containment and safe storage of wastewater laden with chemicals and by-products.

Our main concerns revolve around two things. The first is the regulation of the unconventional gas industry. The major recommendation of the Hawke inquiry in 2014 was that the environmental risks associated with hydraulic fracturing could be managed subject to the creation of an effective regulatory regime. Despite stringent regulations within Australia and internationally, there appears to be a broad failure of regulatory regimes when it comes to unintended negative environmental consequences. The other issue we have is that, at present in the Northern Territory government, the budget is severely limited in regards to groundwater monitoring. Assessment programs are constrained by a lack of resources—both economic and, obviously, knowledge. What has been identified is that the economy of the Northern Territory has both a social and economic dependency on groundwater. The groundwater environment of the Northern Territory is poorly understood when it comes to, especially, groundwater flows into aquifers and the flow of aquifers into river systems. This basically raises concerns that the Northern Territory government does not have the adequate skill set to monitor the impacts of unconventional gas mining and the possible negative environmental effects.

The other issue we have is in regards to the Northern Territory EPA. AFANT believes that any environmental reform in regards to the regulatory regime around hydraulic fracking is meaningless unless the Northern Territory EPA is a truly independent body with the strength and powers of prosecution and significant penalties for breaches of environmental legislation. The current head of the Northern Territory EPA, Dr William Freeland, has himself described the Northern Territory EPA as a toothless tiger in the media when it comes to environmental prosecutions. AFANT has for some time raised the appointment of an impartial EPA, with funding and staff outside of any Northern Territory government department as our primary concern in the process of environmental reforms for the unconventional gas industry.

CHAIR: Mr Armstrong, over to you.

Mr Armstrong: I am fronting the hearing today pretty much as an information session, so to speak, to let you know my involvement in this industry. I established my Darwin-based consulting, Terrabos Consulting, in 2011. The business was focused on Northern Territory oil and gas exploration, mining, the pastoral industry and Aboriginal economic development. I have over 25 years experience in the pastoral industry across rural and remote Australia, with 14 of these in the Northern Territory. Prior to establishing Terrabos, I worked for five years at the Northern Land Council in rangeland management, which was focused on sustainable pastoral development on Aboriginal land, successfully increasing Aboriginal involvement in the pastoral industry by placing approximately 50,000 head of cattle back on country, plus opening up numerous employment opportunities. I negotiated long-term pastoral lease agreements; implemented infrastructure development programs, weed and feral animal control programs; negotiated multi-use lease agreements encompassing pastoral, exploration and tourism; plus implemented training and employment. This work took me to all corners of the NLC region north of Tennant Creek and gave me enormous insight into Aboriginal culture and decision-making processes and, most importantly, their aspirations. I also developed personal relationships and trust, which does not happen overnight and I do not take lightly.

The 2011 federal government ban on live export to Indonesia knocked my business sideways and made me look at diversification. In 2012 I was engaged by Pangaea Resources to assist them to negotiate pastoral land access, being a local, and help them to navigate the NT environment and introduce them to local businesses, as from the outset the company was committed to engaging local contractors. I have now been involved in negotiating access across four exploration companies and informing pastoralists of oil and gas activities across 56 stations north of Tennant Creek and south of Katherine, plus I have negotiated native title access. To put this into perspective, with an average sized station in the Northern Territory of 3,000 square kilometres, this is two-thirds the size of Victoria.

At the forefront of my role is managing the coexistence exploration companies have with pastoralists and traditional owners. This has given me a solid understanding of the feeling towards oil and gas exploration in the bush. There are concerns, but the main concerns I have come across from pastoralists and traditional owners are about surface impacts the oil and gas industry may have on their business and country and how coexistence will work. Things discussed include protection of assets, weed control and protection of sacred sites.

However, the first thing that nearly all pastoralists ask is: 'Will we get bitumen roads out of this? Will we get power so we can switch off our diesel-guzzling generators? Will we get improved internet, and will we get mobile phone coverage?' Everyday Australians take these things for granted. However, they are close to non-existent in rural and remote NT, and pastoralists are running the world's best practice industry in Third World conditions.

Pastoralists are practical, and they know the geology under their feet and have knowledge about drilling, so the topic of fracking comes up, as do the science, engineering and key points that it is not CSG; it is shale, and it is a minimum of 1.5 kilometres deep, and the cement-casing scenario of sealing off an aquifer is explained. I am yet to see someone with an issue. In fact, I have had pastoralists inquire how they would go about fracking a water bore to increase flow. They do ask about water use, but this industry is emerging in an isolated area, so more water will be used in civil construction of roads than fracking, and pastoralists again understand this. Since they will benefit from improved roads, they have not raised concerns with me. Fracking is not the issue. Through education, information and communication, coexistence can grow and flourish, as proven by the relationship between Pangaea Resources and the Sturt Plateau pastoralists, of which Rohan is one. The two industries can build a cohesive business relationship where both parties benefit.

With regard to traditional owners, the main thing I see at consultation meetings and hear from people I know is that they do not want to get left behind. They want the jobs and the business opportunities that have come and will come. I have been involved with Aboriginal training for a number of years. Pangaea Resources ran a training program last year that saw participants come out with a certificate in resource management. This training had one of the highest retention rates I have seen of any training program.

I see the oil and gas industry as a game changer for Aboriginal people in remote parts of the NT. The job opportunities are one part of it, but the potential royalties that will come to traditional owners will give them a real chance of self-determination. As I mentioned, I have assisted TOs in setting up many cattle stations, predominantly third-party whitefella lessees who develop the cattle infrastructure to run a station by holding a lease of approximately 10 years.

The issue here is that TOs want to develop their own business but need finance. They cannot borrow money against their land, so the only option is leasing or government funding. Leasing is great, but it removes them from decision-making and management. Government funding generally dribbles in, with certain outcomes to be met before any more comes. It is also never enough to undertake serious infrastructure development, and it is never granted to purchase cattle. I see a potential income stream that would have unseen economic development opportunities for TOs.

If TOs do not want oil and gas exploration, they have the ability to say no. I respect that—and some have said no. However, they should be afforded a clear opportunity to investigate all aspects of this industry, and have the same educational opportunities that pastoralists are offered, without protest groups applying pressure and using Aboriginal people to push their own agenda. I have seen this happen before and I can see it happening now. I draw your attention to a recent article in the *National Indigenous Times* 'White FIFO Greens to blame for lost black jobs; Bergmann'. Wayne Bergmann, the former KLC boss, negotiated a $1 billion benefits package for Aboriginal people in the West Kimberley in return for the construction of the James Point gas hub. In this article he stated: 'I still seethe over the role the Greens played in dividing our people and our community and turning Aboriginal family against family. … Perhaps they can stop and have a real look at what is going on before they start their protest.' This deal subsequently fell through. This is a powerful article, and I have it here for you.

The NT is not Queensland, it is not New South Wales, it is not Victoria and it is not America. There are fundamental differences. The main one is that it is shale gas, not CSG, so it is deep. The average size of cattle stations in the NT is 3,000 square kilometres, so a drill pad of 200 metres by 200 metres has negligible impact. The other states have bitumen on roads, mobile phone coverage and decent internet. But the main thing they have is power, and they are not paying from $200 to $600-plus per day to turn a light on or boil a kettle. The positive economic and social impacts of a constant and cheap power source for stations and Aboriginal communities is enormous. I see myself sitting between oil and gas and pastoralists and Aboriginal owners. With respect shown for pastoralists homes and for traditional owners and their country, and with robust regulations and a management of coexistence in place, I see great benefits for the NT.

The four big things that I keep mentioning—roads, power, mobile phone coverage and the internet—will not happen under any government. And nor will they happen with the current industries that are out there—pastoral, some mining and tourism.

CHAIR: Thank you, Mr Armstrong. Mr Silvester, would you like to make some comments?

Mr Silvester: I have lived in the Northern Territory since 1970. I have spent pretty much all of that time in the law, and my main area of practice has been as a barrister. My main skill, which is what I think I have been best known for and certainly best paid for, has been in testing expert evidence in both civil litigation and inquiries. In other words, I know how to read a report—a report prepared by a valuer, a report such as you have before you or any kind of report—and unpick it and find its weaknesses and all that sort of thing. And that is all I have done. I am not qualified in relation to this entire debate to do anything else. But I have looked at Dr Hawke's report. I have read it completely and several times. It is a very dense report and quite hard to read. I have reached two main conclusions. One is that this report is not independent. The other is that it is so badly infected by bias that very little regard should be had to it.

These are complex legal questions, and I can only really touch on them in the time available. First of all, you will all remember that the main finding of the report was that there was no reason to have a moratorium on fracking in the Northern Territory. The first thing to be said about that is that considering that point was not one of the terms of reference. When you look at it in the context of the whole report, you see it came in later as a statement out of the blue. That, of course, indicates that, in effect, the whole tone of the report is about ensuring that the government can proceed with its fracking program—if I can call it that—virtually immediately.

In fairness to Dr Hawke, he and those who worked with him set out a huge amount of additional inquiry that needs to take place with a lot of planning and that kind of thing. That would take a long time, but the whole tenor of the report is that there is no reason why it should not start immediately. I have looked at the treatment of the individual witnesses by Dr Hawke's inquiry. I think there are some terrible examples of bias. When someone writes an expert report and it gets into court to be relied upon to guide the court in making its ultimate decision, bias is one of the first things that gets that sort of evidence chucked out. If I may, I want to develop what I hope is an easy-to-understand example of the bias that is in this report.

First of all, I take you back a little bit. In Dr Hawke's letter to the Chief Minister of 28 November 2014 presenting the report into hydraulic fracturing and the potential effects on the environment, Dr Hawke writes:

> Having regard to the above, and the substantive weight of agreed expert opinion, the Inquiry finds that there is no justification whatsoever for the imposition of a moratorium on hydraulic fracturing in the NT.

He is the expert running this entire inquiry. He is the man in charge, and what is he doing but venturing where he was not asked to go? That is the first rule of writing an expert report. You follow your terms of reference. You do not just make it up.

It follows from that that, if he is the head of a supposedly independent inquiry with no authority to inquire as to whether or not there should be a moratorium, he is venturing a political opinion about something he never inquired into. He was, in effect, providing a gratuitous endorsement of an immediate commencement of hydraulic fracturing. This sits at stark odds with much of his report, which identifies years of threshold scientific investigation and other essential work before there would be the necessary bureaucratic and management environments in which fracking could take place. In that regard his report is a very valuable tool in understanding the sheer amount of work that would have to be done—the bureaucracies that would have to be created, the issues of reporting and ensuring there was no political interference in these processes. There are years of work in that. That is fairly described in his report, but he has jumped ahead of all of that work to offer those gratuitous remarks. In my view, that is an unwarranted intrusion into the politics which is created by widespread public opposition to fracking. It renders his report completely unreliable, from my perspective—and I am sure that if this went to a court that would be the judge's opinion—and therefore all but useless. Just to use words that barristers sometimes use between each other but probably do not ever say out loud in court: Dr Hawke has unmasked himself as a barracker.

Anyone charged with conducting an inquiry affecting parties with a relevant interest should conduct themselves free of bias. This is because shale gas fracking, or hydraulic fracturing, involves fundamental risk to the Territory's underground water aquifers. That fundamental risk to the water aquifers flows strongly through his report, because there is so much time in that report spent on how one might deal with it. There are recommendations for whole systems of bureaucracy and everything else to, if you like, make sure this does not happen.

I think the issue is whether your inquiry will support our right as citizens to sufficient supplies of clean, fresh water for all purposes—our fundamental right now and indefinitely into the future. Only if that threshold can be reached should the question arise as to whether we are going to permit this deep underground fracking—and this is squarely conceded in Dr Hawke's report—which should not be allowed to happen. I will not go into bias, but I cannot really resist explaining a little bit about the way the bias just jumps off the pages. Have you got a few minutes?

CHAIR: We are running out of time.

Mr Silvester: Say no and I will leave it.

CHAIR: If you could condense it a little further, that would be great.

Mr Silvester: All right. This is what is in the executive summary of the report:

CSG exploitation has attracted the ire and attention of the Lock the Gate movement and kindred spirits, and the high profile of this issue has led to public concern about 'fracking' in any form.

Then two paragraphs later it says:

Nevertheless, fracking and the unconventional gas industry have served as a proxy in the eastern States and the NT for a more deeply held opposition to fossil fuels *per se*. This ideological position has been fanned by documentaries—

And he refers to a couple of documentaries there. Going back to the use of those two words 'per se' in 'a more deeply held opposition to fossil fuels *per se*', just consider for a moment what that means. It was in italics in the report for emphasis. 'Per se' means in and of itself, which translates to a statement by Dr Hawke to the effect that any opposition to fracking can be dismissed as for its own sake—that is, without any possible substance and without having to delve more deeply into the evidence of those who oppose hydraulic fracturing. What he said at the commencement of this report, in the executive summary, was that all negative concerns expressed by witnesses to the inquiry were to be disregarded as having an ideological position which has been fanned by documentaries.

In other words, all concerns expressed about fracking were to be disregarded because they were ideological. That is a classic case of bias. If that was in a report about the value of a high-rise building, or something, it would be thrown out by the judge before he even looked at it.

I think I will probably leave it there. I have prepared, for your assistance, a detailed examination of Dr Hawke's report, as seen by a barrister who has spent much of his life pulling apart other people's expert reports—about which, of course, there is a lot of law. Sometimes you lose and sometimes you win; when you win, you win when you are in court.

The other main thing that bothers me is Dr Hawke's prescription that the whole of the effort, that needs to go into making fracturing safe, as it were, is to be covered by a subcommittee of cabinet and all the work that is done is reported to that cabinet. I do not mean to reflect upon any particular government but I, for one, would find it very hard to have something of this importance, in effect, ruled by a subcommittee of cabinet. Not least because members tend to go in and out of cabinet a lot—that kind of thing. It is not appropriate for something of this thing—

In this report I see a deliberate attempt to give the government a reason and a narrative that will allow them to virtually start fracturing in the Northern Territory from tomorrow. It is too difficult; it is too dangerous; and it is too stupid for anyone to allow that happen. Thank you.

Ms Quinlivian: I have a very short piece to say. I have lived in the Territory for 17 years. When I first moved up here I worked as a tour guide; travelling thousands and thousands of kilometres on our roads. I would like to talk about the traffic related environmental impacts of onshore gas processes.

I refer to an article—I have a copy for you—from the school of Civil Engineering and Geosciences at Newcastle University in the UK, investigating the traffic related environmental impacts of hydraulic fracturing. This is a relatively new opposition to fracking. It has come up as people talk about the environmental impacts around aquifers but I think this is relevant to the NT in particular with our road infrastructure.

Table 1 of this article shows the volume of truck visits over the lifetime of a well; 70 per cent or greater of that volume of trucks is associated with the fracking and flow back processes. From 30 to 60 days prior to fracking, a huge amount of water comes in—up to 600 trucks visits from the high water use well—shale gas well. Then 42 to 56 days prior to fracking we have the removal of flow back fluids which is estimated in this article as being 50 per cent of the truck visits. So there are 600 truck visits for a high water use well and 300 truck visits on a exit with the flow back fluids. This is for a single well; however, we are now seeing with multiple well pads—up to six well pads—that amount of truck volume can be up to 3,600 truck visits per pad of a six-well pad.

The increase in heavy-duty vehicle activity comes with an increase in roadway damage. A 2014 study in the USA on shale gas shows estimated road reconstruction costs associated with one single well range from $13,000 to $23,000 per well. Despite negotiations with drilling companies to rebuild smaller roads that are visibly damaged, the researchers' conservative estimate of uncompensated roadway damage amounts to $5,000 to $10,000 per well. Although this is a relatively small figure, the increasingly large number of wells substantially raise that figure.

In Pennsylvania, in 2011, there were more than 1,700 horizontal wells and the state wide consumptive road costs for that year were between $8.5 million and $39 million. I think this is relevant to the NT in particular. The infrastructure up here is such that in many areas there is but one road in and one road out. We have one road that leads to Darwin. There is one road that leads to Borroloola. There is one road that leads to many of the pastoral places up here. With the increased volume of heavy-duty traffic there is also an increase in road traffic accidents, which puts an increased demand on emergency services.

In the event of accidents resulting in road closures, of which there is evidence, we definitely need to have measures in place to deal with community severance. I think that this has not been looked into from the point of view of the Northern Territory. We definitely need more looking into this as an issue up here. In other parts of Queensland or in America if there were an accident you could divert traffic and go around but, up here, we just have these big long one-way roads. I think it is relevant.

Miss Cass: I really appreciate the opportunity to speak to the inquiry today. Unconventional gas mining is a multibillion industry. It has the potential to make some people extremely wealthy, but the people in the corporations that are going to be made wealthy do not live in the gas fields. They are not impacted by the consequences of their industry. Hydraulic fracturing for gas has catastrophic potential for the Northern Territory.

It is opposed by the majority of the people. Just last week Mix FM had an over-the-radio poll. It was an online poll and 89 per cent of people that listened to the radio were against fracking—89 per cent is a very large percentage of people against it. The majority of the people—the local citizens, the farmers, the Indigenous, the ordinary families, people like me—we are the ones that will be impacted by fracking. Make no mistake, we are going to be impacted. Over 90 per cent of the Northern Territory is, currently, under application for gas exploration. That means that if it all goes through we will have major impacts. As a result, you cannot blame some people for becoming emotive when their homes, their lifestyles and their livelihoods are threatened. Fracking is a very real threat to the people, the places and the activities we love. These are things which money cannot replace.

Taxpayer funded advertising is designed to manipulate the public into accepting unconventional gas extraction. It touts onshore natural gas as being a clean energy. While the gas itself may be cleaner to use than coal, the land clearing infrastructure, the water usage, the chemicals required, the waste water produced and the gasses leaked while mining onshore gas debunk this claim.

Horizontal hydraulic fracturing for gas is a relatively new technique. It has only been happening for a couple of decades at most. It is a very clever technique but, most importantly, it is a dangerous one. And the dangers are real. International and national scientific and anecdotal evidence proves this. Fracking has destroyed aquifers and rivers through contamination and over extraction. It has caused seismic activity. It has caused air pollution, leading to health issues and acid rain. It does contribute to climate change by releasing greenhouse gases. It does impinge on lifestyles and livelihoods—our lifestyles and livelihoods—and this is a fact.

Numerous reports list these risks, including the report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory, the Hawke report. The Hawke report states that these risks can be managed by regulation. I believe this to be false. While regulation and mitigation might offer some protection, accidents do occur. Human error, mechanical failure, unforeseen circumstances, wastewater ponds flooding, trucks of fracking fluid crashing, wells leaking and wellheads catching fire can happen and have happened. The repercussions of these can be catastrophic for the affected area and its inhabitants.

Once a water body is contaminated there is no way to decontaminate it. It is lost as a water source. Clean water is critical for economic growth. It is critical for public health and for national security. We need our aquifers, our lakes and our rivers to survive. They provide water for households, irrigation for crops and water for livestock. They support our crocodile industry. Our pristine waterways attract over 1½ million tourists and fishermen to the territory every year. Our agriculture, horticulture, aquaculture, real estate and tourism industries will be destroyed if the water is accidentally polluted, and accidents do happen.

These industries are also impacted by the resources and infrastructure required by the gas industry. Employees leave their local jobs to work for the mining companies. Real estate prices skyrocket and then plummet with the

various stages of mining. That means that locals cannot afford to rent in their own home towns and when the prices plummet people who have bought lose out big time.

Frack pads and production water ponds required large areas of land. Some production water ponds are over five square kilometres in area. That is a lot of land full of poisoned water. Pipelines and access roads will bisect properties, acting as unintended fences for livestock. These pipelines and roads also require land clearing, which will deter tourists who come to see the untamed wilderness of the outback, not a gas field with heavy truck traffic or polluted hot springs.

Risking these local industries, the revenue that they generate and the jobs that they provide so that the gas industry can make billions is not justified. The risks are too great. Then there is the impact to our environment. Increased traffic on our roads will lead to more wildlife becoming roadkill. Land clearing, access roads and pipelines act as barriers isolating native populations and affecting biodiversity. Pollution in waterways poisons fish and all aquatic life as well as the animals that drink the water. Methane is a more potent greenhouse gas than carbon dioxide, accelerating the climate change that we are already experiencing. This is not acceptable.

Principal 15 of the Rio Declaration on Environment and Development states:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

The precautionary principle must be implemented in the case of unconventional gas mining. It is international law and we are signatories to that. It is also in the EPBC Act and the sustainable development, which are Commonwealth laws. That is a pretty big principle. These risks are unacceptable and too great to allow franking to occur in Australia. Just because we can do something does not mean that we should. We can live without gas, but we cannot live without clean air and water. Unconventional gas mining needs to be banned. Thank you.

CHAIR: Thank you, Miss Cass, and thank you for your time. Would you like to table that?

Miss Cass: Yes, please.

Senator PERIS: Mr Silvester, to be clear, you have obviously been through the report with a fine-tooth comb and, from what I understand, you said we should give very little regard to the report and that it was quite influenced.

Mr Silvester: Yes, it is, just in the context of deciding that there is no reason to have a moratorium. Of course, the converse of that is that, if there is no reason to have a moratorium, franking can go ahead straightaway. That is what a moratorium is, isn't it? It has a beginning and an end. So, if you do not have moratorium, out with the shovels, boys.

Senator PERIS: We heard from a number of other witnesses how the department is both the promoter and the regulator. The report says that risk can be managed through regulation, but, if you have a regulator who is also doing the promoting, is there some sort of conflict of interest?

Mr Silvester: In fairness, the proposal is to have—apart from it all being oversighted by a subcommittee of cabinet—a regulatory body and an overriding body that is there to secure the honesty and, if you like, the probity of the processes which are adopted. Dr Hawke's report clearly contemplates, as you would expect, a bureaucracy to be developed which is capable of running fracturing in 50 years or so, but the primacy has to be directed at the science and the proper responses to the science and not to the political will of this Chief Minister or that Chief Minister as time goes by. Do you see what I mean?

CHAIR: Thank you again for giving us your time.

Mr Tapp: I am a pastoralist in the Northern Territory. I had a bit of a spiel this morning, so I will not go back over that. There are a couple of things I would like to bring to your attention. There have been discussions with the Northern Land Council on consent issues with traditional owners. I have been asked by TOs to attend meetings with them to help digest what they have been talking about, and I do not believe that the NLC is working in favour of the traditional owners. There is very much bullying and ignoring of the cries of TOs that do not want fracking on the land. This is evident from the TOs that spoke before.

Another concern I have got is that fracking is not localised. Whether you had the right to say no or not, fracking on my land is going to affect people thousands of kilometres away, if aquifer contamination or depletion occurs, because aquifers are thousands of square kilometres in size. It is not just a local issue.

Another issue I have got is with mandatory/voluntary land access agreements. They have been endorsed by the Cattlemen's Association and the government on landholders. How do you put mandatory and voluntary in the

same sentence? Basically, we have got no right to say no and, even if we did have the right to say no, the land that is at risk is too far for one person to have the right to say yes or no.

I have spoken before to pastoralists about the frack-free community studies we have been doing—where 95 per cent of the people in the communities do not want fracking in their communities. Of the pastoralists I have spoken to—probably 50 to 60 per cent of the pastoralists in the Northern Territory—very few of them want fracking, but they cannot do anything about it because of the mandatory/voluntary agreements, so they are basically just sitting on their hands.

My last concern is: if there is a failure with water contamination or depletion, how do you fix it? There is no amount of money—whether you have got $100 or $100 billion, you just cannot physically fix a broken aquifer, or a well, for that matter. If it has cracked and leaked down there, you plug it off—no worries; plug it—then the gas leaks out somewhere else. What leads me to think that there are going to be failures is (1) evidence on the ground and (2) our governments and mining companies will not give us a guarantee that it will not happen—therefore, if they cannot give you a guarantee, I believe it is inevitable.

Mr Wright: I recently got a little bit involved with fracking, because I was witness to a presentation very recently. My background is 37 years of underground mining. What I heard and what I saw made me do a bit more research. It, personally, scares me. Most of what is being said in a lot of this stuff—if you can get past some of the secrecy—is so misleading for the public. When you get pictures like this one in the paper, you know—this looks like a marble cake to me. If underground looked like that, I guess they could have a lot more control over fracking, the structures and all the rest of it, but, unfortunately, it does not look like that at all.

The real underground looks like a zigzag of a crossword puzzle and is nothing like this structure here. Faults, shears and everything like that that come from underground are going to be what cause you problems. Your aquifers are all offset. There is no such thing as a great big line of a natural aquifer—there is in some areas, but it does not go far. Then you will end up with a structural fault that will separate that—then you will end up with water down here and water up here. The whole thing is all over the place.

I have been in most Australian mines. I have travelled in different mines throughout the world. I have been in the deepest mine in the world, which is Western Deep in South Africa. I have heard comments like, 'Well, I only know the underground part of it. Let me tell you, I know the underground part of it for the first two kilometres fairly substantially, and there is nowhere I have been where I can see a marble cake like this, where all the layers are nice and level and we could actually do something predictable. It does not happen.

On the '60 years' of fracking: if you are talking about gas extraction, yes it has been happening for 60 years; but for fracking like we are talking about now, which is horizontal—and if you say 'horizontal' they will challenge that and say, 'No, we're talking about deviation'—the first horizontal fracking became available after trials from 1982 to 1986. That was when they first started doing what they called at the time 'navigational drilling', where they could actually guide a pilot hole on a blind drill, 300 millimetres in diameter, to several hundred feet deep. That gave them the ability to turn the bit and do what they now call horizontal drilling.

When they talk about horizontal drilling now, when they say they are drilling down five kilometres, they drill down 1½ kilometres or two kilometres and turn the drill. People think they are only going to go out one or two kilometres. But they can go out five, six, eight or 10 kilometres and in any direction they like. If you think they are just going to go down on one pad and drill six wells, they are not. They are going to go down and drill another pad over here in five years time and drill back the other way and intersect everything in between. It is not just one lot; it will just keep on happening.

The risk of ground contamination is huge. Once you start putting this fracture down there—15,000 PSI, at 265 litres per second, with 2½ kilograms of chemical—you are putting a lot of pressure on the ground down there and you are going to create seismic activity. If you are doing it in what they call the octopus, you are going to create a huge area of unstable ground. You have got the faults and shears that come through here—not like this marble cake. With these faults and shears, as soon as they start to de-water the hole and take the pressure off, the gas is released and out it goes to the easiest access—and it is not always up the hole. On the seismic activities in there, I have seen holes and displacements of ground that has moved half a metre or a metre. Do you think a steel collared pipe is going to stop that? I guarantee you it will not. Seismic activity in Indonesia a few months ago rattled windows in Darwin. If that happened underground here, do you think you could stop that? You cannot—and nor can they.

The secrecy and the misleading information make it even more dangerous. No proof of contamination for any water throughout the world? Sure. You drill a hole five kilometres deep. Who is going to get down there to prove it? Once the gas comes out of that hole, what proof have you got? How can you prove it? You cannot drill another

hole down alongside it; you cannot go down there. They are saying their hole is perfect. We do not know. How do we know that every hole they drill has all this casing in it? We do not know.

I heard that, when they were drilling a hole out on the Sturt plateau last year, they went through a void, broke a drill and lost a bit. They tried for several days to pressurise that hole—unsuccessfully. This is just hearsay. I have been in the mining industry for 37 years, and you hear some things and people talk about you once you start letting them know that you know the language. In the Northern Territory area, you are basically looking at limestone and sandstone. All the river systems that run down in through Queensland—the O'Shannessy and the Gregory—all start around a place called Gallipoli, which is at the base of sandstone cliffs and the limestone from the Barkly Tablelands in the Northern Territory. If you contaminate that, you are contaminating all the rivers right through the Gulf of Carpentaria and beyond—that is, if it does not kill all the stuff up here in the meantime, which I believe it will.

Who will monitor it? Is there a set of regulations that can control it? I do not believe so. And then you are going to put these miners out there on their own. What, are they going to regulate themselves? Take all the policeman off the road, we all have licences and we are going to do the right thing. Bullshit. We are not. They are going to break the law. What are they going to do with all this water they bring out of the holes? They have to keep de-watering to keep the pressure off to let the gas come out. What is going to happen with all that water? Are they going to track it back to a safe place? No. They are going to put it out on the ground; they are going to contaminate it again.

If there is damage to any of the aquifers, it takes years and years and years for that water to get into the Great Artesian Basin. The water we are pumping out of the Great Artesian Basin has been there for hundreds of thousands of years; it has taken that long to build up. If you de-water an aquifer, it is not going to fill up again in six months; it is going to take years and years and years. All the contaminated fluid that is on top of the ground will leach back through there to fill those aquifers. You are not going to find contamination in these waterways for years and years and years to come.

Another issue is employment. They keep saying that there is employment here for 6,300 people. Eighteen months ago they put 7,000 people off in Queensland. Do you think they are going to employ new people here? Because of the secrecy surrounding the industry, they are going to put the same people back in there again. The mining industry worldwide is so small. I used to say to people, 'See you again.' They would say, 'Yes, righto.' I said, 'Well, you stay in mining, I'll find you somewhere.' That is pretty much how it was. It is so small. These guys are not going to employ new people; they are going to put people on that they know.

Mr Ryan: I would like to table apologies for the NTCA President, Tom Stockwell, and CEO, Tracey Hayes, who were both unable to attend today. The NTCA acknowledges the right of the Commonwealth to access the energy resources that we have here in the Territory. In light of that, it is also important to acknowledge the fact that the pastoral industry has been here for many, many generations prior to the resources sector and it will be here for many generations once it has gone. So, in the context of this committee, I think it is important to note that the NTCA supports the establishment of a robust regulatory regime that protects our water, our pastures and our livelihoods not just during the exploration and extraction process but also long into the future—50, 100, 200 years after the wells are abandoned.

The NTCA believes the regulatory regime should be based, firstly, on mandatory land access agreements. If I could correct Mr Tapp on a point that he made. They are actually mandatory land access agreements, which the NTCA fought very hard for for over 20 years to have implemented, prior to which the only acknowledgement of a pastoralist's right was a registered letter in the mail. So those are mandatory land access agreements. We believe they are the first step in ensuring pastoralists' rights are acknowledged. Having said that, we think there is a long way to go. Mandatory land access agreements between explorers, miners and pastoral lessees that recognise pastoralists' long-term custodianship and stewardship of the land and water that must be crossed and drilled through to access shale oil and gas deposits are essential. It is incumbent on the oil and gas sector to understand the short- and long-term needs of the pastoralists and to seek to add to the lease district and community rather than impose their operations as a right, as it were.

The NTCA supports the establishment of a regional royalty system for industry, community and landholders to distribute benefits to the primary land users and the pastoral industry. The NTCA supports the establishment of a system of adequate bonds in perpetuity to fully secure the rehabilitation expenses and rectification of negative impacts of the petroleum activity. We also support baseline monitoring data and maximum safeguards for water integrity below and above the ground through appropriate legislation and regulation. The Northern Territory government and the oil and gas industry need to prove to us in practical terms how safety for water in particular

will be assured, how we can see they are assured and monitored and, if something does go wrong, how it is detected and remedied in a timely manner.

Water required for mining activities should ideally not be drawn from the same aquifers that pastoralists' operations rely on. Well integrity is absolutely key not only for the life of the exploration on a mining time frame but following cessation of production—and, like I said earlier, not just at the end of a mine's life or a well's life but long into the future. Thank you.

Mr B Sullivan: Rohan Sullivan and I are not related, so we are not doubling up. I am 73 years old this year, and I have been in the Northern Territory since about 1967. My son was born here in the old Darwin hospital. There is a park in Darwin named after my uncle. I consider myself to be a Territorian, a real Territorian, not like some of the Hogan's heroes who fly in here representing the Wilderness Society, who masquerade as Territorians and are here to save the planet from the multinationals. The other thing I would like to point out is that we are talking about shale gas, not CSG. We know nothing about CSG and I do not really want to know anything about CSG.

I am here today primarily representing myself, which is MS Contracting. We are a major contractor in oil and gas exploration. We have probably provided 80 per cent of the construction services to the oil and gas exploration industry in the Northern Territory over the last four years. Last year we provided construction of the camps, the catering, the men and every other thing on all except two exploration holes that were drilled in the Northern Territory. The year before was similar and the year before that we did 100 per cent of the holes that were drilled. We do not drill; we are not drillers. We will not go into that part of the expertise. We do fully support the exploration production of shale gas under the proper regulatory regimes.

I have seen many booms and busts, mostly caused by politicians who have no idea of the real world and are led around by the nose by a noisy minority. In the Northern Territory we have seen federal politicians of all shades for over 100 years. There is evidence of that everywhere. They all, in one way or another, pay lip service to the great dream of developing the North. After more than 100 years of politicians they still have not learnt that private enterprise is the only way that development will happen anywhere. Development will occur by enterprising Australians who are getting out and having a crack by risking their own capital to back their judgement.

I am primarily a cattleman. Most of my life has been spent in the cattle industry and most of it here in the Northern Territory. That has been through either managing someone else's property or running my own. At present I run a few cattle on a couple of small blocks. My son owns Flying Fox Station on the Roper River. The Roper runs right through it. I own MS Contracting and I am supposed to be semiretired, but I am sitting here today talking to people who are going to fix a problem that does not really exist in the first place.

We are in the oil and gas industry because of the live cattle export ban fiasco that sent us, and nearly every other cattle business, broke. I am sure that Senator Ludwig has fond memories of that, but we do not. We nearly went out the back door. We had to diversify or perish. We have now outlayed millions of dollars, most of which we borrowed. We mortgaged our houses, our properties and everything we had to go into the oil and gas exploration industry. We went in in good faith and we are still in there in good faith.

Now the politicians from the Northern Territory are at it again and want to place a moratorium on fracking, which means a moratorium on the entire exploration industry. No-one is going to export the gas if they cannot frack. It would be totally unrealistic for anybody to be granted a licence by a government to do a certain thing on land that is owned by a government and then, halfway through, have the rules changed. The licence was given by government, which was the Northern Territory Labor government when they were in power. They issued the licence, they issued the permits and now they are saying that they need to review the science. Why didn't they do that before? Why didn't they put the regulations in place before they started? Why didn't they just say, 'No, it's not going to happen'? We cannot have it both ways.

My son and I are fourth and fifth generation cattlemen and horsemen. That is all we have ever done. We are only new into the oil and gas game. We are part of an industry, the cattle industry, that leads the world in what is cutting-edge, world's best practice, large-scale, rangeland cattle breeding. We are the only large-scale cattle breeding country in the world that is disease free, thanks to the B-tech program in the eighties and nineties. I will not go into it, but I had quite a lot to do with that B-tech program.

The cattle people across Northern Australia live in what can only be described as Third World conditions. We do not have government services that people who live in cities take for granted and demand as their right. We have no mobile phone coverage, poor internet, if any, no garbage collection and we supply our own power, water and sewerage. Most cattle stations are hours away from the most basic health care let alone a hospital or a school. Recently there was a huge outcry around the country when the Telstra mobile network was out for a few hours.

We do not have one. When you get 100 kay out of Darwin that is it. Children on cattle stations contend with an internet that cannot download their school lessons.

Last year I was in Uganda, a Third World country of 34 million people, where the average monthly wage for a construction worker is A$34. There is nowhere in that country that does not have mobile phone and internet coverage. Nowhere. Tracking gorillas up the side of a mountain on the Rwanda border, you can talk on your mobile phone. Here, we get Adelaide River, zilch. Says a lot for Australia, I am afraid.

Pastoralists pay more per day to generate their own power than the average household pays per month. Our cost at Flying Fox Station is around $250 a day to run our own power. When we are fully staffed it can run up to $600 a day. We pump our own water from bores and rivers on our properties. We, our families, staff and livestock all drink and rely on that water. Does anyone really think we are stupid enough to contaminate that water that is our lifeblood? We have been in this cattle game all our lives. We are bigger environmentalists than anyone in the Green movement. Without water and without our pastures we have got nothing. There is no way in the world that we are going to contaminate it.

The shale oil and gas industry does not pay royalties or any other money to pastoralists, but the infrastructure that will come with the oil and gas exploration will be of great benefit. Pangaea Resources, our client, was proposing to bitumen 80 kilometres of the Western Creek Road at a cost approaching $100 million, giving all-weather access to a dozen or more family owned properties, as well as their own producing gas field. The 10-kilometre duplication of Tiger Brennan Drive between Darwin and Palmerston cost $103 million, so the city people do not have to sit for 15 minutes in a traffic jam. We go five months without being able to drive on a road. You are starting to get the picture. This is about economics.

We are the people that produce the food for Australia and the rest of the world—I am talking about industry wide, not just us. A producing gas field on the Sturt Plateau, for instance, where we have been working, would have a state-of-the-art internet and mobile phone network into which all the pastoralists and all their contractors and other people could tap. Large producing gas fields also have medical facilities for their staff which could be used by locals in an emergency. Most people are five and six hours away from their closest medical centre of any sort, let alone a hospital.

The proposed moratorium by the Northern Territory opposition has taken away the certainty required by Pangaea to invest hundreds of millions of dollars over the next two years, so all of the above benefits are merely a lost opportunity.

MS Contracting, which is our company, has lost a $12 million dollar exploration contract this year, as well as, the full reconstruction of the Western Creek Road over the next four years. That is 50 jobs this year that we are not putting on, so there are 50 families around Darwin that do not have a job at the moment. Instead of sitting here I should be starting to oversee, right now, 70-odd people out in the field on road construction and other construction.

CHAIR: Mr Sullivan, we will ask you to wrap up there. I am sorry. We have run out of time.

Mr B Sullivan: Maybe you should have wrapped some of the others up a bit earlier.

CHAIR: I am going to have to ask you to finish.

Mr B Sullivan: If I was anti I would be fine.

CHAIR: No, that is not true at all.

Mr B Sullivan: It is true.

CHAIR: It is not true at all.

Mr Fraser: Good afternoon. At short notice, I actually work for an North Hill service company, so I guess I represent the industry in some ways, but I do not have a go ahead from my employers to speak on behalf of the company, so I will speak on behalf of myself.

I started in the oil and gas industry in the very early eighties in Queensland. I also come from a small farm, so I have a farming background. I understand Queensland. I understand drought. I understand water. Also, I understand a lot, over 30-plus years in the oil and gas industry, of what goes on—the goods, the bads, both sides of those things.

This whole discussion about fracking in general is getting heavily polluted with topics that are totally unrelated to what is at the core. We hear things about mining; it is not mining as in open-cut mining. It is not coal. For the purpose of the Northern Territory, it is not coal seam gas because we do not do coal seam gas here, and personally, in my own view, I am not that comfortable with coal seam gas. Shale is a different story, and we probably do not have enough time today to talk about the nitty-gritty of the differences in those things.

There is also a lot of stuff out there about certain toxic chemicals. The word 'chemicals' itself sounds very bad. Things that you put in your swimming pool are things that you would not drink, yet are they toxic or are they not? I think there is some room for people to throw some chemicals into the debate, make them sound more toxic than they really are, include toxic chemicals from other countries—say, America, where they are using BTEX, which is a group that has carcinogens; we do not use that in Australia—and try and bring these other debates into Australia.

I have worked with a number of people from around the world and I have worked overseas, and I have seen the behaviours and practices of other countries and cultures. I have to say, the Americans are cowboys and we should not take lessons from what is happening in America as being indicative of how things will be in Australia. We should look more carefully, isolate those arguments and say, 'Stop talking about this place in America. Stop talking about the way Americans behave with their land and the way the operators do things and look at how we do things in Australia. Don't talk about chemicals that aren't used in our country. Don't talk about, for instance, CSG, which is not being done in the Territory.'

I want to talk very briefly about what we do. Our company specialises in the well integrity side of things. We manufacture, repair, modify and inspect the casing which goes in the well and protects the well. The things that I see that are different between offshore behaviour and onshore behaviour are probably the money that is spent and the different levels of things. You go from the Rolls Royce down to the Morris Minor. I would not like to see some of the cheap coal seam practices being done in the Northern Territory—that is a given. I would like to see the shale in the Northern Territory being done more like it is done offshore. In offshore mining, they do fracking. Fracking has been around a long time. Unlike someone was saying before, I was making bent subs for directional drilling in about 1982 or 1983. Directional drilling has been around a long time; fracking was being done back then. It is not that new. I would say that using vertical fracking gives you more propagation up vertically into other aquifers than going horizontally down through a seam that is trapped between impermeable layers. If anything, going horizontal is probably better than going vertical, but then it comes down to what you do with the well bores. What are the technologies and what is being used?

CHAIR: I am going to have to wrap you up. I am really sorry.

Mr Fraser: Can I say one thing?

CHAIR: Yes.

Mr Fraser: One thing I see on the outer casings at the surface is that some of them are just taking plain casing and welding it onto the rig, whereas we manufacture the connectors that go together with seals, and they are all welded to an API standard. There is a lot of casing which is made in proper API mills. In coal seam gas operations in Queensland, you are seeing cheap Chinese stuff. When you put the pressure in to fracture, you need good-quality casing in there to protect it from any kind of rupturing. So I would say there is an argument to go into the science on that side better.

CHAIR: Thank you.

Mr Earley: I have been in the territory for 48 years. I was born here and I will die here. I was raised on the Roper River on a cattle station. About three years ago, the then minister for mines told me and a group of other ministers—not that I was a minister—that the terms of reference for the Hawke report had been viewed by a gas company prior to Dr Hawke receiving the terms of reference. Growing up on the Roper River, I am very closely associated with the people from Jilkminggan. I concur with what other people have said here today that the Northern Land Council is selective with regard to its representation, and I think that that should be reviewed at a federal level. I think you should be reviewing the terms of reference for the Hawke report, given that it was not peer reviewed and given that it was compromised prior to Dr Hawke receiving it. I think that the fracking industry is scurrilous and questionable in a lot of its activities, so much so that I have gone out and started a political party. If we get into power, we will ban fracking in the Northern Territory.

CHAIR: I remind people that we will still look at submissions. I know the date for submissions has closed, but, if you want to put submissions in, we will still look at them and publish them if we feel that they are necessary. I thank all witnesses for their evidence today. Answers to questions taken on notice should be provided by close of business on Tuesday, 19 April. That concludes today's proceedings. I thank the staff from Hansard and broadcasting for their assistance today.

Committee adjourned at 14:39

From Mud to Cement—Building Gas Wells

Claudio Brufatto
Petrobras Bolivia S.A.
Santa Cruz, Bolivia

Jamie Cochran
Aberdeen, Scotland

Lee Conn
David Power
M-I L.L.C.
Houston, Texas, USA

Said Zaki Abd Alla El-Zeghaty
Abu Dhabi Marine Operating Company (ADMA - OPCO)
Abu Dhabi, United Arab Emirates (UAE)

Bernard Fraboulet
Total Exploration & Production
Pau, France

Tom Griffin
Griffin Cement Consulting LLC
Houston, Texas

Simon James
Trevor Munk
Clamart, France

Frederico Justus
Santa Cruz, Bolivia

Joseph R. Levine
United States Minerals Management Service
Herndon, Virginia, USA

Carl Montgomery
ConocoPhillips
Bartlesville, Oklahoma, USA

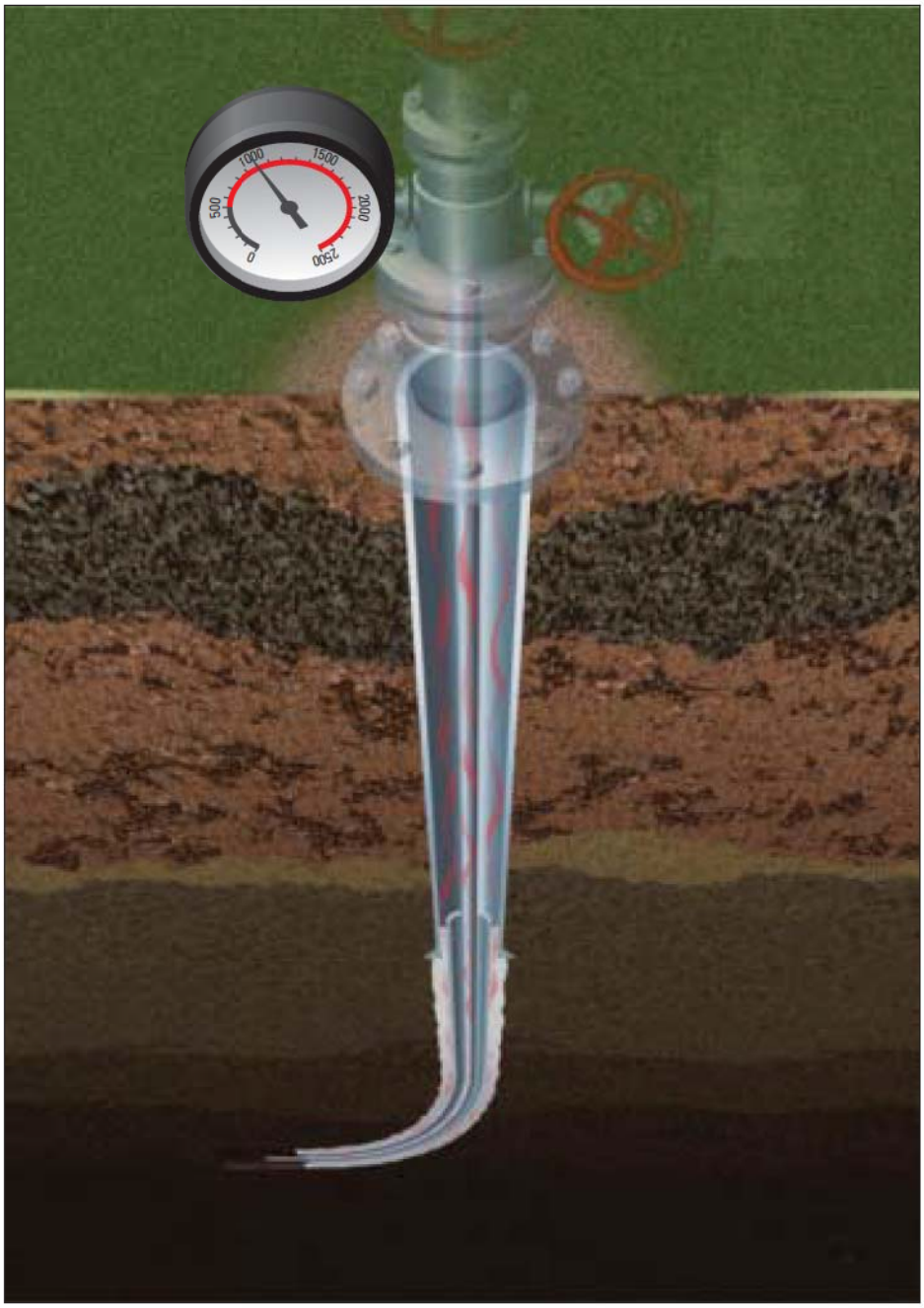
Dominic Murphy
BHP Billiton Petroleum
London, England

Jochen Pfeiffer
Houston, Texas

Tiraputra Pornpoch
PTT Exploration and Production Public Company Ltd. (PTTEP)
Bangkok, Thailand

Lara Rishmani
Abu Dhabi, UAE

As demand for natural gas increases, wellbore construction across gas-bearing formations takes center stage. With few cost-effective remedial measures available, prevention of annular gas flow and sustained casing pressure is key to drilling and completing long-lasting gas wells.



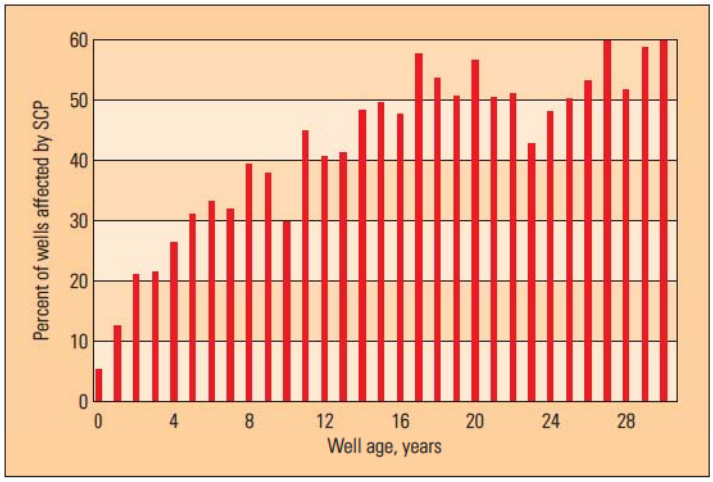
The science of constructing gas wells is thousands of years old. Legend has it that the Chinese dug the first natural gas well before 200 BC and transported the gas through bamboo pipelines.[1] Subsequent well-construction history is unclear until 1821, the year of the first US well drilled specifically for natural gas.[2] This well, in Fredonia, New York, USA, reached a depth of 27 ft [8.2 m] and produced enough gas to light dozens of burners at a nearby inn. Eventually the well was deepened and produced enough gas to provide lighting for the whole town of Fredonia. By this time, well-casing technology in the form of hollowed-out wooden logs had been developed for salt dome drilling, but it is not known whether such casing was used in the gas wells drilled during this era. In all likelihood, these first gas wells were leak-prone.

During the rest of the 19th Century, natural gas became an important energy source for many communities. Techniques for locating, exploiting and transporting natural gas to our homes and industries have had huge advances since the early days.

Despite these advances, many of today's wells are at risk. Failure to isolate sources of hydrocarbon either early in the well-construction process or long after production begins has resulted in abnormally pressured casing strings and leaks of gas into zones that would otherwise not be gas-bearing.

Abnormal pressure at the surface may often be easy to detect, although the source or root cause may be difficult to determine. Tubing and casing leaks, poor drilling and displacement practices, improper cement selection and design, and production cycling may all be factors in the development of gas leaks.

Planning for gas by acknowledging the interdependencies of various well-construction processes is critical to building gas wells for the future. This article focuses on an early phase in the gas journey—constructing the gas well. Case studies from South America, the Irish Sea, Asia and the Middle East demonstrate effective methods for selecting drilling muds, displacing mud before cementing, and constructing long-lasting wells with high-integrity cement.



^ Wells with SCP by age. Statistics from the United States Mineral Management Service (MMS) show the percentage of wells with SCP for wells in the outer continental shelf (OCS) area of the Gulf of Mexico, grouped by age of the wells. These data do not include wells in state waters or land locations.

Wells at Risk

Since the earliest gas wells, uncontrolled migration of hydrocarbons to the surface has challenged the oil and gas industry. Gas migration, also called annular flow, can lead to sustained casing pressure (SCP), sometimes called sustained annular pressure (SAP). Sustained casing pressure can be characterized as the development of annular pressure at the surface that can be bled to zero, but then builds again. The presence of SCP indicates that there is communication to the annulus from a sustainable pressure source because of inadequate zonal isolation. Annular flow and SCP are significant problems affecting wells in many hydrocarbon-producing regions of the world.[3]

In the Gulf of Mexico, there are approximately 15,500 producing, shut-in and temporarily abandoned wells in the outer continental shelf (OCS) area.[4] United States Minerals Management Service (MMS) data show that 6692 of these wells, or 43%, have reported SCP on at least one casing annulus. In this group of wells with SCP, pressure is present in 10,153 of all casing annuli: 47.1% of the annuli are in production strings, 26.2% are in surface casing, 16.3% are in intermediate strings, and 10.4% are in conductor pipe.

The presence of SCP appears to be related to well age; older wells are generally more likely to experience SCP. By the time a well is 15 years old, there is a 50% probability that it will have measurable SCP in one or more of its casing annuli [above]. However, SCP may be present in wells of any age.

In the Gulf of Mexico OCS area, SCP generally results from either direct communication of shallow gas-bearing sands with the surface or poor primary cementing that exposes deeper gas-bearing sands through gas migration. Most wells in the Gulf of Mexico have multiple casing strings and produce through production tubing, making locating and repairing leaks difficult and expensive.

In Canada, SCP occurs in all types of wells—shallow gas wells in southern Alberta, heavy-oil producers in eastern Alberta and deep gas wells in the foothills of the Rocky Mountains.[5] Most of the pressure buildup is due to gas, although, in fewer than 1% of all wells, oil and sometimes salt water also flow to surface.

Continued demand for natural gas coupled with increasingly more difficult drilling environments has heightened operator awareness worldwide to the short- and long-term implications of poor zonal isolation. Whether

For help in preparation of this article, thanks to Raafat Abbas and Daniele Petrone, Abu Dhabi, UAE; and Matima Ratanapinyowong, Bangkok, Thailand.

CBT (Cement Bond Tool), CemCADE, CemCRETE, DeepCEM, DensCRETE, FlexSTONE, GASBLOK, LiteCRETE, MUDPUSH, USI (UltraSonic Imager), Variable Density and WELLCLEAN II are marks of Schlumberger. SILDRIL, VERSADRIL and Virtual Hydraulics are marks of M-I *L.L.C.*

1. For an overview of natural gas history: http://r0.unctad.org/infocomm/anglais/gas/characteristics.htm (accessed August 20, 2003). http://www.naturalgas.org/overview/history.asp (accessed August 20, 2003).
2. For a chronology of oil- and gas-well drilling in Pennsylvania: http://www.dep.state.pa.us/dep/deputate/minres/reclaiMPa/interestingfacts/chronlogyofoilandgas (accessed August 20, 2003).
3. Frigaard IA and Pelipenko S: "Effective and Ineffective Strategies for Mud Removal and Cement Slurry Design," paper SPE 80999, presented at the SPE Latin American and Caribbean Petroleum Engineering Conference, Port-of -Spain, Trinidad, West Indies, April 27–30, 2003.
4. United States Minerals Management Service statistics: http://www.gomr.mms.gov (accessed August 21, 2003).
5. Alberta Energy and Utilities Board: http://www.eub.gov.ab.ca (accessed August 15, 2003).

constructing a gas well, an oil well, or both, long-term, durable zonal isolation is key to minimizing problems associated with annular gas flow and SCP development.[6]

Identifying Causes of Gas Migration

Annular gas may originate from a pay zone or from noncommercial, gas-bearing formations.[7] Some of the most hazardous gas flows have originated from unrecognized gas behind conductor, surface or intermediate casing. Typically, gas flow that occurs immediately after cementing or before the cement is set is referred to as annular gas flow, or annular gas migration. This flow is generally massive and can be interzonal, charging lower-pressured formations, or can flow to the surface and require well-control procedures. Flow to surface occurring later in the life of the well is known as SCP. Later flow also can be from gas-bearing formations to formations of lower pressure, generally at shallower depths.

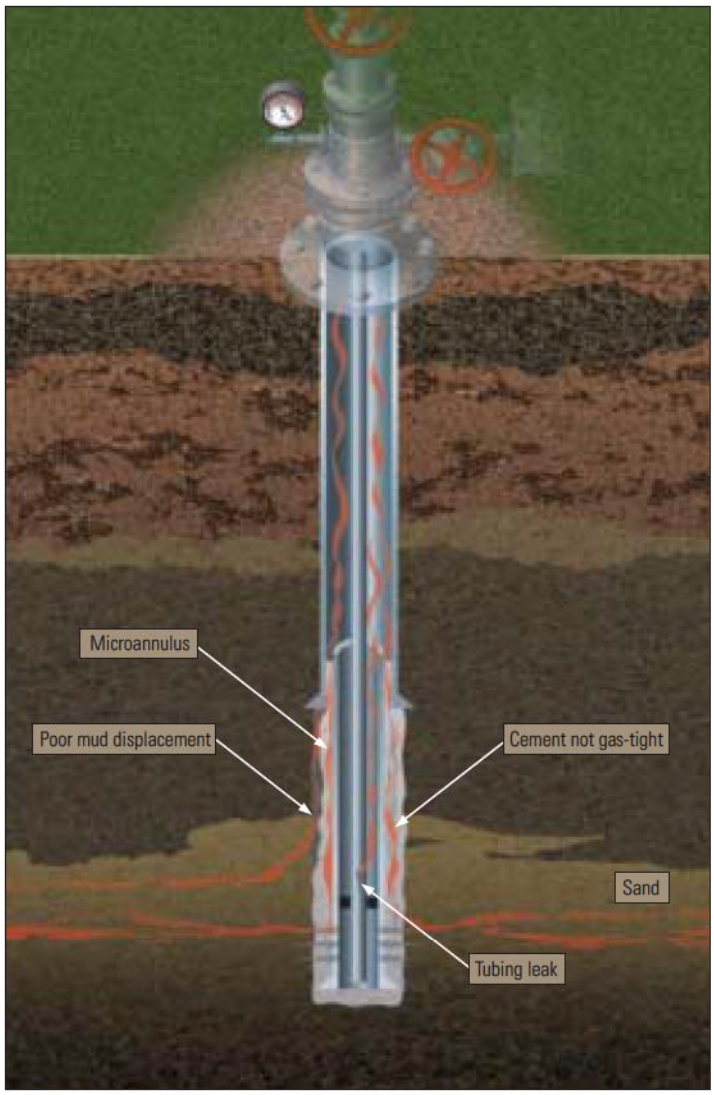
Determining the precise source of annular flow or sustained casing pressure is often difficult, although likely causes can be divided into four primary categories: tubing and casing leaks, poor mud displacement, improper cement-slurry design and damage to primary cement after setting [below].

Tubing and casing leaks—Production tubing failures may present the most serious SCP problem.[8] Leaks can result from poor thread connection, corrosion, thermal-stress cracking or mechanical rupture of the inner string, or from a packer leak. Production casing is typically designed to handle tubing leaks, but if the pressure from a leak causes a failure of the production casing, the outcome can be catastrophic. With pressurization of the outer casing strings, leaks to surface or underground blowouts may jeopardize personnel safety, production-platform facilities and the environment.

Poor mud displacement—Inadequate removal of mud or spacer fluids prior to cement placement may result in failure to achieve zonal isolation. There are several reasons for mud-removal failure, including, but not limited to, poor borehole conditions, improper displacement mechanics and failures in displacement process or execution. Inadequate removal of mud from the borehole during displacement is a major contributing factor to poor zonal isolation and gas migration. Mud displacement is discussed in greater detail (see "From Mud to Cement," *page 66*).

Improper cement-slurry design—Flow occurring before cement has set is a result of loss in hydrostatic pressure to the point that the well is no longer overbalanced—hydrostatic pressure is less than formation pressure. This decrease in hydrostatic pressure results from several phenomena that occur as part of the cement-setting process.[9] The change from a highly fluid, pumpable slurry to a set, rock-like material involves a gradual transition of the cement from fluid to gel and finally to a set condition. This may require several hours, depending on the temperature, quantity and characteristics of retarding compounds added to prevent setting of the cement prior to placement. As the cement begins to gel, bonding between the cement, casing and borehole allows the slurry to become partially self-supporting.

This self-supporting condition would not be a problem if it occurred alone. The difficulty arises because, while the cement becomes self-supporting, it loses volume as a result of at least two factors. First, where the formation is permeable, the hydrostatic pressure overbalance drives water from the cement into the formation. The rate of water loss depends on the pressure differential, formation permeability, the condition and permeability of any residual mudcake and fluid-loss characteristics of the cement. A second cause of volume loss is hydration volume reduction as the cement sets. This occurs because set cement is denser and occupies less volume than the liquid slurry. Volume loss is relatively small at first, since little solid product forms during early hydration. However,



^ Scenarios for gas flow. Shown are possible scenarios of gas migration to the surface resulting in SCP. Tubing and packer leaks may allow gas to migrate. Microannului may develop soon or long after cementing operations. Poor mud displacement may result in inadequate zonal isolation. Gas may slowly displace residual nondisplaced drilling fluid, eventually pressurizing the annular space between tubing and casing strings. Gas may also flow through poorly designed nongas-tight permeable cement.

ultimately the volume loss can be as much as 6%.[10] Volume loss coupled with the interaction between partially set cement, borehole wall and casing causes a loss of hydrostatic pressure, leading to an underbalanced condition.

While the hydrostatic pressure in the partially set cement is below formation pressure, gas may invade. If unchecked, the invasion of gas may create a channel through which gas can flow, effectively compromising cement quality and zonal isolation.

Free water in cement may also cause a channel. Under static conditions, slurry instability may lead to water separating from a cement slurry. This water may migrate to the borehole wall and collect, forming a channel. This is of particular concern in deviated wellbores where gravity may drive density separation and fluid inversion, resulting in the development of a free-fluid channel on the top side of the borehole.

Cement damage after setting—SCP can occur long after the well-construction process. Even a flawless primary cement job can be damaged by rig operations or well activities occurring after the cement has set. Changing stresses in the wellbore may cause microannuli, stress cracks, or both, often leading to SCP.[11]

The mechanical properties of casing and cement vary significantly. Consequently, they do not behave in a uniform manner when exposed to changes in temperature and pressure. As the casing and cement expand and contract, the bond between the cement sheath and casing may fail, causing a microannulus, or flow path, to develop.

Decreasing the internal casing pressure during completion and production operations may also lead to microannuli development. Underbalanced perforating, gas-lift operations or increased drawdown in response to reservoir depletion all reduce internal casing pressure.

Any of these conditions—tubing or casing leaks, poor mud displacement, improper cement system design or damage to cement after setting—may result in flow paths for gas in the form of discrete conductive cement fractures, or microannuli. Once the gas-migration mechanism is understood, steps can be taken to mitigate the process.

Controlling Gas Migration

As the borehole reaches deeper into the earth, previously isolated layers of formation are exposed to one another, with the borehole as the conductive path. Isolating these layers, or establishing zonal isolation, is key to minimizing the migration of formation fluids between zones or to the surface where SCP would develop. Crucial to this process are borehole condition, effective mud removal, and cement-system design for placement, durability and adaptability to the well life cycle.

Wellbore condition depends on many factors, including rock type, formation pressures, local stresses, the type of mud used and drilling operational parameters, such as hydraulics, penetration rate, hole cleaning and fluid-density balance.

The ultimate condition of the borehole is often determined early in the drilling process as drilling mud interacts with newly exposed formation. If mismatched, the interaction of the drilling mud with formation clays can have serious detrimental effects on borehole gauge and rugosity. Once a well is drilled, displacement, cementing and ultimately, zonal-isolation efficiency are dependent on a stable borehole with minimal rugosity and tortuosity.

Mud companies have created high-performance water-base muds that incorporate various polymers, glycols, silicates and amines, or a combination thereof, for clay control. Today, water-base and nonaqueous invert-emulsion fluids account for 95% of all drilling fluids used. The majority, about 70%, are water-base and range from clear water to mud that is highly treated with chemicals.

Drilling fluid engineers and related technical specialists have applied various techniques to investigate rock response to drilling fluid chemistry; these include exposing core samples to drilling fluids under simulated downhole conditions and physical examination of core and cuttings with scanning electron microscopy.[12] The results are often inconsistent, so drilling fluid selection often is based simply on field history. Many times, particularly in new fields where formation clay chemistry may be unknown, effective field development may hinge on understanding the nature of formation clays as they vary with depth [above].



^ Cuttings response to drilling fluids. Cuttings samples were taken from a well in the southern Gulf of Mexico drilled with oil-base mud; these cuttings had not been exposed to water-base mud prior to testing. After cleaning oil from the cuttings surface, Schlumberger laboratory technicians sorted the rock pieces. Three initially identical samples of rock were photographed after receiving a different treatment. Sample A (*left*) was placed in tap water, Sample B (*middle*) into a generic lignosulfonate drilling fluid and Sample C (*right*) was immersed in a glycol-polymer-potassium chloride fluid. Each sample was rolled in a stainless-steel cell in a hot-roll oven for 16 hours at 250°F [121°C] to simulate drilling and transport up the borehole to surface. The sample in tap water, Sample A, was most damaged, and Sample C in the glycol-polymer-potassium chloride fluid was essentially undamaged. The lignosulfonate system generated intermediate damage for Sample B. Drilling with a mud having low inhibition values would be expected to generate borehole instability and washout. In contrast, excellent clay control would be obtained by a more advanced chemistry, such as glycol-polymer-potassium chloride.

6. For more on zonal isolation: Abbas R, Cunningham E, Munk T, Bjelland B, Chukwueke V, Ferri A, Garrison G, Hollies D, Labat C and Moussa O: "Solutions for Long-Term Zonal Isolation," *Oilfield Review* 14, no. 3 (Autumn 2002): 16–29.
7. Bonett A and Pafitis D: "Getting to the Root of Gas Migration," *Oilfield Review* 8, no. 1 (Spring 1996): 36–49.
8. Bourgoyne A, Scott S and Manowski W: "Review of Sustained Casing Pressure Occurring on the OCS," http://www.mms.gov/tarprojects/008/008DE.pdf (posted April 2000).
9. Wojtanowicz AK and Zhou D: "New Model of Pressure Reduction to Annulus During Primary Cementing," paper IADC/SPE 59137, presented at the IADC/SPE Drilling Conference, New Orleans, Louisiana, USA, February 23–25, 2000.
10. Parcevaux PA and Sault PH: "Cement Shrinkage and Elasticity: A New Approach for a Good Zonal Isolation," paper SPE 13176, presented at the 59th SPE Annual Technical Conference and Exhibition, Houston, Texas, USA, September 16–19, 1984.
11. A microannulus is a small gap between cement and a pipe or a formation. This phenomenon has been documented by running sequential cement bond logs, first with no pressure inside the casing and then with the casing pressured. The bond log clearly indicates that applied pressure often closes a microannulus.
12. Galal M: "Can We Visualize Drilling Fluid Performance Before We Start?" paper SPE 81415, presented at the SPE 13th Middle East Oil Show & Conference, Bahrain, June 9–12, 2003.

Many drilling fluid additives are available to assist the driller in formation-clay control. Lightly treated, noninhibitive mud provides good borehole cleaning and moderate filtration control for routine tophole sections. Seawater, brackish water or field brines sometimes provide inhibition in clay-laden shale, and high salt levels, up to saturation, are used to prevent washout while drilling massive salt sections.

Where environmental regulations allow, nonwater-base muds can provide optimal borehole control. Drilling fluids based on oil- or nonaqueous-synthetic-base materials, commonly referred to as invert-emulsion muds, have evolved into high-performance systems. Even though synthetic-base mud can cost two to eight times more than conventional fluids, superior performance-to-cost ratios combined with environmental acceptability have established synthetic-base fluids as the top choice for critical wells, particularly those in which gauge hole and zonal isolation are significant concerns.

Like the fluids themselves, drilling fluid hydraulics play a fundamental role in constructing a quality borehole. Balance must be maintained between fluid density, equivalent circulating density (ECD) and borehole cleaning.[13] If the static or dynamic fluid density is too high, loss of circulation may occur. Conversely, if it is too low, shales and formation fluids may flow into the borehole, or in the worst case, well control may be lost. Improper control of density and borehole hydraulics can lead to significant borehole rugosity, poor displacement and, ultimately, poor cement placement and failure to achieve zonal isolation.

Rheological properties of drilling fluids must be optimized in such a way that the frictional pressure losses are minimized without compromising cuttings-carrying capacity. Optimal fluid properties for achieving good borehole cleaning and low frictional pressure loss often appear to be mutually exclusive. Detailed engineering analysis is required to obtain an acceptable compromise that allows both objectives to be satisfied [below].

In a recent deepwater project offshore Brazil, where wellbore erosion has been a severe problem, M-I's Virtual Hydraulics software established the drilling parameters and fluid properties required to provide ECD management and good borehole cleaning with reduced flow rates. In this case, less than ideal flow rates were required to minimize borehole erosion. However, carefully balancing the drilling fluid rheology, flow rate and density allowed the driller to maintain penetration rate while effectively cleaning the borehole and minimizing mechanical borehole erosion.

Software such as the M-I Virtual Hydraulics application provides an excellent tool for in-depth analysis of fluid properties and evaluation of the impact of drilling fluid parameters on downhole hydraulics and borehole erosion. During drilling, optimal fluid characteristics may change depending on the task, such as running casing or displacement of borehole fluids. Modeling and simulation can be useful in optimizing fluid properties in anticipation of changes in rig operations.

Integrating carefully designed drilling fluids with other key services is critical for achieving successful wellbore construction, zonal isolation and well longevity.

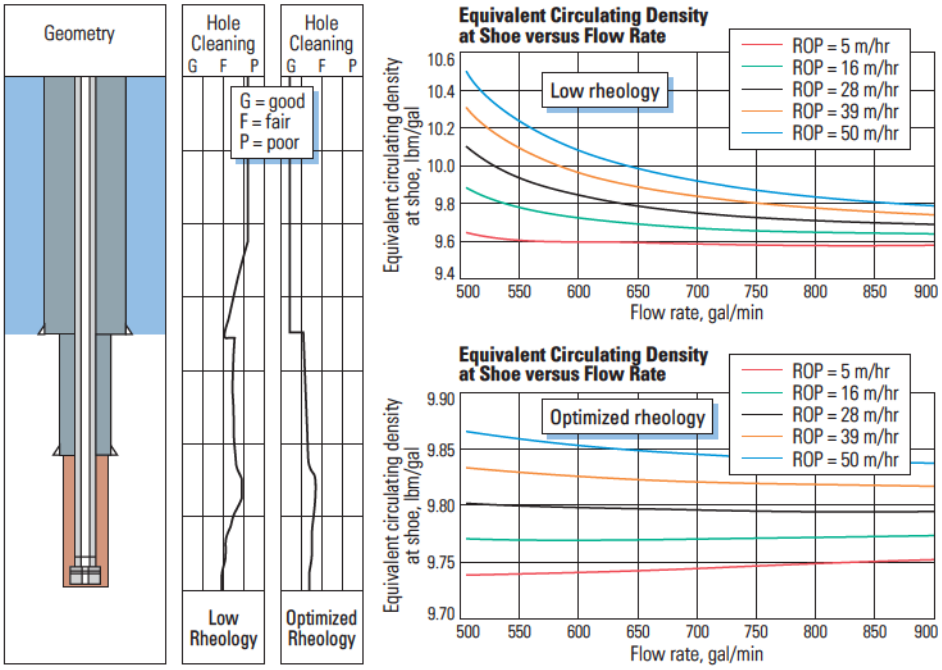
From Mud to Cement

Proper mud selection and careful management of drilling practices generally produce a quality borehole that is near-gauge, stable and with minimal areas of rugosity, or washout. To establish zonal isolation with cement, the drilling fluid must first be effectively removed from the borehole.

Mud removal depends on many interdependent factors. Tubular geometry, downhole conditions, borehole characteristics, fluid rheology, displacement design and hole geometry play major roles in successful mud removal. Optimal fluid displacement requires a clear understanding of each variable as well as inherent interdependencies among variables.

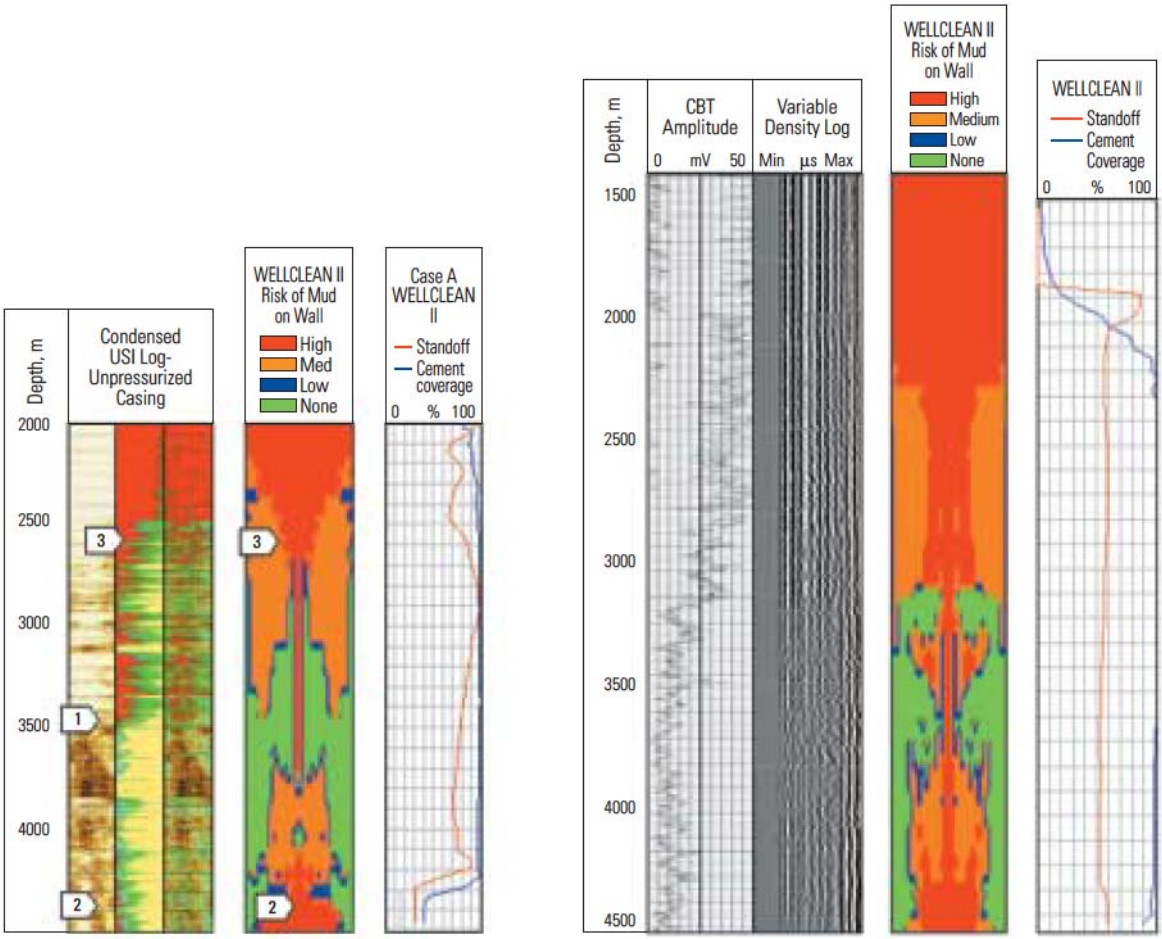
Since the early 1980s, the availability of computing technology has significantly advanced the way drillers approach wellbore displacement. Software applications and faster computer processing now allow for a significant level of prewell modeling, simulation and engineering. Fluids can be built, complex interactions predicted, and displacements simulated on the computer screen rather than at the wellsite where minor mistakes may result in major costs.

Key elements of an engineered displacement begin with an understanding of borehole characteristics such as hole size and washouts, rugosity, borehole angle and dogleg severity. Once these are understood, decisions regarding displacement flow dynamics, spacer design and chemistry, and centralization requirements can be made.



^ Optimized rheology with Virtual Hydraulics analysis. In this simulation, the M-I Virtual Hydraulics software demonstrates that borehole-cleaning capacity can be optimized against flow rate and equivalent circulating density (ECD). The simulation indicates that even when pumping at high rates, borehole cleaning (*left, Track* 2) with a low-rheology mud is poor in the upper sections and ECD is high (*chart - upper right*). Once optimized, ECD is significantly lower (*chart - lower right*) and borehole-cleaning efficiency improves from poor to good (*left, Track 3*).

13. Equivalent circulating density is the effective density exerted by a circulating fluid against the formation that takes into account the pressure drop in the annulus above the point being considered.



Flag Notes:

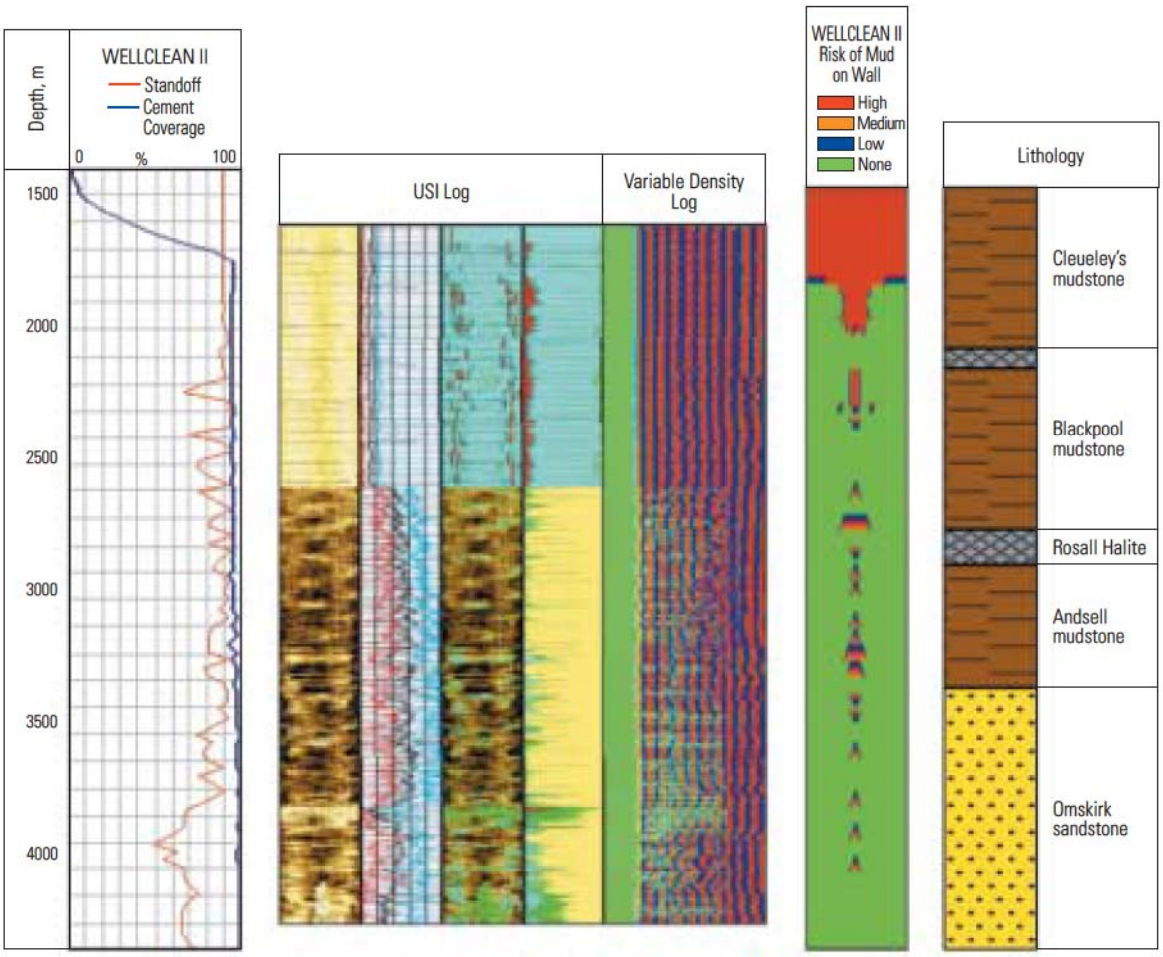
1 Poor coverage and bond after this point—lead/tail interface.
2 Mud on wall has produced channel, seen on USI plot also.
3 Increasing risk of mud on wall leads to poor cement coverage and microannuli.

^ Post-placement WELLCLEAN II analysis. Wells L10 (*left*) and L11 (*right*) were both producing at the time these simulations were run, each with SCP between the 13⅜- and 9⅝-in. casing strings. Post-placement analysis of each well indicated a high risk of mud left in the borehole, implying poor displacement and a high potential for primary cement failure and annular gas migration. The red and orange areas on Track 4 (*left*) and Track 3 (*right*) provide clear indications of the mud-removal risk level. The USI UltraSonic Imager log on the left image (Track 2) correlates with the WELLCLEAN II prejob simulation in Track 4 where poor mud removal potential is indicated. On the USI log (Track 2), the yellow shading indicates bonded cement.

An example of an engineered displacement is seen in a case study from the Irish Sea. BHP Billiton Petroleum experienced problems resulting from poor mud removal on their Lennox field project. Located in the Liverpool Bay sector of the Irish Sea, this series of wells, producing both oil and gas, suffered repeated zonal-isolation failures and SCP occurring between the 9⅝-in. and 13⅜-in. casing strings. Aside from other pressure-related safety hazards, gas from these wells contains a high concentration of hydrogen sulfide [H_2S], up to 20,000 parts per million (ppm), and periodic venting of annular pressure posed a serious environmental issue.

To reduce risk and establish zonal isolation on future wells, engineers from BHP Billiton and Schlumberger assessed two previous wells and developed a forward-looking plan to attack the SCP problem. Using well data from the already producing L10 and L11 wells, engineers ran WELLCLEAN II Engineering Solution simulations to determine the cause of zonal-isolation failures. The simulation results compared favorably with the original cement bond logs and other data from both wells, confirming the accuracy and utility of the WELLCLEAN II simulations in predicting mud removal and cement placement [above].

Based on modeling of the L10 and L11 wells, the engineering team determined that poor mud removal was the primary cause of inadequate zonal isolation. Utilizing CemCADE cementing design and simulation software and



^ Results of a prejob displacement simulation. Prior to cementing the 9⅝-in. casing string on the L12 well, engineers modeled and simulated borehole conditions and displacement parameters using WELLCLEAN II software. By optimizing mud properties and spacer and cement design, along with proper centralization, the simulation predicted near-complete displacement of the drilling fluid (Track 7). A USI log run after cementing confirmed proper placement and zonal isolation as seen in Tracks 2 through 5. The yellow shading in Track 5 indicates optimal cement bonding. Well L12 is currently producing with no detectable SCP.

WELLCLEAN II software, engineers designed and executed a displacement and cementing program on Well L12, effectively eliminating SCP development [above]. Optimizing spacer design, the casing centralization program and cement properties led to effective displacement and cement bonding, bringing significant value to the operator.

Gas Isolation with Cement

Integration of drilling fluids, spacer design and displacement techniques provide the foundation for optimal cement placement.[14] Long-term zonal isolation and control of gas require the cement to be properly placed and to provide low permeability, mechanical durability and adaptability to changing wellbore conditions.

Cement permeability depends on the solid fraction of the formulation. For high-density slurries, a high solid fraction is inherent, thus the permeability tends to be low. For low-density slurries, special products and techniques create low-density, high solid-fraction slurries.

Mechanical durability varies with strength, Young's modulus of elasticity and Poisson's ratio. The cement should be designed so these properties are sufficient to prevent failure of the cement when it is exposed to changing well pressures and temperature fluctuations, which create stresses across the casing-cement-formation system. Special materials are required to give the cement flexibility in this environment.

During placement, overbalance must be maintained across gas-bearing formations until the vulnerability of the cement to invasion by gas is reduced through the setting process. The higher the overbalance, the later in the hydration cycle invasion can occur.

A technique for increasing or maintaining overbalance is the application of pressure to the annulus following the cementing operation—usually by applying pump pressure to the annulus at the surface. In Canada, a common practice is to pump rapidly setting cement ahead of more conventional cement. This allows the first cement pumped, or lead cement, to set in the annulus near the surface. Pressure can be applied through the casing to the cement that has been slightly underdisplaced. A precaution to the application of pressure is that weak formations must be evaluated for the risk of losses.

A modification of this pressure application is a technique called cement pulsation, the application of pressure pulses to the annulus following the cementing operation.[15] The advantage of this technique is that the pressurization-depressurization cycles generate a small amount

of motion of the fluids in the wellbore, delaying gel-strength development, and thereby slowing hydrostatic-pressure decay.

Foamed cement may also be used across gas formations. As volume decreases through dehydration, the pressure-volume relationship of the compressed gas used in the foaming process allows a higher pressure to be maintained against the formation, thus minimizing gas influx.

Planning for Gas

Sealing an annular space against gas migration can be more difficult in gas wells than in oil wells. Wellbore construction, particularly in the presence of gas-bearing formations, requires that borehole, drilling fluid, spacer and cement designs, and displacement techniques be dealt with as a series of interdependent systems, each playing an equally important role. Often, the relationships among these systems is overlooked, or at the very least, poorly appreciated.

Effective management of these interdependent technologies requires that drillers and cementers work together throughout the drilling process, selecting muds that achieve drilling goals while managing the borehole in a manner that allows effective mud removal and zonal isolation. Efficient slurry placement for complete and permanent zonal isolation relies on effective displacement of drilling fluids from the borehole—modeling, simulation and spacer system design play key roles in this process, as illustrated in an example from South America.

In early 2002, Petrobras, operating in a remote region of southern Bolivia, experienced repeated occurrences of SCP on their Sabalo project in the San Antonio field [right]. Each of the first three 13⅜-in. surface casing primary cement jobs developed SCP, some as high as 1000 psi [6895 kPa]. Pressure was also detected on several 9⅝-in. intermediate and 7-in. production-liner casing strings.

The next borehole segment to be drilled was the 8½-in. deviated section of the X-3 well, which would traverse the gas-laden, potentially commercial, Huamampampa formation. Concerns over lubricity in a deviated borehole, minimizing production zone damage and the requirement for an in-gauge stable borehole led the drilling team to select a low-fluid-loss VERSADRIL oil-base mud system.

Fluid-loss control, bridging and filter-cake quality are important drilling-fluid properties for minimizing both formation damage and excessive filter-cake buildup across permeable zones. Formation damage issues aside, excessive filter-cake buildup can severely hamper mud displacement prior to cementing. The filtration properties of the system were controlled utilizing a blend of high melting-point gilsonite and specifically sized calcium carbonate particles.

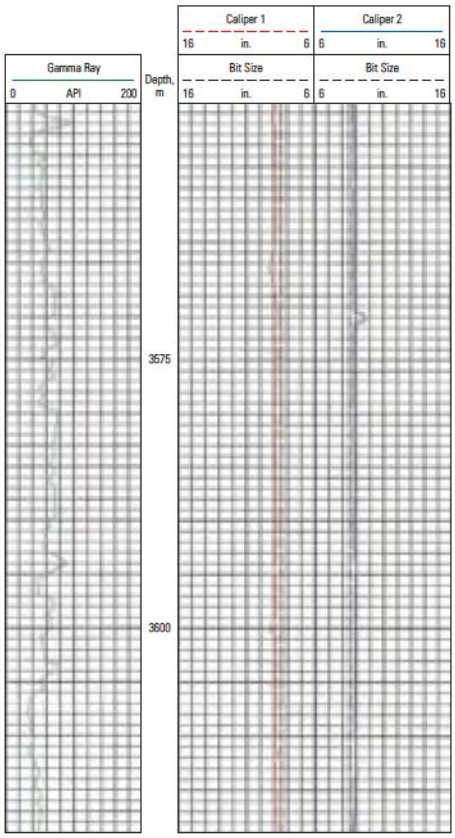
The inclination of the borehole caused operational concerns about borehole cleaning and barite sag.[16] Cuttings-bed development and static sag problems are most prevalent at 30 to 60 degree borehole inclination; either condition could result in borehole destabilization. Since the X-3 borehole inclination was 62 degrees, the well was considered high risk.

To mitigate these concerns, the driller maintained high annular flow rates, and the drilling fluid engineer adjusted the mud-product mix to produce higher viscosity at low shear rates. Strict adherence to these and other good drilling practices minimized the accumulation of cuttings along the lower side of the borehole and minimized borehole erosion. No evidence of sag was recorded. The 8½-in. interval was drilled with a mud weight of 14.1 lbm/gal [1690 kg/m^3]

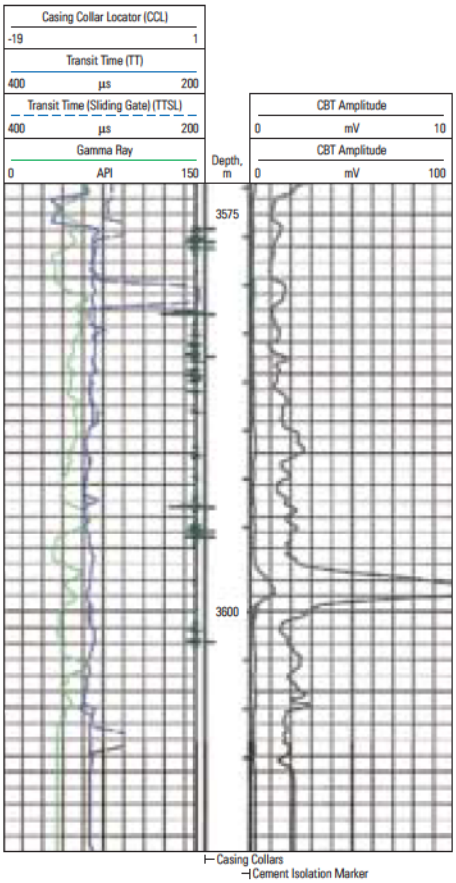


^ Petrobras remote location drilling. Petrobras is drilling multiple well templates in the San Antonio field in southern Bolivia.

14. Fraser L, Stanger B, Griffin T, Jabri M, Sones G, Steelman M and Valkó P: "Seamless Fluids Programs: A Key to Better Well Construction," *Oilfield Review* 8, no. 2 (Summer 1996): 42–56.
15. Dusterhoft D, Wilson G and Newman K: "Field Study on the Use of Cement Pulsation to Control Gas Migration," paper SPE 75689, presented at the SPE Gas Technology Symposium, Calgary, Alberta, Canada, April 30–May 2, 2002.
16. Sag is defined as settling of particles in the annulus of a well, which can occur when the mud is static or being circulated. Because of the combination of secondary flow and gravitational forces, weighting materials can settle, or sag, in a flowing mud in a high-angle well. If settling is prolonged, the upper part of a wellbore will lose mud density, which lessens the hydrostatic pressure in the hole, allowing an influx of formation fluid to enter the well.



^ Well X-3 caliper logs. Tracks 2 and 3 indicate a near-gauge borehole.



< Well X-3 casing bond log. The CBT Cement Bond Tool Variable Density log was run three days after cementing. The average CBT amplitude was 2 mV (Track 2) across the gas zone, which was extremely low for wells in the area. Amplitude values decrease with cement bond quality. The 8½-in. borehole was drilled at a 62° angle with oil-base mud at 14.1 lbm/gal [1689 kg/m^3]. Borehole conditions were excellent for displacement and cementing. No SCP has been detected, indicating successful zonal isolation.

from 10,981 to 11,870 feet [3347 to 3618 m]. At total depth (TD), the four-arm wireline caliper log indicated excellent borehole conditions [left].

Proper fluid design, on-site engineering and proper drilling practices provided a clean in-gauge borehole. Engineers optimized the spacer system for actual borehole conditions, mud characteristics and liner design. Based on WELLCLEAN II and CemCADE simulator recommendations, 40 centralizers, one per casing joint, were placed on the liner. Since an oil-base mud was used for drilling, a MUDPUSH XLO spacer system for cementing with surfactant at 12 gal/1000 gal [286 cm^3/m^3] and mutual solvent at 100 gal/1000 gal [2380 cm^3/m^3] was designed for optimal mud removal.

Because the Huamampampa formation typically contains a high level of gas, Schlumberger cementing specialists designed a 16.6-lbm/gal [1989-kg/m^3] DensCRETE slurry system incorporating a gas-control additive to prevent gas migration after cement placement. To minimize cement slurry dehydration across permeable zones, API fluid loss was controlled at 19 mL/30 min.[17]

Displacement and cementing operations were executed according to stringent design specifications. On reentering the borehole, the driller located the top of cement at 10,646 ft [3245 m] measured depth (MD), 335 ft [102 m] below the top of the tieback, or overlap between the liner and previous casing string.

Petrobras routinely evaluates primary cement using cement bond logs and formation leakoff tests. A CBT Cement Bond Tool Variable Density log was run three days after the cementing operation.[18] The CemCADE simulator predicted a CBT amplitude of 1.7 mV for 100% mud removal and 3.1 mV for 80% mud removal. The logging results indicate an average amplitude of around 2 mV, so the 7-in. liner cement job had a 95% average bond index [below left]. These results agree with CemCADE and WELLCLEAN II predictions. Good zonal isolation was achieved.

The holistic approach to gas-migration control adopted by the engineering teams, combined with state-of-the-art technology, resulted in effective zonal isolation with no gas leakage to surface. As of September 2003, after producing as much as 20 MMscf/D [0.57 m^3/d] of gas for over a year, the X-3 well has shown no indication of microannuli or SCP development. By applying an integrated approach to wellbore planning and construction, the engineering team successfully modified their operational, drilling fluids and cementing programs to achieve zonal isolation on two subsequent casing strings.

A Solution for Shallow-Gas Isolation

Shallow-gas flows present a specialized problem in the control of gas migration. While operating in the Gulf of Thailand in the fall of 2001, PTT Exploration and Production Public Company Ltd. (PTTEP) experienced serious problems with shallow-gas flows and SCP development. Originally discovered in 1973, the Bongkot field is 600 km [373 miles] south of Bangkok, Thailand, and 180 km [112 miles] off the coast of Songkhla. The field primarily consists of gas reserves with some limited oil production.

The WP11 drilling project was part of a 12-well development-drilling program. Geophysical and wireline log data indicated the potential for shallow gas at a depth of 312 to 326 m [1023 to 1069 ft] below mean sea level. PTTEP engineers planned to set 13⅜-in. casing at 310 m

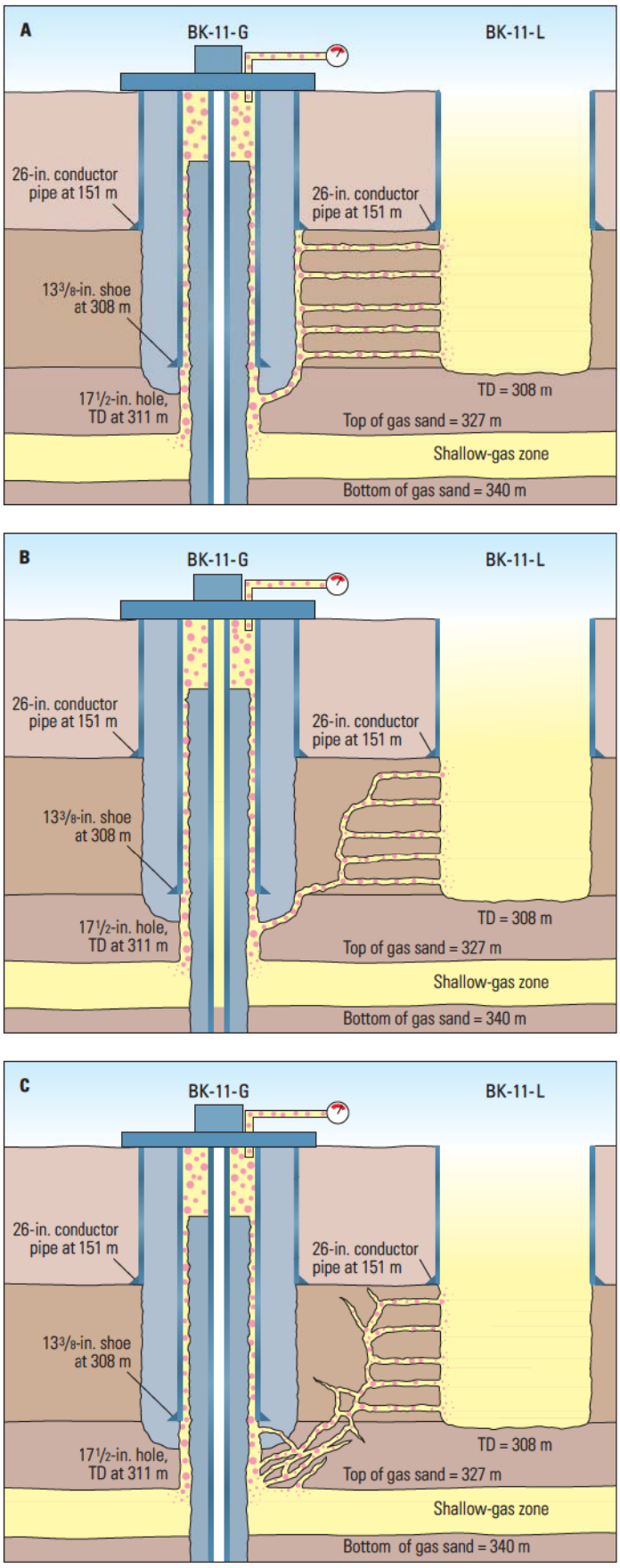
17. This is the American Petroleum Institute (API) standard for cement fluid loss.
18. Butsch RJ, Kasecky MJ, Morris CW and Wydrinski R: "The Evaluation of Specialized Cements," paper SPE 76731, presented at the SPE Western Regional/AAPG Pacific Section Joint Meeting, Anchorage, Alaska, USA, May 20–22, 2002.

[1017 ft], then drill a 12½-in. borehole through the shallow-gas sand and set 9⅝-in. casing at about 500 m [1640 ft]. Zonal isolation behind the 9⅝-in. casing was critical to the success of the project. Even though a gas-tight, or gas-influx-resistant, cement-slurry design was used, the first three 9⅝-in. casing primary cement jobs failed, resulting in both SCP at the surface and gas charging of upper-zone normally pressured sands [right].

Although not under contract for the project, Schlumberger and M-I engineers working in conjunction with PTTEP and their partners, Total and BG, proposed a plan to integrate borehole stabilization with mud displacement and cement-system design.

The shallow formations in the 12½-in. section consisted primarily of sand and shale, 30 to 40% of which was reactive clay. Historically, conventional water-base muds had been used to drill these formations, resulting in significantly washed-out sections, poor displacements, inadequate primary cement placement and loss of zonal isolation.

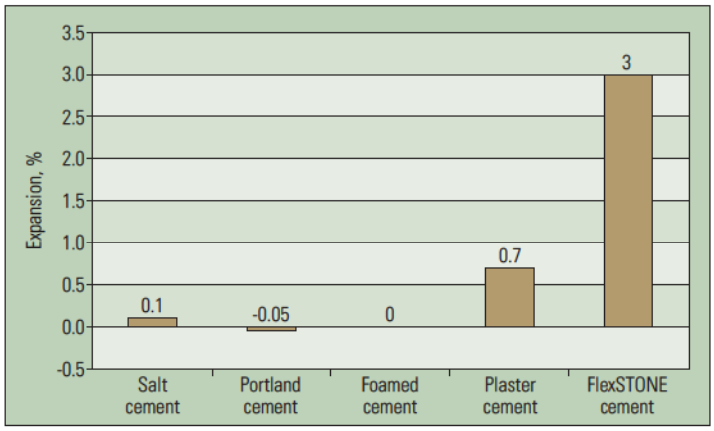
The M-I engineering team recommended controlling the borehole and cuttings integrity with SILDRIL mud, a sodium-silicate-base drilling fluid. The objective was to obtain a near-gauge borehole allowing optimized casing centralization, mud displacement and cement placement across the gas-bearing sand.



> Scenarios for upper-sand charging. In early drilling operations, previously nongas-bearing upper sands were charged with gas. Several scenarios were developed to explain gas cross-flow between Wells BK-11-G and BK-11-L, and the development of SCP at surface. Gas is shown as red bubbles originating in the shallow-gas sand. In the three scenarios shown, gas migrates around poorly bonded cement (A). Gas moves around poorly bonded cement to vertical fractures (B). It migrates around poorly bonded cement and through a microfracture network (C). In all cases, primary cement failed to provide zonal isolation, resulting in gas migration to both upper sands and between casing strings, resulting in SCP.



^ Controlling cuttings with silicate mud. The SILDRIL silicate-base mud, used to drill the 12¼-in. sections, produced a stable borehole with an average diameter of 12.54 in. [318 mm]. Cuttings shown crossing the shaker have a high level of integrity, confirming control of formation clay hydration and dispersion.



^ Changing volume of cement during the setting phase. Most cements have only a slight volume change during the setting process. FlexSTONE advanced flexible cement system can be formulated to expand by as much as 3%.

Silicate muds have proved useful in stabilizing the erosion of shallow unconsolidated formations and in providing gauge boreholes while maintaining optimal penetration rates. In highly reactive formations such as those encountered on the WP11 project, silicate ions bond with active sites on formation clays. This results in highly competent cuttings and borehole stabilization through direct chemical bonding of the polymerized silicate [top].

Spacer design and mud displacement were the next challenge. Schlumberger engineers, using WELLCLEAN II simulations, designed a spacer system composed of MUDPUSH XL spacer and CW7 chemical wash to efficiently remove the SILDRIL fluid from the borehole prior to placing cement. The design used 22 casing centralizers to provide better than 75% standoff. A pump rate of 7 bbl/min [1 m^3/min] would allow 5 minutes of spacer contact time across the gas sand at 327 m [1073 ft]. WELLCLEAN II modeling predicted 100% cement coverage across the openhole section. For added safety, PTTEP engineers planned for an external casing packer (ECP) to be placed just above the gas sand.

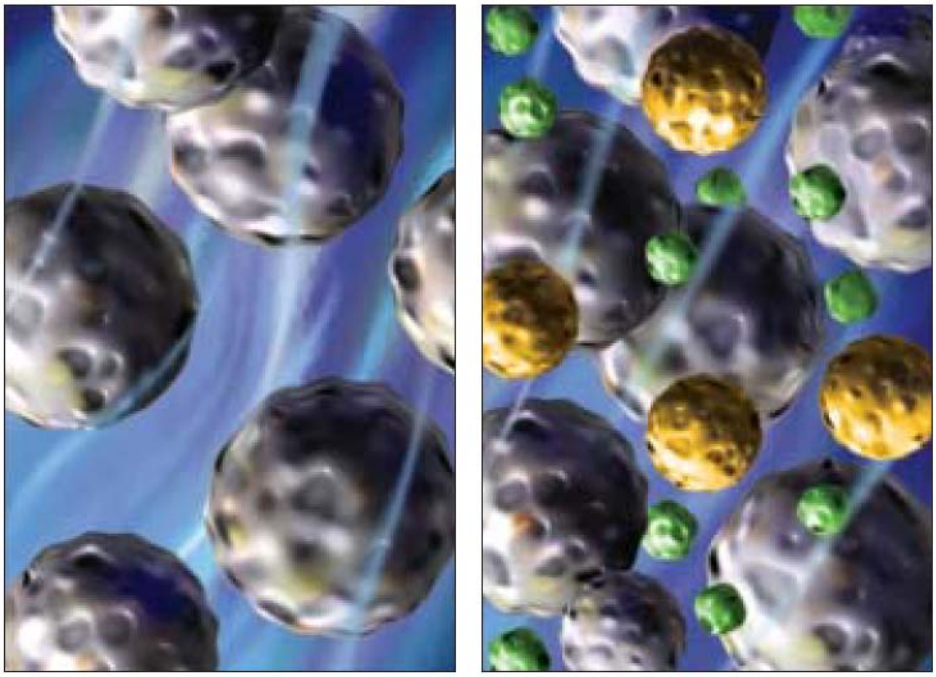
Cement-slurry design was also challenging. To avoid losses while cementing, a lightweight gas-tight cement slurry was required. The low borehole temperature, 35°C [95°F], meant long cement setting time. Low fluid loss and rapid static gel-strength development during cement setting would aid in minimizing gas influx. Schlumberger engineers designed a low-temperature LiteCRETE cementing system containing GASBLOK LT gas migration control cement system additive and DeepCEM deepwater cementing solutions additive to minimize the transition time from liquid to solid, thus limiting gas-migration potential through the setting cement.

Caliper logs indicated an average borehole diameter of 12.54 in. [318 mm]—optimum formation-clay inhibition had been achieved using the SILDRIL mud system. Although four of seven ECPs failed to lock after inflation, the LiteCRETE cementing system in conjunction with a gauge borehole, an optimized spacer system and effective displacement provided excellent cementation and zonal isolation. Ultimately, there was no evidence of gas migration or SCP behind the 9⅝-in. casing string.

An integrated drilling and wellbore-fluids approach effectively isolated the troublesome gas zone at 327 m [next page, bottom]. Although consideration had been given to changing locations to avoid the shallow-gas sand, this solution allowed PTTEP to keep the platform in place and continue the drilling program. Seven wells have since been successfully completed.

Improving Cement Bond over Time

Preventing gas migration and SCP has been helped by recent developments in cementing technology that offer significant advantages in durability and adaptation to changing wellbore conditions. Cement properties have traditionally been designed for optimal placement and strength development rather than long-term post-setting performance. The rapid development of high cement-compressive strength after placement was generally considered adequate for most wellbore conditions. Today, operators and service companies realize that the emphasis on strength at the expense of durability has often led to the development of SCP and reduced well productivity.



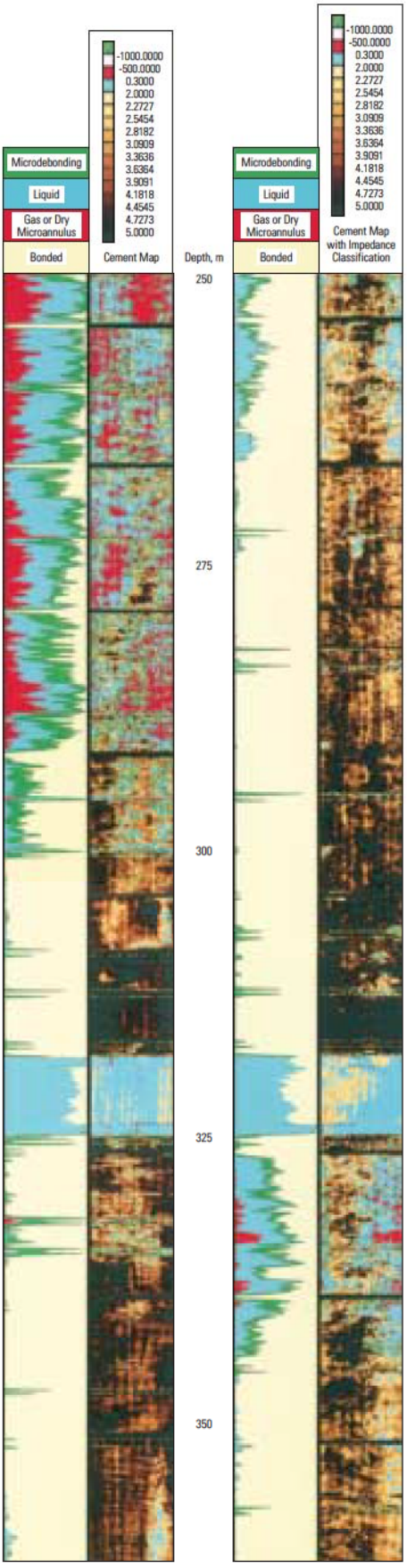
^ Filling the voids. The void space between particles in standard cements (*left*) is filled with water. FlexSTONE systems fill the void space with medium and small particles (*right*). Less water is used in the formulation, and slurries can be made more gas-tight, stronger and more flexible. As the cement sets, specific particles in the FlexSTONE system contribute to expansion while others are designed to provide flexibility of set cement.

Cement particle characteristics and size distribution can contribute significantly to both the resistance to gas influx and maintenance of a sustainable hydraulic seal, particularly in wellbores subjected to pressure and temperature cycling. FlexSTONE advanced flexible cement technology, part of the CemCRETE concrete-based oilwell cementing technology, is one of several solutions that effectively address cement flexibility and durability.

Conventional Portland cements are known to shrink during setting [previous page, middle].[19] In contrast, FlexSTONE slurries can be designed to expand, further tightening the hydraulic seal and helping to compensate for variations in borehole or casing conditions. This capability helps avoid microannuli development. By adjusting specific additive characteristics and by blending the cement slurry with an engineered particle size distribution, a lowering of Young's modulus of elasticity in cement can be achieved [above]. Annular cement can then flex in unison with the casing rather than failing from tensile stresses. Thus, the potential development of microannuli and gas communication to the surface or to zones of lower pressure are minimized.

An example of the expansion capabilities of FlexSTONE cement comes from the Middle East. During 2002, Abu Dhabi Marine Operating Company (ADMA), operating the Umm Shaif field, 20 miles [32 km] northeast of Das Island, offshore Abu Dhabi, UAE, used an expandable FlexSTONE cement system to address recurrent gas-migration problems behind 9⅝-in. casing strings.

19. Dusseault MB, Gray MN and Nawrocki PA: "Why Oilwells Leak: Cement Behavior and Long-Term Consequences," paper SPE 64733, presented at the SPE International Oil and Gas Conference and Exhibition, Beijing, China, November 7–10, 2000.



> Improved zonal isolation. Prior to optimization of the drilling and cementing process, zonal isolation was not obtained, as indicated by Tracks 1 and 2 (*left*). Areas shaded in red in Track 2 indicate gas. In Track 1, blue and green shadings along the left side indicate the presence of liquid and debonding respectively, signs of a potential gas channel. Effective procedures and optimized wellbore-construction processes successfully isolated the gas sands. In the figure at right, Track 1 shows areas of solid yellow, indicating bonded cement and zonal isolation. Significant levels of gas are seen only proximal to the shallow-gas sand.

While logging the 7-in. liner section, the operator ran a USI UltraSonic Imager log for a second time across the 9⅝-in. section cemented with a FlexSTONE cement two months earlier. Although a gas-tight seal was obtained during primary cementation, further tightening of the cement bond occurred with time. This finding demonstrates the expansive characteristics of the FlexSTONE design [right].

Modeling Cement Systems

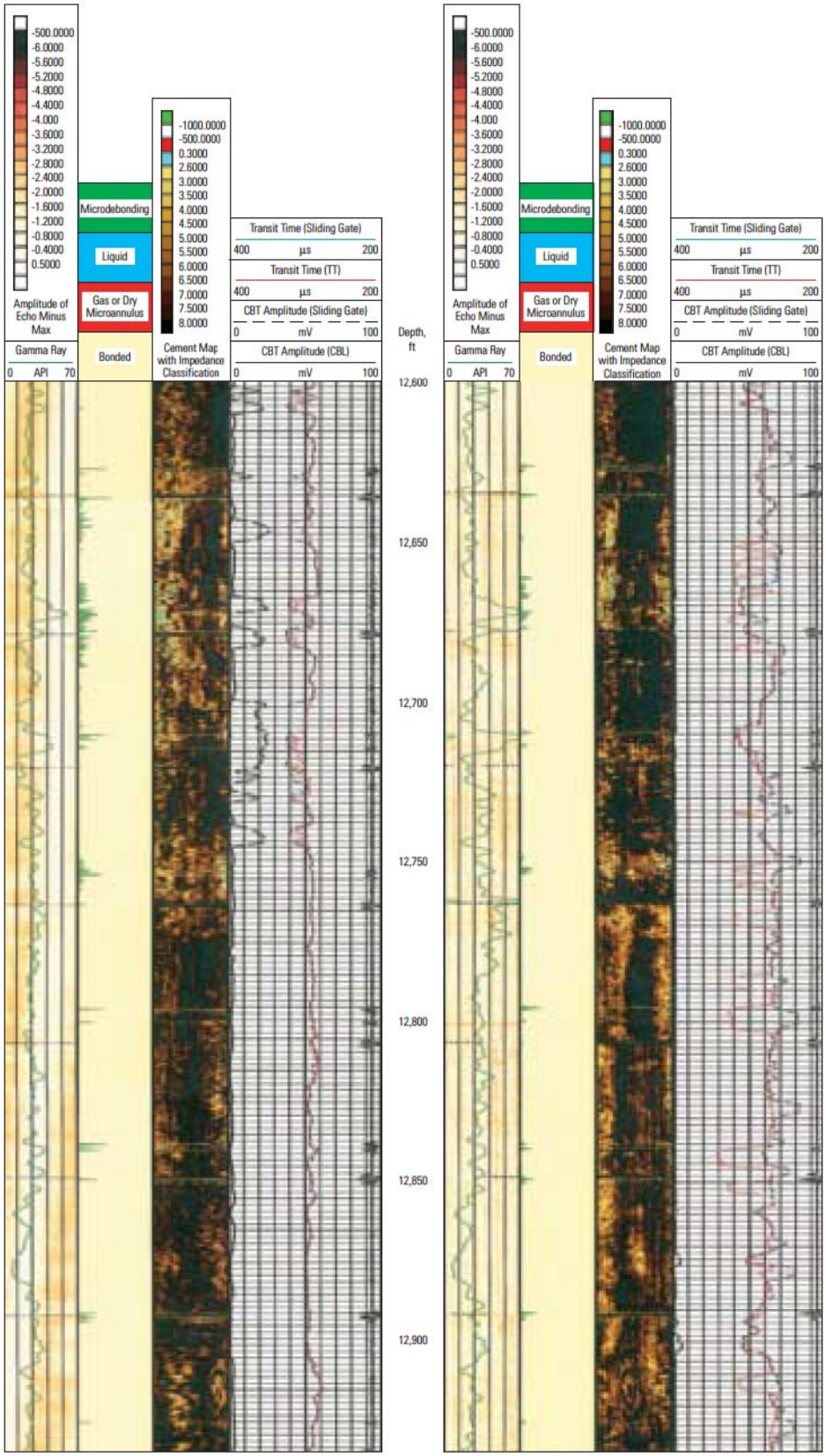
The role of modeling in cement-system design is evident in another Middle Eastern example. The Abu Dhabi Company for Onshore Oil Operations (ADCO) has drilled 70 gas wells in the Bab and Asab fields, offshore Abu Dhabi. Many of these wells have SCP problems, attributed by ADCO engineers to poor primary cementing practices.

These SCP problems threatened a 2003 development program. A different approach to cement-sheath integrity was needed. A planned horizontal, gas-producing appraisal well offered the opportunity to test a new cementing system.

Schlumberger and ADCO engineers agreed that historical failure mechanisms must be clearly understood to achieve sustainable zonal isolation. Schlumberger engineers used a stress analysis model (SAM) to evaluate potential cement systems. They ran a series of simulations to predict cement-sheath behavior across different borehole sections. In one scenario, an 80-lbm/ft^3 [1280-kg/m^3] mud system was displaced from the cased wellbore with a 74-lbm/ft^3 [1184-kg/m^3] completion fluid. The displacement resulted in a pressure reduction of 540 psi [3723 kPa] across the liner section.

Typically, these liner sections are cemented with 125-lbm/ft^3 [2000-kg/m^3] conventional cement systems. Laboratory records indicated that locally formulated conventional cement systems generally have an unconfined compressive strength (UCS) of about 4000 to 8000 psi [27 to 55 MPa] and a Young's modulus of 1,450,000 psi [10,000 MPa] to 1,700,000 psi [11,721 MPa]. Simulations with the SAM model predicted that a 540-psi decrease in hydrostatic pressure inside the casing would result in cement-to-liner bond failure and development of a channel or microannulus. The model suggested that a more flexible expanding cement would withstand the variation in internal casing pressure without causing microannulus development.

While SAM modeling and other analyses were under way, appraisal-well drilling began. The 9⅝-in. section was cemented with a conventional cement system, allowed to set and then



^ FlexSTONE cement expansion with time. USI logs of a borehole made in October (*left*) and December (*right*) indicated cement expansion over the two-month period. Track 2 indicates more debonding (green) in October than in December (Track 6). The reduction in CBT amplitude in Tracks 4 and 8 also indicates improved bonding.

logged with a USI tool to evaluate the cement bond. Once the cement had cured, the operator pressure-tested the section to 3500 psi [24 MPa]. To check cement integrity, USI logs were rerun under the same conditions as the first logging run. The second log indicated that the nonflexible conventional cement-system formulation failed to produce a slurry capable of compensating for casing deformation, resulting in loss of cement-to-casing bond [right].

Even though the casing had already been cemented, Schlumberger engineers simulated the pressure-test conditions in SAM. Cement properties were imported from the job design for analysis. SAM predicted that the conventional cement slurry would fail in tensile load. The model indicated that the change in internal casing pressure exceeded the cement tensile strength by 153%. To withstand this level of tensile load, the SAM model recommended cement designed with a Young's modulus of 1,200,000 psi [8273 MPa], 500,000 psi [3447 MPa] below that typical for conventional cement-system formulations.

Additional SAM modeling and cement slurry tested in the Schlumberger laboratory indicated that the FlexSTONE cement system would provide sustainable zonal isolation under anticipated downhole conditions [below]. The results suggested that both the expansive and flexible properties of FlexSTONE cement would be required to effectively cement the 7-in. liner section.

As with many high-performance cementing systems, FlexSTONE cements must be carefully designed. The increase in flexibility is associated with a decrease in compressive strength. Thus, compressive strength cannot be used as a primary indication of a cement's long-term durability. The cement systems must be designed to ensure a compromise between both properties. After evaluating several potential slurries including tests to determine the balance between expansion and the compressive-strength requirements, engineers settled on a suitable FlexSTONE cement formulation for the 7-in. liner.

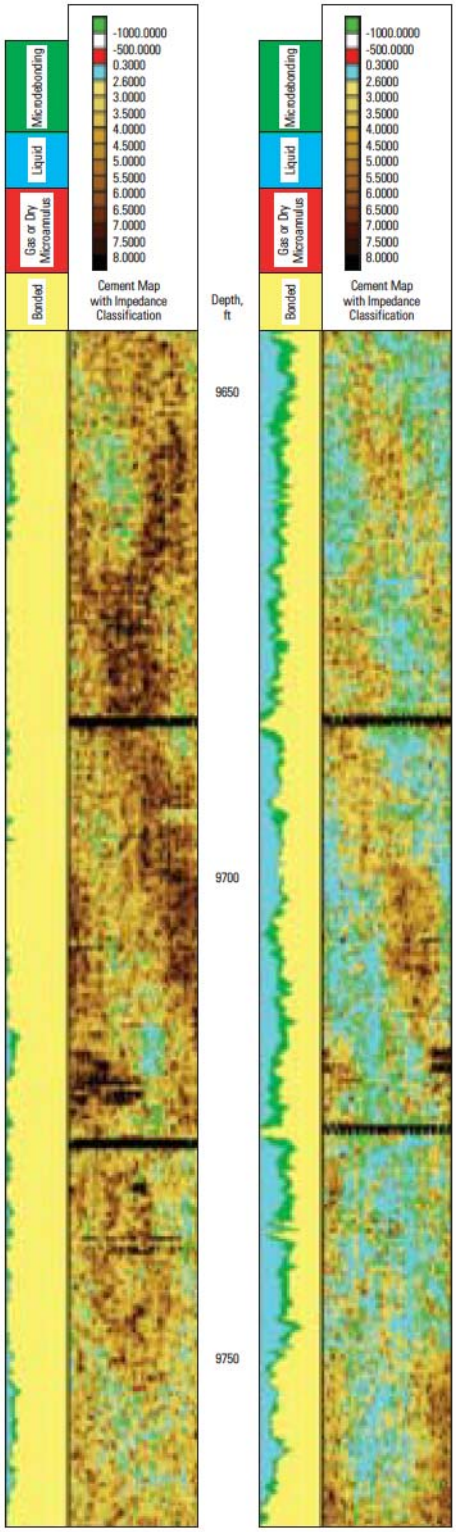
The 8½-in. borehole section would be drilled through a limestone formation. Special mud systems generally are not necessary when drilling through carbonate rock. Engineers could safely assume that borehole conditions would be optimal with little washout. The WELLCLEAN II program simulated and designed the displacement, and CemCADE software provided cement-job design and execution guidelines.

Engineers designed the BB-545 appraisal well with a 7-in. liner section extending to 11,621 ft [3542 m] MD, (11,104 ft [3385 m] TVD). This section ended with a 90° section in the Arab ABC reservoir, a gas-bearing formation with 32% H_2S content. The liner overlap, potentially a problematic source of SCP, extended 365 ft [111 m] back into the 9⅝-in. casing. Well production came from a 2250-ft [686-m], 6-in. openhole horizontal section drilled from the 7-in. liner shoe.

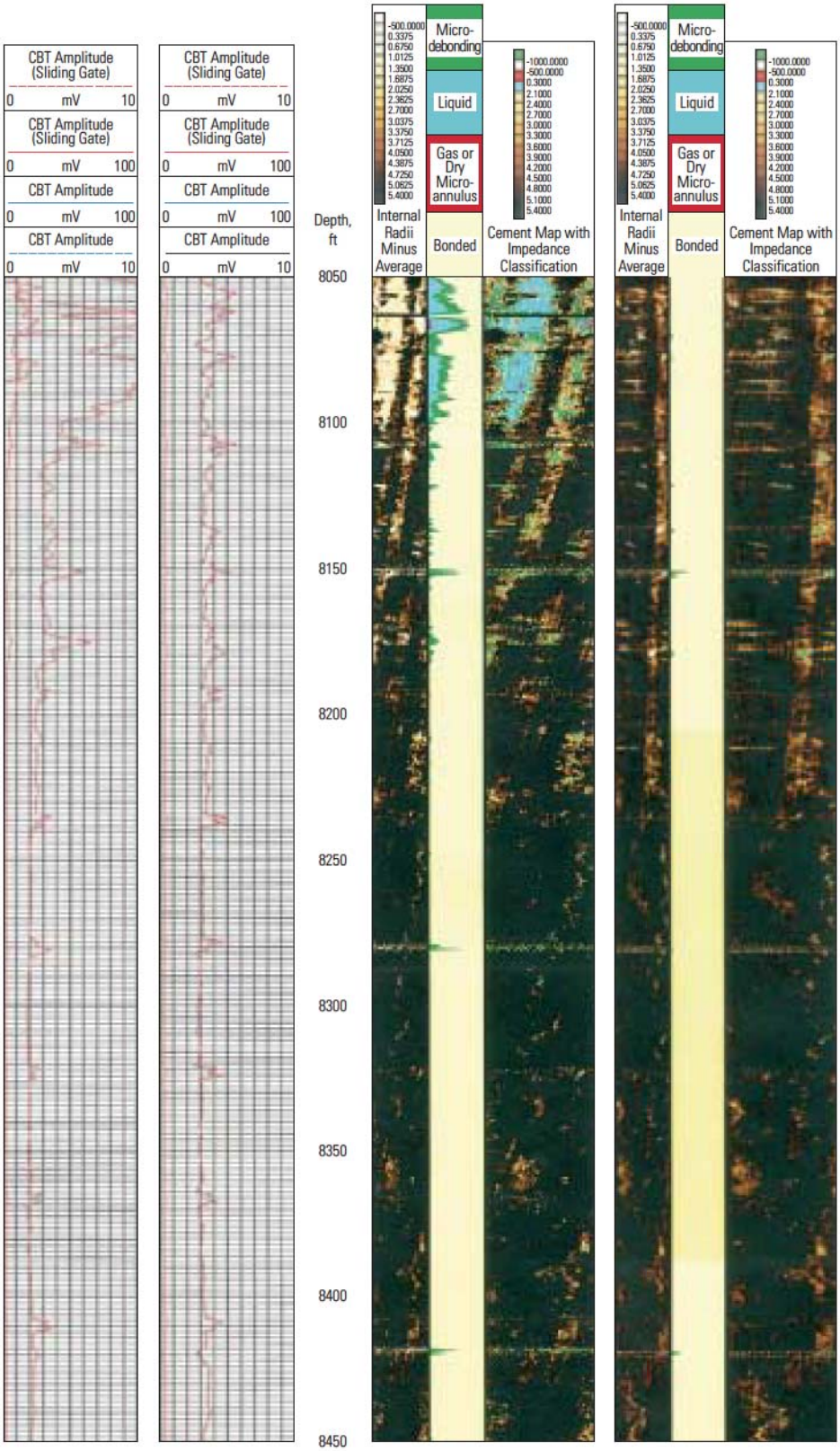
On February 4, 2003, the 7-in. liner was cemented as designed. After the cement had set, a USI log confirmed complete cement placement with no detectable channels or microannuli. After seven months, the BB-545 appraisal well showed no sign of SCP.

Slurry	Young's Modulus, psi	Poisson's Ratio
Slurry 1–FlexSTONE	900,000	0.20
Slurry 2–Type G conventional cement 1	1,700,000	0.19
Slurry 3–Type G conventional cement 2	1,500,000	0.22

^ Flexible cement designs. The FlexSTONE system was designed with a 50% lower Young's modulus than conventional slurry to meet the specifications determined from SAM simulations. Slurry 2 reflects the properties for the conventional cement slurry used to cement the 9⅝-in. casing string. FlexSTONE Slurry 1, which has a substantial increase in flexibility, was used to cement the 7-inch liner section.



^ Cement debonding after pressure-testing. The USI log image (*left*) shows well-bonded cement in Track 1 (yellow). After the well was pressure-tested to 3500 psi [24 MPa], another USI log was run (*right*). When the pressure was removed, the casing decreased in size but the cement sheath did not move, or flex, with the casing. Near total debonding resulted as indicated in Track 3 (blue).



^ Zonal isolation on Well BB-548. Both CBT (*left, Tracks 1 and 2*) and USI (*right Tracks 3 to 8*) logs were obtained while logging the 9⅝-in. casing section of Well BB-548 in April and again in June. The April USI results in Track 4 indicated good overall bonding (yellow) with a few small liquid zones (blue). These zones, shown in the April CBT log (Track 1/8080 ft [2463 m]), reflect a CBT amplitude of 20 mV. As indicated by less liquid in the June USI result (Track 7) and a drop of CBT voltage to 5 mV (Track 2), pressure-testing did not affect the hydraulic seal developed by the expansive and flexible FlexSTONE cement. In Tracks 1 and 2, the CBT amplitude and CBT amplitude (sliding gate) essentially overlap one another.

FlexSTONE cement was also used to cement the 9⅝-in. casing section of Well BB-548, a wellbore similar to the BB-545 well that also penetrated the Arab ABC formation. Even though the well underwent significant pressure variations during testing, USI logs run after 72 hours and again after two months indicated sustained zonal isolation and improved bonding with time [left].

The Future under Construction

Gas migration and sustained casing pressure occur with unpredictable frequency in many parts of the world. Regulatory agencies and the oil and gas industry both have a vested interest in focusing on factors contributing to its development and prevention.

Continuing efforts to develop sound well-construction practices will eventually mitigate the frequency of SCP development. Further advances are needed, particularly in the areas of monitoring wells, locating the source of leaks and providing cost-effective methods of repair.

Operator experiences presented in this article demonstrate that integration of interdependent services and technologies coupled with advances in simulation, modeling and product technologies have moved the industry forward in addressing gas-well security and potentially, gas-well longevity—DW

CLIMATE COUNCIL

POLLUTION AND PRICE: THE COST OF INVESTING IN GAS



CLIMATECOUNCIL.ORG.AU

Thank you for supporting the Climate Council.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

Published by the Climate Council of Australia Limited

ISBN: 978-1-925573-22-0 (print)
978-1-925573-23-7 (web)

© Climate Council of Australia Ltd 2017

This work is copyright the Climate Council of Australia Ltd. All material contained in this work is copyright the Climate Council of Australia Ltd except where a third party source is indicated.

Climate Council of Australia Ltd copyright material is licensed under the Creative Commons Attribution 3.0 Australia License. To view a copy of this license visit http://creativecommons.org.au.

You are free to copy, communicate and adapt the Climate Council of Australia Ltd copyright material so long as you attribute the Climate Council of Australia Ltd and the authors in the following manner:

Pollution and Price: The cost of investing in gas by Andrew Stock, Professor Will Steffen, Greg Bourne, Petra Stock and Dr Martin Rice.

Peer review: Tim Forcey, Energy Advisor, and an anonymous reviewer.

—

Image credit: Cover photo: "Gas processing plant" by Flickr user John Carney licensed under CC BY-NC 2.0.

This report is printed on 100% recycled paper.

facebook.com/climatecouncil

twitter.com/climatecouncil

info@climatecouncil.org.au

climatecouncil.org.au



Andrew Stock
Climate Councillor



Petra Stock
Energy and Climate Solutions Analyst, Climate Council



Professor Will Steffen,
Climate Councillor



Dr Martin Rice
Head of Research, Climate Council



Greg Bourne
Climate Councillor

Contents

Key Findings ii

Recommendations for Policy Makers iv

1. Introduction 1

2. Emissions Reduction: Limiting Global Temperature Rise Means Moving Away From Gas as Well as Coal . 3

2.1. Delivering Australia's Emission Reduction Commitments 4

2.2. Australia's Electricity Sector, Our Largest Source of Emissions 7

2.3. Emissions Associated with Gas Powered Electricity Generation 8

2.4. Power Plant Emissions 11

2.5. Methane Emissions 13

2.6. Ageing Infrastructure 16

2.7. Gas and the Global Carbon Budget 19

2.8. Has Australia Already Over-Spent its Gas Carbon Budget on LNG Exports? 22

2.9. Australia Needs to Transition Rapidly to a Zero Emissions Electricity System 24

3. Affordability: Greater Reliance on Gas Will Drive Higher Power Prices 25

3.1. Renewable Energy is Cost Competitive and Without the Associated Fuel Costs of Gas 26

3.2. LNG Exports are Pushing Up the Price of Gas in Australia 27

3.3. Gas is an Expensive Transition Fuel Compared to Renewable Technologies 29

3.4. Will Greater Reliance on Gas Power Make Electricity More Affordable? 33

3.5. Policies Transitioning Directly to Renewable Energy are a Lower Cost Alternative to Increased Reliance on Gas 34

4. Reliability: A Secure, Dependable Electricity System Can Be Achieved Without Gas 36

4.1. Reliable Renewable Electricity Can Meet Consumer Demand 24/7 Throughout the Year 37

4.2. Greater Interconnection Can Improve Security of Power Supply 41

4.3. Renewable Electricity Can Provide Grid Stability 42

4.4. Energy Security and Climate Change 44

5. A Secure, Dependable, Cost Effective, Zero Emissions Power System Can Be Achieved Without Gas 46

Appendix: Gas in Australia Explainer 47

References 50

Image Credits 54

Key Findings

1

Australia's electricity system is ageing, inefficient and polluting.

- As coal fired generators close new power plants must be built to provide clean, affordable, secure power.
- Tackling climate change and protecting Australians from worsening extreme weather requires our electricity system to produce zero emissions before 2050.
- Fossil fuels: coal, oil and gas all produce greenhouse gas emissions driving climate change. Limiting global temperature rise requires that they are all phased out.

2

Gas is not sufficiently less polluting than coal to garner any climate benefit.

- Greenhouse gas emissions are produced both from gas power stations and gas production (for instance, methane from gas leaks). Methane is 86 times more potent as a greenhouse gas than carbon dioxide over a 20-year period.
- Old gas plants in Australia, such as Torrens Island, are as polluting as coal fired power stations.
- New gas power plants are less polluting than coal, however, when the entire supply chain of gas production is considered, gas is not significantly less polluting than coal.
- Current levels of reliance on gas power in Australia must be reduced to play our role in limiting global temperature below 2°C. Expanding gas usage is inconsistent with tackling climate change as it locks in emissions for decades into the future.

3

Greater reliance on gas will drive higher power prices.

- Australia's Liquefied Natural Gas (LNG) exports are pushing up the price of gas power as domestic gas prices are now inextricably linked to world market prices for oil. This will continue into the foreseeable future.
- The most economic and accessible reserves are now being exported. Further gas expansion will drive increased reliance on unconventional gas, which is expensive.
- Reliance on gas power is also driving power price spikes particularly in South Australia, Queensland and increasingly in New South Wales, due to lack of competition among gas power companies.

4

Investment in new gas plants is financially risky.

- The large increases in future gas prices and volatility resulting from LNG exports together with domestic gas prices controlled by relatively few producers, make investments in new power plants using gas very risky.
- New gas power plants would rely on ageing gas infrastructure (e.g. processing plants and high pressure pipelines) that is increasingly vulnerable to failure. Costs of updating this infrastructure and accounting for methane leakage must be factored into policy and investment decisions.
- New gas infrastructure locks in carbon emissions for decades. Future regulations may impose higher costs or stricter limits on emissions in the future, impacting on the economic viability of gas production and electricity generation, stranding investments.

5

Significant development of new gas plants is unfeasible without a massive expansion of unconventional gas, including thousands of new unconventional gas wells.

- The sheer volume of gas required, the cost, the lock in of long-term emissions, and community concerns makes this unrealistic.
- Currently the emissions from unconventional gas in Australia are unknown due to a lack of measurement and data. This presents a long-term carbon risk to investors as high emissions fossil fuel infrastructure faces the possibility of future regulation due to climate change.
- Development of new unconventional gas is entirely out of step with meeting the Federal Government's climate change goals.

6

Renewable energy can provide a secure, affordable alternative to new fossil fuels.

- New renewable energy is cost competitive with new gas. The cost of renewable power and storage, particularly solar, wind and batteries, continues to fall and has no associated fuel costs. This contrasts with rising and volatile gas prices.
- Technologies such as solar thermal, hydro and biomass plants can meet demand for electricity at all times of the day as well as meeting technical requirements for grid stability. Combining these technologies with wind, solar PV, and large-scale energy storage, can meet electricity demand round-the-clock.
- Using existing gas-fired generators and supply infrastructure prudentially to complement wind and solar power while scaling up a range of renewable energy technologies, energy storage, and energy efficiency measures could deliver a limited benefit, provided the end goal is phasing out the use of all fossil fuels as quickly as possible.

Recommendations for Policy Makers

UNDERSTAND EMISSIONS FROM GAS PRODUCTION AND POWER PLANTS.

1. Require independent field measurements of methane emissions (baseline before development is approved, after development, throughout operations and after abandonment) at every current and proposed unconventional gas project in Australia to determine accurate emissions factors for gas production and generation and national greenhouse gas reporting.

ROLE OF GAS IN AUSTRALIA'S ENERGY SYSTEM

2. Do not provide policy support for new gas power plants or gas supply infrastructure. New gas infrastructure risks "locking in" expanded gas use and exploration for decades into the future, and carries risks associated with emissions, electricity costs and asset stranding.

3. Design any new policy, for example an Emissions Intensity Scheme, taking into account the full emissions profile of gas (including supply chain emissions), as well as the full cost implications. This is critical for affordability and emissions.

4. Existing gas plants should be thought of as a short-term, expensive, emergency backup as renewable energy and storage is rapidly scaled up.

A NATIONAL PLAN FOR AUSTRALIA'S ELECTRICITY SYSTEM

5. Introduce a national transition plan for Australia's electricity system that:

a. ramps up a diverse range of renewable energy, energy efficiency and storage technologies to enable the phase out of fossil fuelled electricity generation over the next 2-3 decades;

b. is secure and robust, particularly in light of worsening extreme weather events; and

c. reaches net zero emissions before 2050 at the latest.

6. Incentivise greater interconnection between states by transmission lines to provide more diverse, distributed, and secure electricity supply and increase competition in the electricity market.

7. Incentivise a more distributed system (with power generation spread geographically rather than large, concentrated power plants) involving a wider variety of supplies - wind, solar, biomass, hydro, and energy storage – to ensure more resilience to disruption from increasing extreme weather events due to climate change.

1. Introduction

Australia is at a critical juncture on energy and climate policy.

Australia's energy infrastructure is ageing, inefficient and polluting, and must be replaced over the next few decades. Already nine coal fired power stations have shut down in the last five years (McConnell 2016; ABC 2017a). Meanwhile, over the last 20 years, 1.6 million households have invested in solar panels for their homes, and the cost of renewable energy, particularly solar photovoltaic and wind power, has rapidly decreased. The Australian energy system is experiencing a transition, which is similarly being experienced around the world as the cost of renewable power drops and countries seek to tackle climate change.

Meanwhile, it is now clear that climate change is already worsening extreme weather events. The 2016/2017 summer has been described as the "Angry Summer" highlighting the significant number of weather records broken. This follows a long-term trend of global warming over a number of decades. Climate change is driven by emissions of greenhouse gases from the burning of fossil fuels (coal, oil and gas). Tackling climate change requires transitioning away from fossil fuels for electricity to renewable energy generation, storage and improvements in energy efficiency. The regulatory and investment decisions made in the next decade will either lock in more emissions intensive infrastructure, or accelerate the transition to zero emissions electricity generation before 2050.

At the same time community concerns about high and climbing electricity prices, as well as discussion about the reliability of our electricity system are issues dominating the news media.

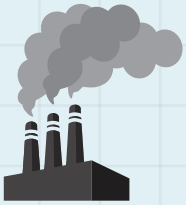
This report investigates the role of gas as Australia transitions its electricity sector to net zero emissions before 2050. Gas has been commonly referred to and promoted by the gas industry as playing a 'pivotal role ... in the transition to a low-carbon economy' (APPEA 2016). This report looks at how gas-fuelled electricity generation measures up against the principal policy criteria for Australia's electricity system: affordability, reliability and emissions reduction (Finkel 2016). While focusing chiefly on gas-powered electricity generation, this report considers other relevant factors where necessary, such as Australia's Liquefied Natural Gas (LNG) export market and methane emissions associated with unconventional gas production.

The report finds limiting global temperature rise means moving away from gas as well as coal for power generation. Greater reliance on gas will also drive higher power prices. The report shows that a secure, dependable, cost effective power system can be achieved without gas.



THE COST OF INVESTING IN GAS

POLLUTION



POLLUTING GAS PLANTS

Some gas plants are as polluting as coal plants. Carbon dioxide (CO_2) emitted by gas power plants: **360 - 910kg CO_2/MWh**



SUPPLY CHAIN EMISSIONS

Methane emissions from unconventional gas (e.g., coal seam gas) may cancel out any benefit of gas over coal.



AGEING INFRASTRUCTURE

Gas infrastructure built 1960s onwards. Risk of failure and emissions.

PRICE



EXPORTS RAISING PRICES

Liquefied Natural Gas exports are pushing up domestic gas prices.



UNCONVENTIONAL GAS PRODUCTION

Increasing reliance on more expensive gas sources.



LOW COMPETITION

Lack of competition between gas power companies is driving electricity price spikes in some markets.

Figure 1: Gas - polluting, ageing and expensive.

2. Emissions Reduction: Limiting Global Temperature Rise Means Moving Away From Gas as Well as Coal

Climate change (fuelled by the burning of coal, oil and gas) is already influencing extreme weather events across Australia.

Australia has agreed with world leaders to limit global temperature rise to well below 2°C, which means Australia's electricity system needs to reach zero emissions before 2050. Gas power generates greenhouse gas emissions at the power plant and along the gas supply chain. Greater reliance on gas for power generation is inconsistent with action on climate change.

2.1. Delivering Australia's Emission Reduction Commitments

2016 was the hottest year on record globally for the third year in a row. The record global warmth of 2016 is part of a long-term trend. All of the world's 10 warmest years have occurred since 1998. 2016 was the 40th consecutive year with above-average global temperatures (NOAA 2017). Human activities, such as the burning of coal, oil and gas for electricity, are driving up greenhouse gas emissions and fuelling this long term warming trend.

In 2016, Australia sweltered through its warmest autumn on record. Highest temperatures on record were experienced throughout much of eastern and northern Australia including Queensland, New South Wales, Victoria and the Northern Territory. From late February through to March 2016, the sea surface temperatures over the northern, pristine part of the Great Barrier Reef were around 1 to 1.5°C above the recent long-term average (2002-2011). Warm waters caused devastating bleaching and the death of 67% of coral in the northern section. Western Australian and other reefs throughout the world were also badly affected by this mass global bleaching event, the worst in recorded history, driven by climate change and a recent El Niño event.

During the "Angry Summer" of 2016/17, over 205 records were broken around Australia. For example, Brisbane, Canberra and Sydney experienced their hottest summer on record. The extreme summer heat in New South Wales was made at least 50 times more likely to occur due to climate change (King et al. 2017). The "Angry Summer" of 2016/17 follows hot on the heels of previous Angry Summers in 2012/13 and 2013/14, with Australians facing record-breaking extreme weather events driven by climate change, yet again (Climate Council 2017a).

Climate change is influencing all extreme weather events in Australia and around the globe (Trenberth 2012). Heatwaves are becoming hotter, lasting longer and occurring more often (Perkins and Alexander 2013; e.g., Figure 2). Marine heatwaves that cause severe coral bleaching and mortality are becoming more intense and occurring more often (e.g., Moore et al 2012). Extreme fire weather and the length of the fire season are increasing, particularly in the south and east of the continent, leading to an increase in bushfire risk (Clarke et al 2013). Sea level has already risen and continues to rise, driving more devastating coastal flooding during storm surges (IPCC 2012). The impacts of extreme weather events are likely to worsen unless global greenhouse gas emissions are reduced rapidly and deeply (Climate Council 2017b). Australia is the 16th largest emitter of carbon dioxide in the world, larger than 180 other countries (Global Carbon Project 2016). Australia must do its fair share in reducing emissions.

As global temperatures continue to rise, there are serious consequences for human health and wellbeing, as well as the natural systems that support us, like land, air and water. The burning of fossil fuels (coal, oil and gas) produce greenhouse gas emissions, these gases trap heat in the atmosphere causing global warming. The additional heat in land, ocean and atmospheric systems is driving worsening extreme weather. If we do not rapidly reduce greenhouse gas emissions, then even more harmful and potentially catastrophic consequences for humanity will occur.

Under the Paris Agreement, world leaders including Australia agreed to limit global temperature rise to well below 2°C above pre-industrial levels, and to pursue efforts to limit temperature rise to only 1.5°C. This near universal agreement - signed by 196 nations, ratified by 139 nations and accounting for 97% of global emissions - entered into force on 4 November 2016. Australia ratified the Paris Agreement on 9 November 2016 (UNFCCC 2017).

Figure 2: Heatwaves are now hotter, longer and more often due to climate change (Perkins and Alexander 2013).



While 2°C may not sound like much, this level of temperature rise will have serious impacts on the lives and livelihoods of people all over the world. Already at only about 1°C temperature increase from pre-industrial levels, climate change is intensifying extreme weather events. In order to achieve the 1.5-2°C target, the Paris Agreement sets a goal to reach net zero greenhouse gas emissions globally in the second half of this century (UNFCCC 2017) - specifically, carbon dioxide emissions have to drop to net zero between 2060 and 2075, while total greenhouse gas emissions need to decline to net zero between 2080 and 2090 (WRI 2015).

In ratifying the Paris Agreement, Australia has committed to both a 2030 emissions reduction target, and to rapidly reduce our carbon emissions (including electricity sector emissions), in line with a pathway to zero emissions by 2050 (The Climate Institute 2015).

The Federal Government has set a 2030 emissions reduction target of 26 - 28% below 2005 emissions levels (Australian Government 2015a). Yet in 2015, leading up to the Paris climate talks, the Climate Change Authority recommended - based on climate science, international actors and economic factors - that Australia should reduce its emissions 40 - 60% below 2000 levels by 2030 (or a range of approximately 45-65% below 2005 levels). It is important to note that these Climate Change Authority recommendations are based on only a two-thirds chance of avoiding 2°C warming. For a stronger chance, the emissions reduction target should be higher. Therefore, if global average temperature is to stay below 1.5 - 2°C then the Climate Change Authority recommendations should be seen as a bare minimum for Australia's contribution to tackling climate change in concert with the rest of the world. To stay below 2°C, Australia's electricity system needs to reach zero emissions before 2050 (ClimateWorks 2014).

Australia's electricity system needs to reach zero emissions before 2050.

2.2. Australia's Electricity Sector, Our Largest Source of Emissions

Today, Australia's electricity sector is the nation's single largest source of greenhouse gas emissions - accounting for 35% (189 $MtCO_2$¬e in 2016) of total emissions (Australian Government 2016a). The electricity sector has seen the largest total growth in emissions, increasing 46% (59.5 $MtCO_2$¬e) between 1990 and 2016 (Australian Government 2016a). When emissions from extraction, processing and transporting coal, gas and diesel are added, electricity generation is clearly the dominant contributor to Australia's emissions (Climate Council 2014).

Australia's electricity generation is dominated by high emissions fossil fuels (black coal 43%, brown coal 20%, gas 21% and oil 3%) with renewable energy making up 14% (Australian Government 2016b; note: numbers have been rounded).

If the electricity generation sector is to meet its proportionate share of the 2030 target, it needs to reduce its emissions by 48 $MtCO_2$ per year by then. As power stations are large single point sources of emissions, whereas emissions from many other sectors of the economy are widely dispersed, arguably the electricity sector should bear a higher proportion of the emissions reduction effort (Climate Council 2016a).

Electricity emissions must drop 50 million tonnes per year by 2030.

2.3. Emissions Associated with Gas Powered Electricity Generation

Using gas for power generation releases both carbon dioxide (directly from power plants and gas processing plants) and methane emissions (due to a multitude of gas leaks, venting, equipment purging, incomplete combustion, potential migratory emissions and other sources associated with the gas supply chain). There is an additional risk of large methane releases due to the failure risk from ageing infrastructure, e.g., see Section 2.6.

Methane (CH_4), the main component of natural gas, can be directly released to the atmosphere at each stage of gas production and transport either intentionally (via flaring or venting, equipment purging, or incomplete combustion) or unintentionally (e.g., leaks and failures). Methane is a particularly potent greenhouse gas, which later oxidises in the atmosphere (after 10-12 years) to form carbon dioxide. The global warming potential of methane is 86 times greater than carbon dioxide over a 20-year timeframe (Lafleur et al 2016) and 28 times greater over a hundred years (Schwietzke et al 2016).

Methane released in the gas supply chain is a potent greenhouse gas.

BOX 1: GAS JARGON

CARBON RISK

Due to high emissions associated with fossil fuel infrastructure, companies and investors face the possibility of future regulation due to climate change.

NATURAL GAS

Natural gas is a fossil fuel primarily consisting of methane (CH_4) and small amounts of other gases (less than 10%, such as ethane, propane, butane and carbon dioxide – which can vary up to as much as 50% of the raw gas stream before it is processed) (Parliament of Victoria 2013).

LNG

Liquefied Natural Gas (LNG) refers to natural gas converted into liquid form under very low temperatures (-161°C) in order to be more easily transported internationally and stored (APPEA 2016).

LNG TRAIN

An LNG Train is a facility that liquefies and purifies natural gas to reduce its volume, enabling the gas to be exported.

PETAJOULE (PJ)

The basic unit of measurement for energy is a "joule". A petajoule (PJ) is 1,000,000,000,000,000 joules or 10^{15} joules. The energy in 1PJ is roughly equivalent to the annual electricity use of 30,000 households (Parliament of Australia 2011).

MTPA

An mpta, or million tonnes per annum, is a measure of LNG exports. Producing 1mtpa of LNG requires approximately 60PJ of gas (Queensland Government 2009).

Carbon dioxide (CO_2) is emitted when natural gas is burned, for example when gas is used to generate electricity, heat, or steam. Carbon dioxide is also vented, sometimes in large quantities, in the natural gas production process when raw natural gas produced from underground is treated and carbon dioxide removed to ensure the gas meets pipeline specifications. When gas is used to generate electricity, the CO_2 emissions per unit of electricity depend on the particular gas power plant age, technology, and gas supply chain emissions (see Section 2.4).

Reliance on gas power in Australia poses significant, unaccounted for emissions risks associated with:

- Under-reporting of methane emissions due to lack of field studies and direct measurement by Australia's coal seam gas industry (Lafleur et al 2016, see Section 2.5). Most reporting of methane emissions uses factors derived from out-dated United States (US) industry metrics which have been shown to significantly under-report emissions, particularly from the coal seam gas industry (Kort et al 2014). There were no baseline studies undertaken of methane emissions before development of large coal seam gas deposits took place in the Bowen and Surat Basins (CSIRO Energy Technology 2012). Minimal studies have been done since of actual emissions over this now very large developed area. These factors mean that Australia's actual methane emissions from coal seam gas developments are largely unknown.
- Catastrophic infrastructure failure (e.g., ageing pipelines or gas storage wells) with the potential to release sizeable amounts of methane (see Section 2.6). Much of Australia's gas infrastructure – pipelines, storage facilities and wells were built in the 1970's and are now over 40 years old (The Australian Pipeliner 2016), potentially suffering from corrosion which brings associated catastrophic failure risk. Over the lifetime of any newly built gas power plants (2030 to 2060), this gas infrastructure will reach 60 to 80 years old. For example, the blowout of an underground gas storage well in the US released 100,000 tonnes of methane (equivalent to over 8 million tonnes of CO_2), before it was plugged (Conley et al 2016). There are numerous examples of failures of gas wells, pipelines and production plants in Australia.

These risks adversely impact Australia's ability to meet emissions targets for 2030 and beyond, and our ability to stay within our carbon budget (see Section 2.7).

Actual methane emissions from Australia's coal seam gas developments are largely unknown.

2.4. Power Plant Emissions

Different power plants emit different levels of greenhouse gases. While on average new gas-fired power plants emit less than new coal (Finkel 2016; Table 1), emission levels depend on power plant age and technology (Climate Council 2014), as well as the emissions associated with extracting, processing and transporting the fossil fuel to the power station. For example, some subcritical gas plants in Australia (such as Torrens A and Torrens B in South Australia; Figure 3) emit a similar amount of greenhouse gases per unit of electricity (840-910 kgCO_2-e/MWh) as subcritical black coal plants (Climate Council 2014).

Combined and open cycle gas power plants are less polluting than new coal, but not as substantially as one might expect. While, combined cycle gas turbines are around 50% less emitting than ultra-supercritical black coal plants, open cycle gas power plants (often used to meet peak demand) are around 10% less emitting than ultra-supercritical black coal plants. Most Australian gas power plants are emissions intensive open cycle plants. If run for peaking only, the amount of emissions would be contained, but if run more often, emissions will be little better than coal plants.

Table 1: Estimated emissions from new power stations (and Torrens Island power plants).

Generation type	Estimated operating emissions as generated (kg CO_2-e/MWh)
Coal	
Subcritical brown coal	1,140
Supercritical brown coal	960
Subcritical black coal	940
Supercritical black coal	860
Ultra-supercritical brown coal	845
Ultra-supercritical black coal	700
Gas	
Torren Island power plants*	840 - 910*
Open cycle gas turbine	620
Combined cycle gas turbine	370
Renewable energy	
Wind	0
Hydro	0
Solar PV	0

Source: Finkel 2016; Climate Council 2014*.



Figure 3: Torrens Island Power Plant, South Australia.

Some gas plants in Australia are as polluting as subcritical black coal plants.

BOX 2: SOURCES OF GAS

There are two main sources of gas produced for economic use globally, so called "conventional" and "unconventional" gas. The main sources and attributes of each are:

- **Conventional Gas** – typically sourced from deep underground, rocks 1,000 metres or much more below ground level, either onshore or offshore. The gas is usually produced at very high pressures requiring a relatively small number of wells to extract it. Sometimes, if rates of production are naturally low, the rocks may be fractured using injected fluids, to increase output. Conventional gas may be produced in association with oil, light oil (called condensate), or with small amounts of water. It has varying levels of impurities – such as carbon dioxide – that are removed to meet pipeline specifications. The carbon dioxide is usually vented (released to the air).
- **Unconventional Gas** – typically sourced from shallower levels, from a few hundred metres to less than 1,000 metres, and only onshore. The gas is usually produced at lower pressures, requiring tens to hundreds of wells to achieve the same output as a single conventional gas well. Low natural production rates may be increased through fracturing the coals or shale rock that the gas comes from. There are two main source rocks – coals (coal seam gas) and shales (shale gas and shale oil). Coal seam gas typically contains no oil or condensate, may have some carbon dioxide, and considerable produced water. Shale gas often is produced along with shale oil, or contains light oil.

Further details of gas industry terms and an introduction to gas in Australia can be found in the appendix near the back of this report.

Source: Parliament of Victoria 2013.

2.5. Methane Emissions

When considering emissions from gas power, methane emissions from the gas supply chain also need to be considered to determine whether gas is indeed a lower emissions source of electricity generation compared to coal. To determine the actual emissions intensity of using gas for electricity, emissions from gas production are added to the emissions generated from burning gas.

In national greenhouse gas accounts, the Australian Government applies default emissions factors for methane emissions largely based on figures sourced from the US gas production industry for gas production, rather than direct measurement. Emissions from all gas produced in Australia is reported as 0.5% of gas production (Lafleur et al 2016).

Published emissions data based on field studies and direct measurement from Australia's unconventional gas industry are extremely limited (GISERA 2015). Generally, no baseline emissions surveys were done prior to widespread exploration and development drilling of unconventional coal seam gas in basins like the Bowen, making reliable estimates of increased methane emissions difficult to determine (CSIRO 2012).

However, satellite and aircraft-based measurements of methane emissions from unconventional gas production in the US have demonstrated that the US industry is under-reporting emissions in the San Juan Basin coal seam gas province by between 1.8 to 3.5 times. Viewed from space, the San Juan Basin shows up as a remarkable methane "hot spot" (Kort et al 2014; see Figure 4). These US conclusions indicate that actual methane emissions from coal seam gas extraction in Australia may be substantially higher than the default factors applied to reporting here.

US measurements show methane emissions from unconventional gas production are significantly under-reported.

Figure 4: San Juan Basin methane emissions.

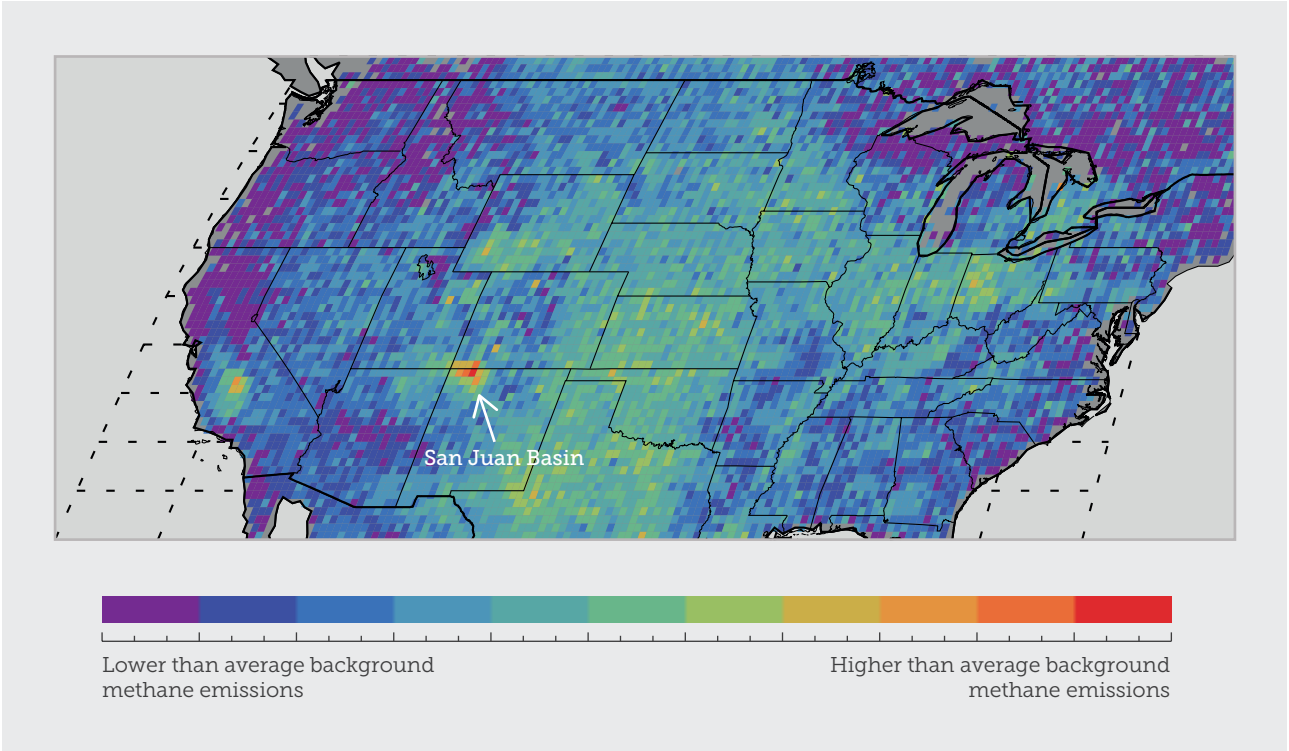


Image: Courtesy NASA/JPL-Caltech/University of Michigan.

Note: The San Juan Basin (located by the arrow and shown in red on Figure 4 above) is the major US hot spot for methane emissions in this map showing how much methane emissions varied from average background concentrations from 2003-2009 (dark colours are lower than average; lighter colours are higher).

If gas power is to have a net climate benefit compared to coal power, methane emissions must be less than 3 to 4% of production (Alvarez et al 2012; Hardisty et al 2012; NAS 2012). When methane emissions from the gas supply chain reach these levels and are added to the carbon dioxide emissions generated from burning gas in a power plant, the greenhouse gas pollution associated with generating electricity from gas is similar to coal. Field measurements in the US have found methane emissions from unconventional gas production are much higher, with some methane emissions recorded in some studies ranging from 2 to 17% of production (US Department of Energy 2010; Pétron et al 2012; Karion et al 2013; Caulton et al 2014; Pétron et al 2014; Schneising et al 2014; Howarth 2015; Lafleur et al 2016).

The lack of measurements and data on methane emissions from unconventional gas in Australia presents a significant carbon risk (facing the possibility of future regulation due to greenhouse gas emissions) for both Australia's LNG export industry and gas power generation. This is particularly concerning given the potency of methane as a greenhouse gas, the rapid and continuing scale-up of unconventional gas exploration and production associated with LNG exports and the growing proportion of coal seam gas in domestic supplies.

Given increased scrutiny by regulators and the investment community of investments at risk of stranding, or to potential damages actions, due to climate change impacts (APRA 2017), it would arguably be reckless to base a national transition strategy to lower emissions in the electricity generation sector around widespread expansion of unconventional gas production in the absence of sound emissions measurements of:

- Baseline methane emissions (i.e., before exploration and development commences)
- The impact of existing unconventional and conventional gas developments on methane emissions levels, particularly around ageing gas infrastructure and unconventional coal seam gas field developments.

Lack of Australian fugitive methane emission measurement and data is a serious unaccounted for risk.

2.6. Ageing Infrastructure

Many of Australia's gas production and storage wells, processing plants and high pressure transmission pipelines are already many decades old (The Australian Pipeliner 2016). Failures of such infrastructure through age or poor operating practices can release substantial volumes of methane, a potent greenhouse gas as described above. Consequently, relying on gas power and infrastructure can pose significant carbon risk (because high emissions fossil fuel infrastructure faces the possibility of future regulation due to climate change). Resulting economic costs and social consequences on society of failures (e.g., injuries or lives lost as a result of explosions) can also be severe.

A recent example (and the largest methane leak in US history) occurred in 2015 when a natural gas storage well in Aliso Canyon, California "blew out" releasing over 100,000 tonnes of methane in less than four months before the well was sealed. The well blowout led to a state of emergency being declared and more than 5,000 families being evacuated (Conley et al 2016).

Australia is not immune to environmental disasters resulting from infrastructure failure from oil and gas exploration and production. Events like the Aliso Canyon well blowout have happened here.

In Australia, there have been a number of major offshore and onshore gas well blowouts, some of which have taken months to stop. In addition, gas pipelines and gas processing plants have suffered major failures leading to significant methane emissions and, in some cases, major economic disruption (Table 2).

Failure of ageing gas infrastructure can cause emissions, economic and social risks.

Table 2: Australian gas-related infrastructure failures and well blowouts.

Offshore Well Blowouts	Year	
Barracouta 1	1965	Gas
Marlin B-1	1966	Gas
Marlin A7	1968	Gas
Petrel 1	1969	Gas
Marlin A4	1971	Gas
Flounder A1	1984	Oil
Montara H1	2009	Gas, Condensate, Oil

Onshore Well Blowouts	Year	
Della 1	1987	Gas Storage
Myall Creek 8	2003	Gas
Habanero 3	2009	Geothermal
Arrow	2011	Gas
AGL	2011	Gas

Gas Plant Explosions	Year	
Longford	1998	Gas
Moomba	2004	Gas
Varanus Island	2008	Gas

Gas Pipeline Ruptures	Year	
Moomba to Sydney	1982	Gas
Varanus Island	2008	Gas
Pt Pirie/Whyalla Lateral	2015	Gas

A major gas escape at a pipeline or processing plant may ignite, potentially increasing the damage caused and time to repair.

If power generation infrastructure were to become increasingly dependent on gas supplies, as the gas supply infrastructure ages further, the risk of failures may increase due to factors such as corrosion, failure of cements, metal fatigue and poor operating practices. The economic impacts of gas infrastructure failures can be major if a city's power supplies, or its industry, is heavily dependent on gas as a major energy source. The Longford Gas Plant explosion in 1998 is estimated to have had an economic cost to Victoria of $1.3 billion (The Age 2002), while the Varanus Island Explosion in 2008 cost the Western Australian economy an estimated $2.4 billion (Parliament of Australia 2008).

One recent major upstream gas release occurred at the Montara Wellhead Platform. In 2009, a well control barrier failed, causing a major oil and gas leak in the Timor Sea which took over 70 days to stop. While numerous reports into this incident made estimates of the amount of oil released (between 4,750 and 23,630 tonnes), no estimates appear to have been made of the volumes of gas released before the platform eventually caught fire and burned after 70 days of raw gas and oil release (AMSA 2010; Borthwick 2010; Australian Government 2016d; Crikey 2016). The gas release was substantial, as images of the rig and platform show (Figure 5).

Figure 5: Montana gas and oil blowout shows the huge cloud of escaping vented gas and oil slick - the platform is not on fire at this stage.



2.7. Gas and the Global Carbon Budget

The carbon budget (cumulative emissions) approach provides a conceptually simple yet scientifically robust way to translate climate policy targets into global carbon emissions budgets and to track progress towards meeting those targets (IPCC 2013). For example, the carbon budget provides a guide to how much carbon can be "spent" to meet the Paris target of limiting global temperature rise to 2°C or less. At any point in time, the carbon budget allows the calculation of a remaining emissions budget. This provides a critical reality check on the effectiveness of climate policies and the required depth and speed of emission reductions into the future.

The scientific basis for the carbon budget approach is the approximately linear relationship between the total amount of human emissions of carbon dioxide (CO_2) since the beginning of the industrial revolution and the resulting rise in global average temperature (Figure 6). As shown in the figure, there is a range of uncertainty around the linear relationship, represented by the coloured band, which allows a probability analysis of meeting specific temperature targets.

Figure 6 is based on projections by a number of different climate models of the rise in global temperature as cumulative global CO_2 emissions increase. The black line on the graph shows the actual cumulative CO_2 emissions since 1870 and the observed rise in global temperature. The figure shows the proportional (approximately linear) relationship between emissions and temperature rise; the more CO_2 we emit, the warmer the climate gets.

The carbon budget is a guide to how much carbon can be "spent" while keeping global temperature rise below 2°C.

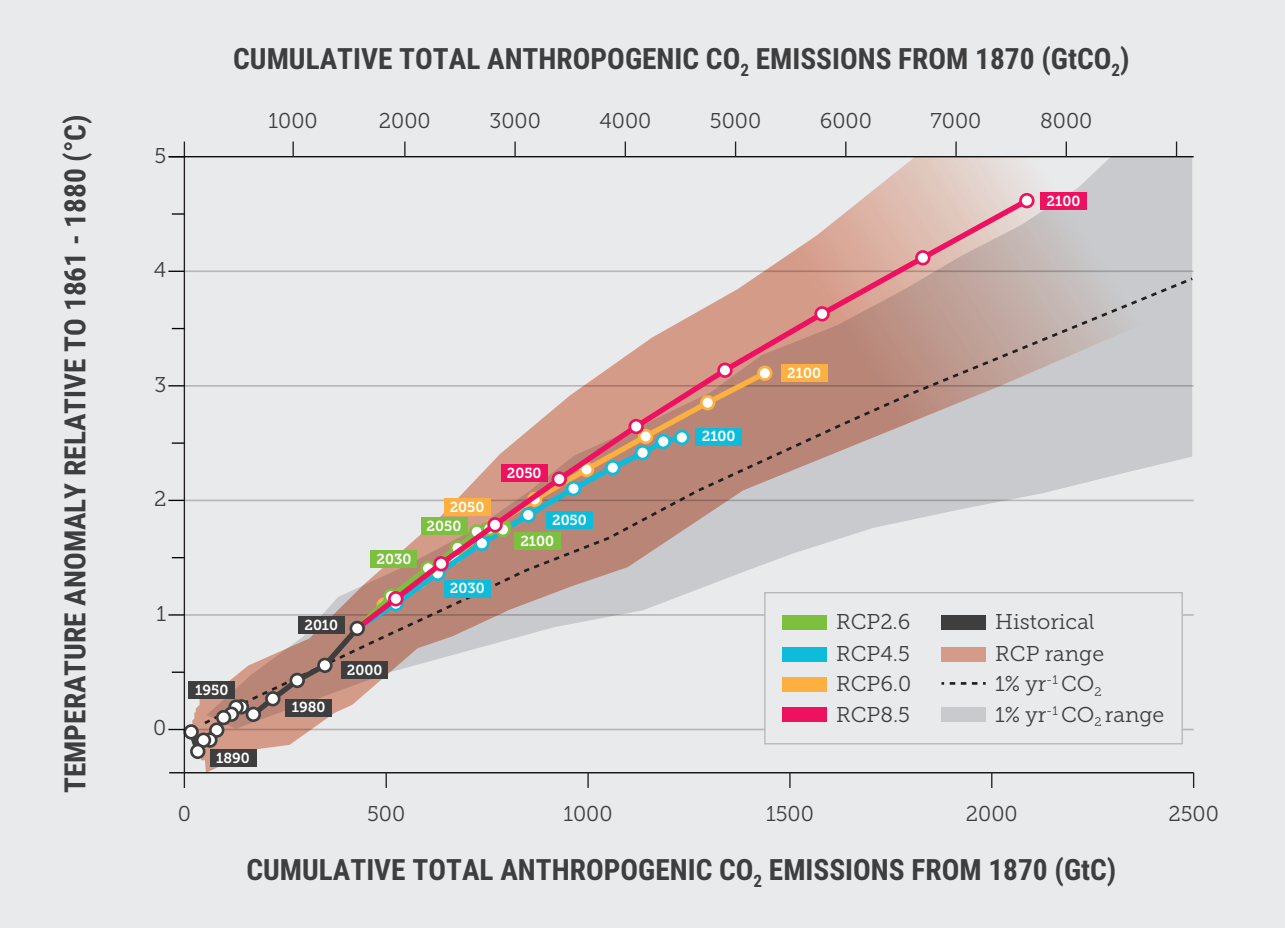


Figure 6: Global mean surface temperature increase as a function of cumulative total global CO_2 emissions from various lines of evidence.

Note: Results from a hierarchy of climate-carbon cycle models for each RCP (emission scenario) until 2100 are shown with coloured lines and decadal means (dots). Some decadal means are labelled for clarity (e.g.,2050 indicating the decade 2040-2049). Model results over the historical period (1860 to 2010) are indicated in black. The coloured plume illustrates the multi-model spread over the four RCP scenarios and fades with the decreasing number of available models in RCP8.5. The multi-model mean and range simulated by CMIP5 models, forced by a CO_2 increase of 1% per year (1% yr-1 CO_2 simulations), is given by the thin black line and grey area. For a specific amount of cumulative CO_2 emissions, the 1% per year CO_2 simulations exhibit lower warming than those driven by RCPs, which include additional non-CO_2 forcings. Temperature values are given relative to the 1861-1880 base period, emissions relative to 1870. Decadal averages are connected by straight lines. **Source:** Adapted from IPCC (2013).

Because 90% of the CO_2 that we emit comes from the burning of fossil fuels, to meet the carbon budget for the 2°C Paris target, most of the world's fossil fuel reserves must be left in the ground, unburned. "Reserves" refers to the fraction of fossil fuel resources that are exploitable under current economic conditions and have a specific probability of being produced.

McGlade and Ekins (2015) analysed the unburnable fossil fuels globally and for the OECD Pacific group (which consists mainly of Australian reserves, see Table 3).

To have a better than 75% chance of staying below the 2°C warming limit, more than 70% of Australia's existing, conventional reserves of gas are unburnable.

Table 3: Percentage of existing fossil fuel reserves that can be burned, based on a carbon budget approach for the OECD Pacific group (largely Australian reserves) for emissions from 2011 through 2050.

Probability of meeting 2°C target	75%
Oil	32
Gas	29
Coal	3

Source: Meinshausen et al. 2009; IPCC 2013; McGlade and Ekins 2015.

This analysis is based on a carbon budget from 2011 to 2050. Thus, results from this analysis will need to be reduced even more to account for the emissions from fossil fuels burned over the 2011-2016 period, which have consumed part of the 2011-2050 budget.

The analysis by McGlade and Ekins (2015) also finds that no amount of unconventional gas reserves (e.g., coal seam gas and shale gas) can be burned (unless they are cheaper than, and thus displace, production from existing conventional gas reserves, which is highly unlikely).

Some in the gas industry have argued that additional gas resource development (conventional and unconventional) is essential to transition to a low carbon electricity generation system. However, this will not be possible within the 2°C carbon budget because tackling climate change requires that most of the world's (including Australia's) existing fossil fuel reserves be left in the ground, unburned. There is no room in the carbon budget for any new fossil fuel development.

For more details on fossil fuels and the carbon budget, see the Climate Council's (2015) report, "Unburnable Carbon: Why we need to leave fossil fuels in the ground".

To have a 75% chance of meeting the 2°C target, over 70% of Australia's existing conventional gas reserves must remain in the ground, unburned.

2.8. Has Australia Already Over-Spent its Gas Carbon Budget on LNG Exports?

On Australia's east coast, substantial unconventional gas reserves and resources (in excess of 25,000PJ – more than 40 times annual domestic gas use) have already been committed to export LNG contracts. However, any further development of unconventional gas will exceed the carbon budget (see section 2.7).

Various estimates have been made of the reserves and resources of unconventional gas on Australia's east coast. Most of the current proven and probable (2P) developed and undeveloped unconventional gas reserves are already committed to Gladstone LNG export contracts (AEMO 2016). The Australian Energy Market Operator (AEMO) determined that additional development of undeveloped 2P Reserves, and less economic Possible or Contingent resources will be needed to meet LNG export obligations to 2035 and beyond, as well as meet existing domestic demand beyond 2019. Other experts (e.g., see Energyquest 2016) form the view that AEMO's estimates of gas reserves and deliverability adequacy are overly optimistic. Energyquest determined gas supply would fall short of existing domestic demand over the period 2016 to 2025 by around 1,500PJ, that existing unconventional gas into LNG exports had been overcommitted, and domestic markets were left short of supplies and increasingly dependent on unconventional gas as traditional conventional supplies reduced (Energyquest 2017).

As more gas is exported overseas as LNG, domestic gas is expected to get even more expensive than it has been of late. AEMO (2107a) notes that new gas supplies to meet LNG export demands and domestic gas needs will rely on unconventional gas resources that are uneconomic at current prices and much more costly to develop and produce. Some gas companies have impaired their LNG investments as they are unable to economically develop sufficient unconventional gas at current prices (e.g., Santos 2016). Energyquest (2017) estimates that gas to Sydney will cost around $14 per gigajoule by 2024. States heavily dependent on gas for peaking power have seen prices for summer 2017 more than double in one year (The Age 2017). These predicted high costs mean that gas power will become more expensive. Forecasts of higher gas costs in future mean that new gas power, will become less attractive, while the cost of electricity from renewable energy technologies continues to fall.

There is a general lack of understanding of just how much additional unconventional gas development would be required if Australia's emissions reduction targets for the electricity sector were to be delivered through new gas power stations replacing coal. Various estimates of the amount of new gas generation have been made, but two recent studies provide indications of the impact. By 2030, between 70,000 GWh/yr (Frontier Economics 2016) and 110,000 GWh/yr (Jacobs 2016) of additional gas fuelled power production (by more than an extra 8,000MW of new power plant by 2030) would be needed to displace coal to achieve the 26-28% reduction in power emissions.

To put this in context, this would require the development of gas reserves and production equivalent to that needed to supply between 2 to 4 additional LNG trains like those at Gladstone (potentially more gas than the entire east coast of Australia currently uses each year). Experienced industry consultants are already anticipating a shortfall against existing east coast domestic demand, and companies like Santos are already impairing their results because they are unable to economically develop sufficient gas to fill out their existing GLNG plant. In these circumstances, it would be economically (as well as environmentally) questionable to base future emission reduction policy for the power generation sector around any policy measure which would require a dramatic expansion of gas exploration and development. Furthermore, while a massive investment in gas development and new power stations might achieve 2030 emissions targets, it would also lock in substantial emissions from the gas power plants and supply chain for the following two decades, a time when the power generation sector needs to achieve zero emissions.

Transitioning to more gas power would use enormous volumes of gas.

2.9. Australia Needs to Transition Rapidly to a Zero Emissions Electricity System

In addition to carbon budget analysis requiring the majority of Australia's gas reserves to stay in the ground, analysis of Australia's electricity emissions has found that even current levels of reliance on gas power are inconsistent with International Energy Agency (2016) modelling of allowable emissions intensity for electricity generation for limiting global temperature below 1.5 - 2°C. In addition to transitioning away from coal, Australia needs to reduce its current reliance on gas for power by 70% (McConnell 2017).

To help protect Australians from worsening climate impacts (e.g., more destructive storms, intense heatwaves and worsening bushfire conditions) Australia needs pathways to transition as rapidly as possible away from coal, oil and gas to reach net zero emissions before 2050. The more quickly Australia, and other nations, reduce emissions, the more likely it is that we will avoid worsening climate impacts.

Using existing gas-fired generators and supply infrastructure prudentially to complement wind and solar power while scaling up a range of renewable energy technologies, energy storage, and energy efficiency measures could deliver a limited benefit, provided the end goal is phasing out the use of all fossil fuels as quickly as possible.

However, attempting to build new gas power plants and infrastructure based on policy schemes which foster new gas development, risks "locking-in" expanded gas use and the associated emissions of carbon dioxide and methane for decades into the future, increasing reliance on rapidly ageing gas infrastructure, and dramatic expansion of new unconventional gas resource exploration and development. More likely would be that neither equity or debt would be forthcoming, such is the associated carbon risk.

It is critical that new developments do not lock in fossil fuel emissions for decades to come.

3. Affordability: Greater Reliance on Gas Will Drive Higher Power Prices

As Australia's ageing coal fired power stations close, new power plants will need to be built to meet our electricity demand.

Renewable power technologies are cost competitive now with new gas and do not have the associated fuel costs or emissions. LNG exports; increased reliance on more expensive unconventional gas to meet export and domestic demands; and lack of competition are all driving higher gas prices.

3.1. Renewable Energy is Cost Competitive and Without the Associated Fuel Costs of Gas

Technologies such as solar thermal, biomass and hydropower are all capable of providing round-the-clock, or on-demand power. These renewable technologies, complemented by small and large scale storage schemes, can play a similar role to gas peaking plants in the electricity system by meeting peaks in demand and complementing much greater uptake of wind and solar PV generation.

Some renewable power technologies are cost competitive with gas power generation now (Table 4). As shown in Table 4, current gas power prices are already increasing due to increased gas costs. Renewable energy sources such as solar PV and wind are already cost competitive, and prices are falling. A range of other studies reinforce this point (e.g. Lazard 2016; Reputex 2017).

While the cost of renewable energy and storage - particularly solar, wind and batteries - continues to fall and has no associated fuel costs; gas power prices are high, volatile and likely to increase as the cost of fuel (gas) increases and bring associated financial risks (due to carbon emissions).

Table 4: Levelised cost of energy for different power technologies in Australia in 2016.

Power Plant Type	Levelised Cost of Energy /Benchmark (US$/MWh)
Solar PV large-scale	$70-135 / $85
Wind	$55-110 / $70 (**)
Gas combined cycle	$55-70 (*) / $62 [*up to $70 - 85 based on current gas prices * up to $95 - 110 based on future gas prices]

Source: Bloomberg New Energy Finance 2016

(*) – NB The BNEF study reflects 2016 Australian conditions and uses a gas cost of US$6/MMBTU (approx. A$8/GJ). Current Australian gas costs are higher than this, and at peak times can be up to 2-3 times higher. Higher current actual Australian gas costs would increase benchmark combined cycle power costs by around US$15/MWh to US$75-80/MWh, while the sorts of costs projected by Energyquest (Energyquest 2017) for 2024 of A$14/GJ (US$11/GJ) would increase benchmark combined cycle costs by US$35/MW to around US$100/MWh.

(**) Some recent Australian wind contract prices are reportedly as low as US$55/MWh (AFR 2017b).

Some renewable power technologies are cost competitive with gas.

3.2. LNG Exports are Pushing Up the Price of Gas in Australia

The escalating diversion of gas reserves to meet LNG export contracts has already resulted in higher prices for gas used in Australia (Australian Government 2015b; Figure 7). The linkage to international oil prices, has pushed Australian wholesale gas prices up dramatically and increased volatility, which in turn increases gas power prices (Australian Government 2015b; Sandiford 2016; The Age 2017). Local manufacturing businesses, such as Victoria Wool Processors, are now being directly affected with gas quotes doubling (ABC 2016). Recently the Australian Industry Group (2017) reported members being quoted contracts for gas priced at around four times higher than 2015 levels and more than five times the historic gas average. AEMO (2016) forecasts that gas prices $2/GJ higher may reduce commercial and industrial gas use by 20PJ/year. Higher gas prices feeding into higher electricity prices may cause businesses at risk from higher gas prices to close.

Figure 7: Gladstone LNG plants, Queensland.



International LNG contracts have led to some companies selling gas supplies overseas rather than using the gas for local power generation. This has led to the mothballing of gas power plants such as Pelican Point in South Australia and Swanbank E gas plant in Queensland (RenewEconomy 2016a), and higher gas prices across the National Electricity Market (Saddler 2016). An inability to access local gas supplies means these power plants are unavailable to respond when needed (AFR 2017a).

With Australian gas now mostly exported as LNG, domestic gas prices are inextricably linked to world market prices for oil. At current oil prices (around US$60/bbl), LNG netback prices are equivalent to around A$8-10/GJ (e.g., see ACIL Allen 2014; Climate Change Authority 2014; Lewis Grey Advisory 2016). If oil prices were to reach US$100/bbl or more again, domestic gas prices (already at high levels) would double to around A$20/GJ.

However, gas prices are much higher than this on occasions even now. LNG export supply contracts have dramatically increased the demand for gas to export, and led to much higher prices for gas available for domestic power production in Australia (Sandiford 2016). The market response to the unavailability of cheap gas sees gas prices routinely reach $20/GJ, driving up local gas and power prices greatly. A gas price of $20/GJ gas needs a power price of between $A140 to $200/MWh, just to cover fuel costs.

Reliance on gas power is also driving extreme price spikes and volatility due to lack of competition among gas power companies, particularly in South Australia and Queensland (Climate Council 2016b; RenewEconomy 2017; The Guardian 2017; The Age 2017). For example, gas power companies played a key role in driving price spikes in South Australia by using their bidding power to push up the price of electricity at opportune times, particularly in July 2016 (Climate Council 2016b).

To meet existing LNG export demands, the major gas companies are pushing for increased onshore gas exploration and for the removal of state government moratoriums or bans on onshore gas exploration, and for changes to workplace laws to reduce costs (Offshore Technology; The Australian 2016).

Lack of competition contributed significantly to recent power price spikes in South Australia.

3.3. Gas is an Expensive Transition Fuel Compared to Renewable Technologies

Gas is commonly referred to and promoted by the gas industry as a "transition fuel" in tackling climate change, as gas power plants emit less carbon dioxide than coal. However, this statement doesn't take into account the associated methane emissions from the gas supply chain (as described in Sections 2.3 and 2.5).

In 2016, the Climate Change Authority commissioned modelling (Jacobs 2016) of policy options for achieving Australia's commitment to keeping temperature rise below 2°C. Every modelled scenario requires Australia to move away from coal as a source of power generation, with power from coal declining from providing 63% of Australia's electricity generation today to almost zero by 2050. The picture for gas varies more widely depending on the policy option pursued. For example, carbon pricing sees increasing gas power supply in the medium term (to 41% in 2030) while a range of other policy options see the contribution by gas to electricity generation fall below 10% by 2030 (Jacobs 2016).

Proposed policies that rely on increased gas power as a transition fuel would require significant investment in new power plants, gas supplies and pipeline infrastructure. By 2030, modelling (Jacobs 2016) showed an emissions intensity scheme reliant only on gas would require between 70,000GWh to 100,000GWh of gas power generation each year. This would involve:

- Over 8,000MW of new gas power plant investment costing $8 billion to $11 billion (for example, see Frontier Economics 2016; Jacobs 2016).
- Additional gas supplies of between 450 PJ to 700 PJ per year (to put this gas demand in context, each LNG Train at Gladstone uses between 200 -220 PJ per year of gas), requiring upstream exploration and development investment of many billions of dollars as well as major spending on new pipeline infrastructure.
- Annual fuel costs ranging from $2.5 billion to $7 billion per year, depending on gas and oil prices.

Investing in new gas power generation assets has both economic and carbon risks.

Future gas price increases and volatility due to LNG exports, and domestic prices controlled by relative few producers, make investing in new gas power plants very risky.

This extra gas development would "lock in" over a billion tonnes of additional carbon dioxide emissions over the lifetime of the 8,000MW of new gas power plants, and the operating lives of the plants would extend well beyond 2050, when electricity sector emissions need to drop to zero.

Investing well over $10 billion in new gas power generation assets, and probably the same amount or more in upstream gas development, is very risky economically. With gas costs linked to volatile international oil prices, new open cycle or combined cycle gas power stations would be uncompetitive relative to renewables, as the latter have zero fuel costs. In addition, new gas power stations would be reliant on 60 to 80 year old gas processing and transmission infrastructure. To upgrade this infrastructure involves significantly more costs.

An emissions intensity scheme is only one of many possible policy mechanisms to transition to a lower emissions power sector. Other schemes, such as a price on carbon, absolute baselines (where emissions limits for power plants are set and reduced over time) or renewable energy reverse auctions supported by contracts for difference can achieve similar emissions objectives (Jacobs 2016). While the estimates of economic transition costs for each of these alternatives, as modelled, do vary, these are critically dependent on modelling assumptions on aspects like the costs of technology alternatives and the costs (and availability) of fuels like gas. Small changes in assumptions can easily lead one to reaching differing conclusions. Rather than rely solely on economic modelling where outcomes are subjectively based on input assumptions, it is important, therefore, that fundamentals such as emissions lock in, and price volatility from ramped up gas power generation beyond the 2030 time horizon are considered in framing policy choices.

At current development costs, there appear to be insufficient economic gas reserves available from current unconventional gas developments in Queensland to run Australia's existing six LNG trains at capacity. Various reports forecast that while more gas resources may be available, there will need to be much higher gas prices to justify production. Already, domestic industrial and household users of gas have seen higher gas and power prices, threatening industry, household budgets and making power more expensive (e.g., see Energy Quest 2016; AEMO 2017b). The large increases in future gas prices, the volatility linking prices to oil, and domestic gas prices controlled by relative few producers, make investments in new power plants using gas very risky.

Investors would be unlikely to make the major power plant investments required by emissions reduction policy with increased reliance on gas power without first securing substantial gas supply and transport contracts covering at least the first 10 years of new power station demand. To meet the power sector emissions reductions necessary by 2030 by increased gas power alone would require some 5,000 to 10,000 PJ of new gas reserves to be proven up (determined to be technically and economically recoverable) by the mid 2020s at the latest. This is because it takes some 3 to 5 years at a minimum to permit and build new large scale gas power plants. On the eastern seaboard of Australia, such gas is much more likely to be proven up from unconventional sources as existing conventional basins have been well explored over the past 60 years.

The development of such unconventional gas would involve drilling thousands more gas wells, much of it likely to be on prime agricultural land (e.g., Figure 8). It is questionable whether the unconventional gas industry would be able to re-establish an acceptable social licence to secure the necessary acreage to explore for and develop such large amounts of gas.

Pursuing more gas power as an emissions reduction policy is fraught with all manner of risks. Over the next decades as the 2°C carbon budget becomes tighter, gas assets run the risk of stranding as a price on carbon is introduced or regulation becomes more stringent. Other policy options which encourage zero emission technologies (including renewables and storage) are likely to be more robust and lower risk to the unknowable variabilities of future fuel and emissions costs.

Policy options which encourage renewables and storage are likely to be more robust and lower risk.



Figure 8: Coal seam gas, Queensland, Australia.

3.4. Will Greater Reliance on Gas Power Make Electricity More Affordable?

Now that Australian gas power prices are linked to export LNG markets (and oil prices), more gas generation will serve to underpin continuing higher power costs and higher volatility.

New, efficient combined cycle gas plants are unlikely to offer competitive power prices given high gas export prices. Two of the most efficient combined cycle plants in South Australia and Queensland have been mothballed and owners have sold their gas into LNG export markets. This demonstrates that making gas plants profitable in Australia requires Australian consumers to compete with global gas prices.

Further, the parties in the best commercial position to plan for new gas power stations are the existing major players in the power (and gas) retail markets. These incumbent "gentailers" (power retailers who generate electricity as well as selling it on the retail market) in South Australia and New South Wales, already control existing gas power plants and have major gas supply and transportation contracts. A focus on more gas power is likely to reinforce the already strong market power of these companies.

It is also important to note that over half of South Australia's and Victoria's gas generation capacity is over 40 years old. Once generators reach this age, the risk of plant failure increases through reliance on obsolete technology (e.g., in March 2017 three units at Torrens Island Power Station were taken offline due to a voltage transformer exploding) (The Advertiser 2017). One of two major gas pipelines supplying South Australia's gas power stations is also nearly 50 years old, adding to supply risks (Climate Council 2016b), as is one of the two major gas pipelines into New South Wales, and gas pipelines in Victoria.

Increasing the gas supply is unlikely to make domestic gas plants offer more competitive power prices given high gas prices due to LNG exports.

3.5. Policies Transitioning Directly to Renewable Energy are a Lower Cost Alternative to Increased Reliance on Gas

Modelling of Australia's National Electricity Market (e.g., Jacobs 2016) shows that accelerated renewable uptake, paired with storage, a smart grid and energy efficiency, best achieves lowest consumer prices, acceptable reliability and meets Australia's emissions reduction commitments. Importantly this also positions electricity infrastructure for a continued trajectory to zero emissions by 2050, with minimal economic stranding of assets newly built to achieve the 2030 target.

For example, Jacobs (2016) modelled a series of policy options to achieve Australia's 2030 commitment under the Paris Agreement and also to achieve the near zero emissions by 2050, consistent with the longer term 2°C Paris Agreement obligations. Modelled options included:

- a carbon tax
- an emissions intensity scheme
- an extended renewable energy target
- a low emissions target (with wider eligibility than the renewable energy target)
- renewable energy feed-in tariffs with contracts for difference (reverse auctions for renewable energy similar to the Australian Capital Territory's approach for reaching its 100% target)
- regulated coal closures
- absolute emissions baselines.

This modelling (Jacobs 2016) found that a policy of reverse auctions driving investment in new renewable energy (through contracts for difference competitively purchased through reverse auctions) results in by far the lowest costs for all classes of retail consumers; and resulted in the second lowest economic costs overall (after a carbon tax) for meeting Australia's emissions reduction commitments. This approach also resulted in one of the lowest levels of gas generation over the modelling period (2020 - 2050).

The modelling results reflect the fact that new renewable energy power generation, such as wind and solar, is now cost competitive with new gas or coal and avoids the asset-stranding risks inherent in new fossil fuelled generation. There is a range of renewable energy and storage technologies that can provide power on demand to complement variable renewables (at times of low wind or sunshine), such as hydro, pumped storage, solar thermal, large and small scale battery storage, smart grids and demand management.

This direct transition approach avoids the risk of additional emissions, stranded gas and power assets, and high power prices for years to come.

Solar and wind is cost competitive and less financially risky than new gas and coal generation.

4. Reliability: A Secure, Dependable Electricity System Can Be Achieved Without Gas

A secure, reliable electricity system needs to ensure that demand for electricity (from households, business and industry) is instantaneously met with enough supply from power stations, storage and demand reductions (via demand management).

The electricity system needs to meet certain technical requirements (such as frequency control and inertia) for grid stability ensuring that power supply and demand is balanced at all times, and must be able to withstand disturbances to the power system such as severe weather (Finkel 2016). In the longer term, security of power supply relies on planning for infrastructure resilience to withstand increasingly severe weather events associated with climate change.

Each of these challenges can be addressed without increasing reliance on expensive, high emission gas power.

New electricity infrastructure needs to cope with increasing intensity of extreme weather events.

4.1. Reliable Renewable Electricity Can Meet Consumer Demand 24/7 Throughout the Year

There are many renewable energy technologies - solar thermal, sustainable biomass as well as existing hydropower - which are able to provide round-the-clock, or on-demand power. These forms of renewable energy are well placed to complement increasing levels of low cost wind and solar generation (Box 3).

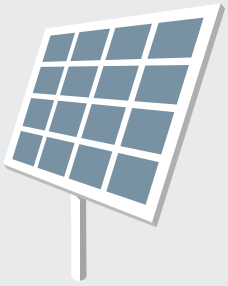
Many renewable energy technologies can provide power on-demand.

BOX 3: RENEWABLE ENERGY TECHNOLOGIES

Renewable Energy Technologies

SOLAR

The sun's energy is converted into heat to drive steam turbines, generating electricity (solar thermal) or converted directly into electricity by solar cells (solar PV).



BIOENERGY

Energy is derived from organic matter (recently living plant or animal material), such as sugarcane waste, landfill gas and algae.



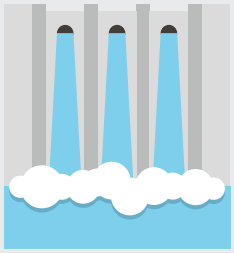
WIND

Wind turns the blades of a wind turbine to generate electricity.



HYDRO

Flowing water turns water turbines to generate electricity.



Source: Climate Council 2015a.

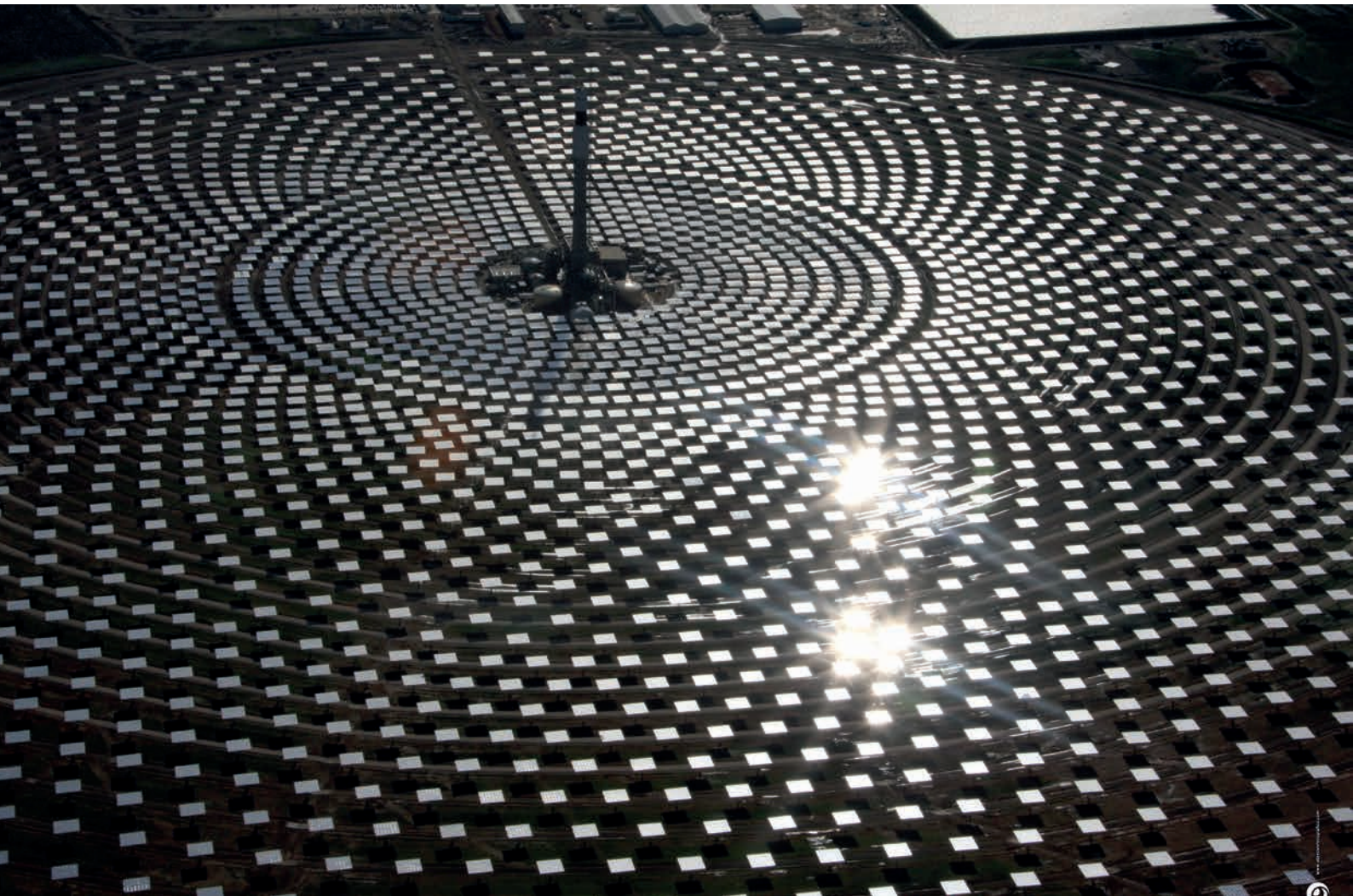
Concentrated solar thermal power plants with storage (e.g., Figure 9) can provide a consistent source of power, or power available on-call to meet periods of high electricity demand such as during heatwaves. These power plants use mirrors to concentrate energy from the sun in order to heat a fluid (such as water, oil or sodium), to produce steam and drive a turbine, generating electricity. Many of these plants also incorporate energy storage. Australian experience to date has been limited, however internationally concentrated solar thermal power plants with storage have proven successful in many countries. The reverse auction process used in Chile (RenewEconomy 2015) stimulated concentrated solar thermal plants with storage, alongside PV and wind projects.

Australia, through Vast Solar, is leading the way in pioneering the use of sodium as a concentrated solar thermal transfer and storage fluid (Vast Solar 2017).

Solar thermal, biomass and existing hydro power can shore up increased generation from low cost solar PV and wind.

Combining wind and solar together, and/or adding large-scale energy storage, are further options to deliver reliable renewable power to meet demand. There are a number of projects underway across Australia pursuing this approach.

Figure 9: Solar thermal plant in Spain.



The Lakeland integrated solar and battery storage power plant in North Queensland (currently under construction) will be the Southern Hemisphere's first large-scale integrated solar and battery storage facility. The project combines a 13MW solar power station together with 5.3MWh battery storage and will be able to provide reliable power quality and supply (Conergy 2016).

The Kennedy Energy Park in North Queensland combines solar, wind and battery storage (19MW solar PV with 22MW wind and 4MWh of battery storage). There are plans in place for a second stage, scaling up to 600MW of solar PV and 600MW of wind power, once the hybrid approach is tried and tested (ARENA 2017).

The Kidston project in Far North Queensland combines up to 320MW of solar PV (phase one 50MW, phase two 270MW) with pumped hydro storage, utilising a former gold mine. The pumped hydro storage stores energy by pumping water from a lower water storage reservoir to an upper reservoir; the water can later be released (generating electricity) at times of high demand. The project will potentially provide up to 320MW of rapid response power into the National Electricity Market. The Kidston project will commence construction this year (GenexPower 2017). There are many similar renewable energy and storage developments being advanced in South Australia, Victoria, New South Wales and Western Australia.

The Victorian Government is seeking expressions of interest to build a large battery storage facility in Western Victoria to complement nearby current and proposed wind and solar plants and improve grid stability (RenewEconomy 2017a). The South Australian Government has received over 90 expressions of interest from local and international companies to build a 100MW, 100MWh battery by summer 2017 to improve supply reliability (SMH 2017). The South Australian Government has also tendered for proposals to supply "dispatchable" renewable energy to meet 25% of the government's electricity requirements with low carbon power, with successful projects required not to negatively impact on energy security, reliability or wholesale electricity prices (South Australian Government 2016). There are multiple projects around the country (RenewEconomy 2016b) combining large-scale solar and wind with energy storage.

The uptake of energy storage systems is rapidly taking off across Australian households and businesses. Battery storage systems (or other forms of small-scale energy storage) enable households and businesses to maximise their use of rooftop solar panels by storing excess power generated during the day for use later, for example at night time.

These smaller scale, distributed solar and energy storage systems can also benefit the wider electricity grid by smoothing out the electricity demand at peak times, and making more effective local use of solar generation. Distributed energy storage can reduce the need for investment in expanding the network, reducing overall costs for electricity networks and consumers.

In 2016, more than 6,500 households installed a solar and battery system in response to the dramatic cost reductions for solar and storage technology and increasing power bills (Choice 2017).

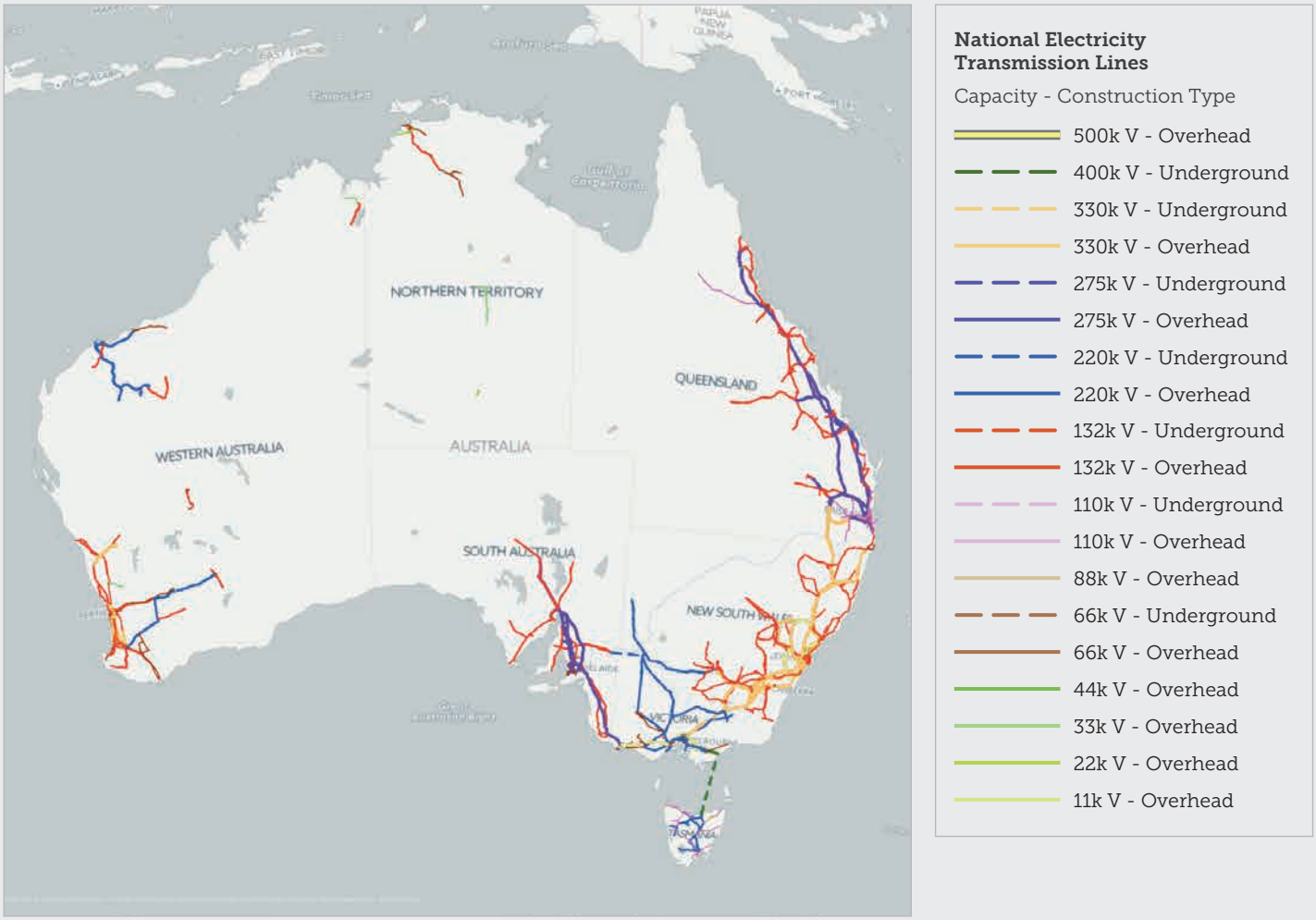
Australia's largest microgrid combining both small and large-scale solar and battery storage is planned for Onslow, Western Australia. The project aims to increase the town's reliance on renewable sources partly in response to cost and reliability issues associated with gas (RenewEconomy 2016c).

4.2. Greater Interconnection Can Improve Security of Power Supply

High voltage transmission lines connect Australia's eastern states and South Australia (referred to as the National Electricity Market, NEM). Some states, like Victoria (which connects to three other states), have higher levels of interconnection than others, such as South Australia and Tasmania.

There are two separate interconnected systems in Western Australia (The North West Interconnected System, NWIS and the South West Interconnected System, SWIS). The Northern Territory has three smaller separate electricity systems (Australian Government 2016c; Figure 10).

Figure 10: Major Australian power transmission lines. **Source:** Australian Government 2017.



While interconnections between states are expensive to build, when available, these interconnections can help to reduce power costs and improve security of supply. They also allow new areas of untapped renewable power to be developed, and enable increased diversity in renewable supplies to several states.

Interconnection can also help prevent blackouts when one state is facing periods of high power demand during a heatwave, exceeding available power generation within the state (Energy Networks Australia 2016).

For example, during February 2017 heatwaves in New South Wales, with near record all-time peak electricity demand, the state narrowly avoided a blackout due to a range of factors. For example, imports of electricity via three interconnections with Victoria and Queensland ran above design limits, contributing 12% to meeting peak demand (AEMO 2017b). Around 3,000MW of fossil fuel plant was not available, including tripping off (400MW), unable to start (760MW), out for maintenance (1,000MW) or output limited due to cooling water limits (600MW). At one stage, the Tomago aluminium smelter shed 580MW of its electricity load. It was these factors, and careful use by consumers (saving 200MW), that allowed New South Wales to avoid widespread blackouts. This heatwave highlights the vulnerability of our energy systems to extreme weather. Climate change will make heatwaves longer, hotter and more frequent (Perkins and Alexander 2013), increasing stresses on Australia's ageing energy infrastructure.

4.3. Renewable Electricity Can Provide Grid Stability

To maintain electricity supply, electricity systems need to keep supply (electricity generation from power plants) closely matched to demand (electricity use by households, businesses and industry). Certain types of power plants provide "inertia" which helps to maintain power when supply and demand become unbalanced, or unequal over short time periods.

Power plants that generate electricity via large rotating steam or water turbines are sometimes called **synchronous generators.** Coal and gas power plants are synchronous generators; so too are solar thermal, hydropower, and biomass power plants (Vithayasrichareon et al 2015).



Figure 11: Quebec wind farm.

Power plants that generate electricity using large rotating steam or water turbines provide **system inertia**, a characteristic that helps to maintain power supply for short periods of time if supply and demand become unbalanced. Inertia provides an initial, immediate response to keep the electricity system working.

Frequency response and operating reserve are needed if supply and demand are not in balance for more than 10 seconds. Frequency response can maintain the system for up to 30 minutes. Frequency response can be provided by technologies such as demand management (where large power users opt to cut their power use for a given time), battery storage systems and large spinning machines called synchronous condensers. For example, the Victorian and South Australian governments have recently called for expressions of interest to build large-scale battery storage in order to improve grid stability (RenewEconomy 2017a; SMH 2017).

Operating reserve is planned spare capacity in the system that can be called upon when there are unexpected variations in electricity demand, or generation or transmission faults.

Solar thermal, hydropower and biomass power plants are all synchronous generators capable of providing system inertia and operating reserve. Demand management, pumped storage and battery storage can provide frequency response.

Traditionally wind and solar power have not been considered capable of providing system inertia or frequency control. However, modern wind turbine technology can incorporate **synthetic inertia,** which enables wind farms to provide similar grid stability services to gas plants. Wind farms in Quebec, Canada (e.g., Figure 11) are required to incorporate this technology. Synthetic inertia will soon be trialled at the Hornsdale 3 Wind Farm in South Australia to demonstrate that wind power is capable of providing similar grid stabilising capabilities as gas-fired power (AFR 2017b).

4.4. Energy Security and Climate Change

One of the largest long-term risks to energy security is escalating extreme weather, driven by climate change. Australia has experienced the impact of extreme weather on power systems in the last six months.

On 28 September 2016, South Australia experienced one of its most severe storms in recent decades. The storm drove at least seven tornadoes, wind gusts of 190 - 260 km/h, large hailstones and intense rainfall. The supercell thunderstorms and tornadoes knocked down 23 transmission towers in South Australia triggering a statewide blackout (Burns et al 2016; Figure 12).

Heatwaves place pressure on electricity systems due to both increased demand for electricity (as everyone turns on their air-conditioners) and because coal and gas power plants struggle to operate in the heat. Ageing fossil fuel power stations don't cope well in the heat. Extreme heat reduces output and they suffer mechanical failures right when they are needed most. For example, in February 2017, New South Wales experienced an extreme heatwave and near record demand for electricity. During this time, 3,000MW of gas and coal fired plant wasn't available; it either tripped off (400MW), couldn't start (760MW), couldn't produce at maximum output due to cooling water or other temperatures exceeding limits (600MW), or was otherwise out for maintenance (1000MW) (AEMO 2017a).

Large, concentrated energy assets - like huge coal and gas power stations, are particularly vulnerable to extreme weather, increasing supply risks if one or more fail at times of extreme demand. Backup gas fuelled plants have a poor record of reliability as recent events in New South Wales and South Australia have shown (ABC 2017b; AEMO 2017b). Fossil plant failures also lead to blackouts or load shedding which places significant stress on people and industry.

Electricity systems relying on single massive sources of power transported over long distances, like a large gas power plant with a long grid, are vulnerable to extreme weather such as bushfires, storms and heatwaves.

Coal and gas power stations are vulnerable to extreme weather events.

A more distributed and diverse system with power generation spread geographically rather than large, concentrated power plants from a wider variety of supplies - wind, solar, storage - is far more resilient to disruption.

Cities that have experienced severe damage to their electricity infrastructure from extreme weather, like New York, have diversified the sources and location of power generation. Modern renewable energy means that power can be generated and stored where it is needed. This can reduce risks of grid failure for critical infrastructure.

Figure 12: Severe storms in South Australia brought down transmission towers in 2016.



5. A Secure, Dependable, Cost Effective, Zero Emissions Power System Can Be Achieved Without Gas

The most economic approach to transition away from fossil fuels is to dramatically improve energy efficiency, introduce demand management markets and to move directly to renewable supply, with energy storage, demand management and smart grids.

Existing gas can be considered as a short-term, expensive source of power (while renewable energy and storage technologies are scaled up). However, greater reliance on gas power is not an option, from both an economic and climate standpoint.

Appendix: Gas in Australia Explainer

TYPES OF GAS

There are two types of gas produced in Australia:

1. 'Conventional' gas produced from wells, onshore and offshore, from subsurface porous and permeable reservoir rocks wherein the gas (and sometimes condensate) is trapped by a sealing rock formation.

2. 'Unconventional' gas which is formed in more complex geological systems and requires different methods of extraction. Forms of unconventional gas include coal seam gas (from coal deposits 300-1000m underground), shale gas (from sedimentary rock 1-2km underground) and tight gas (from between tiny pores of rock greater than 1km underground) (Parliament of Victoria 2013).

Both conventional and unconventional gas require several processes to extract and purify the gas to meet specifications for transmission pipelines. Liquid hydrocarbons, carbon dioxide, water (and sometimes mercury and nitrogen) must be removed. The gas must be cooled and compressed. All this uses energy. LNG processing is even more energy intensive as the methane must be liquefied at very cold temperatures, using large refrigeration processes. Around 7-8% of the feed gas is burned to power the LNG process (AEMO 2016).

GAS RESERVES AND RESOURCES

Australia has the 13th largest gas reserves in the world (1.9% of global reserves) of both conventional and unconventional natural gas (BP 2016).

Most of Australia's conventional gas reserves are located off the north-west coast of Western Australia. Unconventional gas resources are located in the coal basins of Queensland and New South Wales and in shales in South Australia, WA and the NT (Australian Government 2015a).

Not all of these potential gas resources are economic to develop or are able to be accessed by existing gas supply infrastructure.

GAS PRODUCTION

The majority of gas produced in Australia is currently exported overseas as LNG, with about a third consumed domestically. The share of gas used domestically is becoming smaller over time due to increasing LNG exports and declining domestic gas consumption (AEMO 2016).

There are three physically separate regional gas markets in Australia:

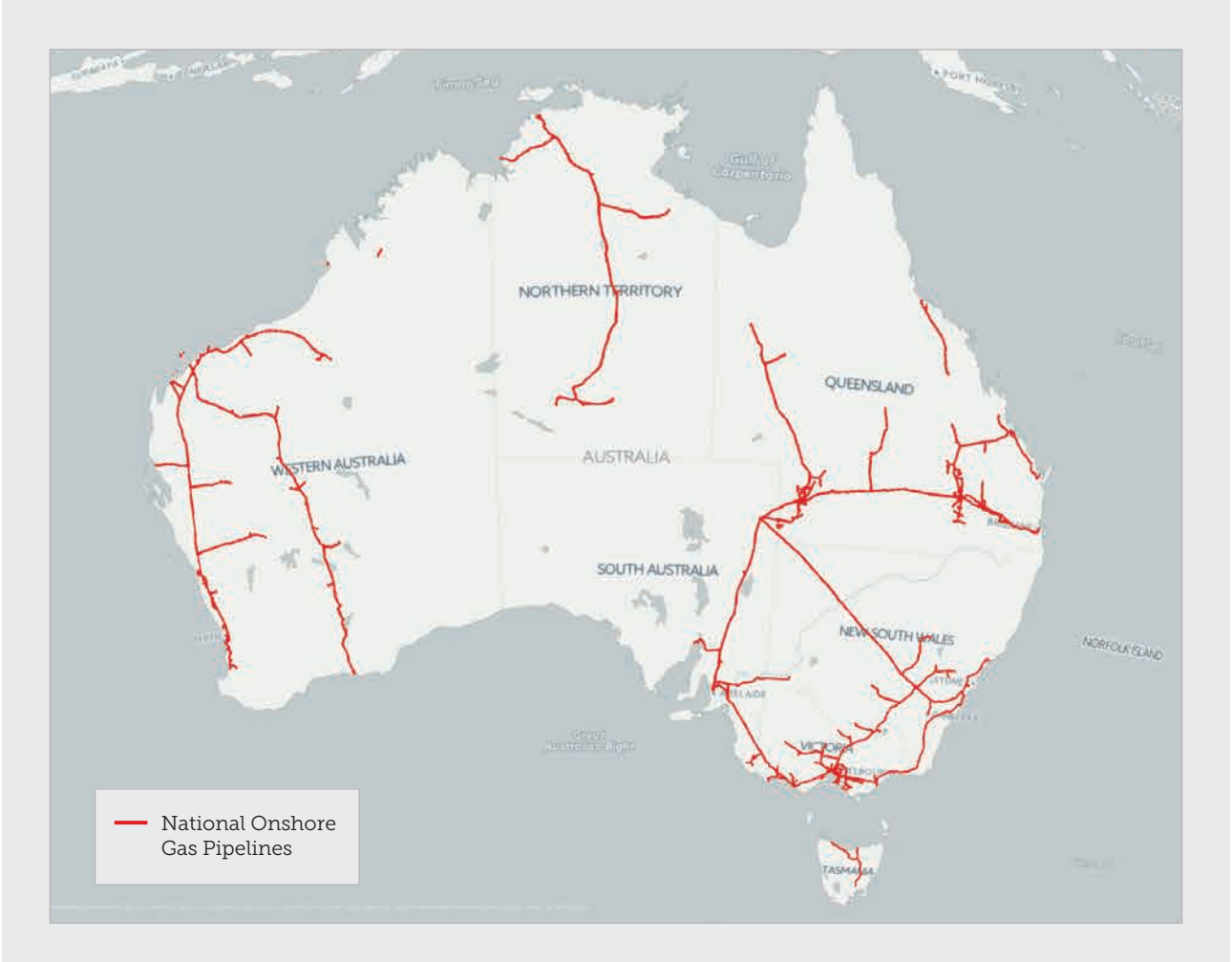
- Western market (WA)
- Eastern market (QLD, NSW, ACT, VIC, TAS and SA)
- Northern market (NT) (Australian Government 2015b).

Currently these markets are not connected. A connection between the northern and eastern markets called the North East Gas Interconnector is likely to be completed by 2018 (Australian Energy Regulator 2015), though this is relatively small in terms of capacity versus demand.

GAS CONSUMPTION

Gas consumed in Australia is mainly used for industrial (46%), residential and commercial uses (32%), and electricity generation (21%) (numbers have been rounded) (AEMO 2016).

Figure A1: Australia's gas markets. **Source:** Australian Government 2017.



LNG EXPORTS

Australia's LNG export industry started in 1989 with gas from the north west coast of Western Australia, followed by gas from Darwin in 2006 (from East Timor's "Joint Petroleum Development Area"), and then by gas from Queensland in 2015.

Australia is currently the third largest exporter of LNG in the world (behind Qatar and Malaysia) and is expected to become the largest producer by 2018 (Reserve Bank of Australia 2015). This is due to an unprecedented expansion of LNG export infrastructure in recent years - with $250 billion spent on LNG infrastructure since 2009 (Forbes 2016).

Three major LNG export projects, each comprising processing facilities and transmission lines - totalling $63.2 billion (Australian Energy Regulator 2015) - have recently been completed in Queensland:

- Queensland Curtis LNG (able to produce up to 8.5 million tonnes of LNG per year, Mtpa)
- Gladstone LNG (7.8 Mtpa)
- Australia Pacific LNG (able to produce up to 9 Mtpa) (AEMO 2016; LGA 2016)
- QCLNG and APLNG are both able to produce at even higher rates (10% above nameplate) (LGA 2016).

A further two projects have also been completed in the Western and Northern market, with still more under construction:

- Gorgon (able to produce up to 15.6mtpa)
- Wheatstone LNG (up to 8.9mtpa).

Australia's LNG export capacity could soon exceed the total imports of our major export market, Japan (LNG imports are expected to continue to fall in Japan as it restarts more nuclear reactors) (Australian Government 2016).

Australia is not alone in increasing LNG exports. The United States, Malaysia, and Russia are also constructing large LNG production and export facilities at a time of slow global demand growth and low prices (IEA 2016). Worldwide, the LNG capacity currently under construction is almost half the global LNG traded annually.

57.4mtpa of LNG has reportedly pre-sold in long-term contracts, totalling more than Australia's entire gas production in 2014-15 (AOG 2015).

References

ABC (2016) Gas supply issues could force Australia's largest domestic wool producer to close its doors. Accessed at http://www.abc.net.au/news/2016-12-02/victoria-wool-processors-gas-shortage/8086732.

ABC (2017a) Hazelwood won't be the last of Latrobe Valley's coal-fired power stations to close. Accessed at http://www.abc.net.au/news/2017-03-24/hazelwood-latrobe-valley-not-the-first-or-the-last-to-close/8380760.

ABC (2017b) SA transformer fire almost caused a second statewide blackout, AEMO says. Accessed at http://www.abc.net.au/news/2017-03-15/aemo-report-torrens-island-fire-almost-second-statewide-blackout/8357316.

ACIL Allen (2014) RET Review Modelling. Market Modelling of Various RET Policy Options.

AEMO (Australian Energy Market Operator) (2016) Projections of Gas and Electricity Used in LNG Public Report. Accessed at https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/NGFR/2016/Projections-of-Gas-and-Electricity-Used-in-LNG-Public-Report-November-2016.pdf.

AEMO (2017a) Gas Statement of Opportunities. Accessed at https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/GSOO/2017/2017-Gas-Statement-of-Opportunities.pdf.

AEMO (2017b) SA power outage: AEMO orders back-up station turned on amid Adelaide heatwave blackouts. Accessed at http://www.abc.net.au/news/2017-02-09/aemo-orders-back-up-power-station-at-pelican-point-on/8256594.

AEMO (2017c) System Event Report New South Wales, 10 February 2017. Accessed at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Incident-report-NSW-10-February-2017.pdf.

AFR (Australian Financial Review) (2017a) Engie's Pelican Point not operated second unit since 2015. Accessed at http://www.afr.com/news/politics/engies-pelican-point-not-operated-second-unit-since-2015-20170213-gucadd#ixzz4Zg7qdt3r.

AFR (2017b) Wind costs fall as French renewable group Neoen seals $300m Hornsdale stage 3. Accessed at http://www.afr.com/news/wind-costs-fall-as-french-renewable-group-neoen-seals-300m-hornsdale-stage-3-20170301-gunv7z#ixzz4a8XXNQK3.

Alvarez RA, Pacala SW, Winebrake JJ, Chameides WL and Hamburg SP (2012) Greater focus needed on methane leakage from natural gas infrastructure" Proceedings of the National Academy of Sciences 109(17): 6435–6440.

AMSA (Australian Maritime Safety Authority) (2010) Response to the Montara Wellhead Platform Incident. Report of the Incident Analysis Team. Accessed at http://www.amsa.gov.au/forms-and-publications/publications/montara_iat_report.pdf.

APPEA (2016) Natural gas will play a pivotal role in post Paris Agreement future. Accessed at https://www.appea.com.au/media_release/gas-pivotal-role-post-paris-agreement/.

APRA (2017) Australia's New Horizon: Climate change challenges and prudential risk, Summerhayes, 17 Feb 2017.

ARENA (Australian Renewable Energy Agency) (2017) Kennedy Energy Park. Accessed at https://arena.gov.au/project/kennedy-energy-park/.

Australian Government (2015a) Australia's Intended Nationally Determined Contribution to a new Climate Change Agreement | August 2015. Accessed at http://www4.unfccc.int/submissions/INDC/Published%20Documents/Australia/1/Australias%20Intended%20Nationally%20Determined%20Contribution%20to%20a%20new%20Climate%20Change%20Agreement%20-%20August%202015.pdf.

Australian Government (2015b) Gas Market Report. Accessed at http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/gas-market/Gas-Market-Report-2015.pdf.

Australian Government (2016a) Quarterly Update of Australia's National Greenhouse Gas Inventory: June 2016 Australia's National Greenhouse Accounts https://www.environment.gov.au/system/files/resources/48275b92-3f4b-44d0-aa4e-50ece408df86/files/nggi-quarterly-update-jun-2016.pdf.

Australian Government (2016b) Australian Energy Update 2016. Accessed at https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/aes/2016-australian-energy-statistics.pdf.

Australian Government (2016c) Energy in Australia. Accessed at https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/energy-in-aust/Energy-in-Australia-2015.pdf.

Australian Government (2017) National Map. Accessed at http://nationalmap.gov.au/.

Australian Industry Group (2017) Energy Shock: No Gas, No Power, No Future? Accessed at http://cdn.aigroup.com.au/Reports/2017/Energy_shock_report_Feb2017.pdf.

Bloomberg New Energy Finance (2016) H2 2016 APAC LCOE Outlook, Coal creeps up as solar declines, Quong and Mills, Borthwick (2010) Report of the Montara Commission of Inquiry. Accessed at http://www.iadc.org/wp-content/uploads/2016/02/201011-Montara-Report.pdf.

BP (2016) BP Statistical Review of World Energy June 2016. Accessed at https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf.

Burns G, Adams L and Buckley G (2016) Independent Review of the Extreme Weather Event South Australia. 28 September - 5 October 2016. Accessed at http://www.dpc.sa.gov.au/__data/assets/pdf_file/0003/15195/Independent-Review-of-Extreme-Weather-complete.pdf.

Caulton DR, Shepson PB, Santoro RL, Sparks JP, Howarth RW, Ingraffea AR, Cambaliza MO, Sweeney C, Karion A and Davis KJ (2014) Toward a better understanding and quantification of methane emissions from shale gas development. *Proceedings of the National Academy of Sciences,* 111(17): 6237-6242.

Choice (2017) Solar battery installations grow as power bills tumble. Accessed at https://www.choice.com.au/home-improvement/energy-saving/solar/articles/solar-battery-installation-growth.

Clarke H, Lucas C and Smith P (2013) Changes in Australian fire weather between 1973 and 2010. *International Journal of Climatology*, 33: 931–944.

Climate Council (2014) Australia's Electricity Sector: Ageing, Inefficient and Unprepared. Accessed at http://www.climatecouncil.org.au/australia-s-electricity-sector-ageing-inefficient-and-unprepared.

Climate Council (2015a) A Whole New World: Tracking the Renewables Boom From Copenhagen To Paris. Accessed at http://www.climatecouncil.org.au/uploads/7caceebb94e8cd34a7b977dfb090e51d.pdf.

Climate Council (2015b) Unburnable Carbon: Why we need to leave fossil fuels in the ground. Accessed at https://www.climatecouncil.org.au/unburnable-carbon-why-we-need-to-leave-fossil-fuels-in-the-ground.

Climate Council (2016a) Submission to the Senate Standing Committees on Environment and Communications. Parliament of Australia. Inquiry into the retirement of coal fired power stations.

Climate Council (2016b) The Perfect Storm. Analysing the Role of Gas in South Australia's Power Prices. Accessed at https://www.climatecouncil.org.au/perfect-storm-report.

Climate Council (2017a) Angry Summer 2016/17: Climate Change Super-charging Extreme Weather. Accessed at https://www.climatecouncil.org.au/angry-summer-report.

Climate Council (2017b) Cranking Up The Intensity: Climate Change and Extreme Weather Events. Accessed at https://www.climatecouncil.org.au/cranking-intensity-report.

ClimateWorks (2014) Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world. Accessed at http://climateworks.com.au/sites/default/files/documents/publications/climateworks_pdd2050_technicalreport_20140923.pdf.

Conergy (2016) Conergy starts construction on Australia's first grid-connected, utility-scale solar and battery storage project. http://www.conergy.com.au/press-release/conergy-starts-construction-australias-first-grid-connected-utility-scale-solar-battery-storage-project.

Conley S, Franco G, Faloona I, Blake DR, Peischl J and Ryerson TB(2016) Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA, *Science*, 18 March 2016, doi 10.1126/science.aaf2348.

Crikey (2016) The Montara oil spill – Australia's shame finally gets to court. Accessed at https://blogs.crikey.com.au/northern/2016/08/03/montana-disaster-youve-never-heard-gets-court/.

CSIRO Energy Technology (2012) Fugitive Greenhouse Gas Emissions from Coal Seam Gas Production in Australia, Day et al. Accessed at http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0010/559549/Fugitive-Greenhouse-Gas-Emissions-from-Coal-Seam-Gas-Production-in-Australia-CSIRO-report.pdf.

Energy Networks Australia (2016) High Voltage - a secure and integrated Transmission system. Accessed at http://www.energynetworks.com.au/news/energy-insider/high-voltage-secure-integrated-transmission-system.

Energyquest (2016) East Coast Gas market Scenario and Implications for South Australia 1 July 2016.

Energyquest (2017) East Coast gas Oversold, 7 March 2017.

Finkel (2016) Independent Review into the Future Security of the National Electricity Market. Accessed at https://www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/files/independent-review-national-elec-market-prelim.pdf.

Frontier Economics (2016) Emissions reduction options - A Report Prepared for the Australian Energy Market Commission, November 2016.

GenexPower (2017) GenexPower. Accessed at http://www.genexpower.com.au/.

GISERA (2015) Characterisation of Regional Fluxes of Methane in Surat Basin, Queensland. Accessed at https://gisera.org.au/wp-content/uploads/2016/04/ghg-emission-proj-methane-seeps.pdf.

Global Carbon Project (2016) Global Carbon Atlas. Accessed at http://www.globalcarbonatlas.org/en/CO_2-emissions.

Hardisty PE, Clark TS and Hynes RG (2012) Life cycle greenhouse gas emissions from electricity generation: a comparative analysis of Australian energy sources, *Energies*, 26 March 2012.

Howarth R (2015) "Methane emissions and climatic warming risk from hydraulic fractuering and shale gas development implications for policy". *Energy and Emission Control Technologies,* 3: 45-54.

IEA (International Energy Agency) (2015) Renewable Energy Medium-Term Market Report. Executive Summary.

IEA (2016) Re-powering Markets: Market design and regulation during the transition to low-carbon power systems. Accessed at https://www.iea.org/publications/freepublications/publication/REPOWERINGMARKETS.PDF.

IPCC (Intergovernmental Panel on Climate Change) (2012) Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field CB, V Barros, TF Stocker, D Qin, DJ Dokken, KL Ebi, MD Mastrandrea, KJ Mach, G-K Plattner, SK Allen, M Tignor and PM Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA.

IPCC (2013) Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis*, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V and Midgley PM. Cambridge and New York, Cambridge University Press, pp. 3-29.

Jacobs (2016) Modelling illustrative electricity sector emissions reduction policies. Final report. Accessed at http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/SR%20Modelling%20reports/Jacobs%20modelling%20report%20-%20electricity.pdf.

Karion et al (2013). "Methane emissions estimate from airborne measurements over a western United States natural gas field." *Geophysical Research Letters,* 40(16): 4393-4397.

King AD, Karoly DJ, Donat MG and Alexander LV (2014) Climate change turns Australia's 2013 Big Dry into a year of record-breaking heat [in "Explaining Extremes of 2014 from a Climate Perspective"]. *Bulletin of the American Meteorological Society,* 95(9): S41-S45.

Kort EA, Frankenberg C, Costigan KR and Wunch D (2014) The largest US methane anomaly viewed from space, *Geophysical Research letters*, 2014.

Lafleur D, Forcey T, Saddler H and Sandiford M (2016) A Review of Current and Future Methane Emissions from Australian Unconventional Oil and Gas production. Melbourne Energy Institute. Accessed at http://energy.unimelb.edu.au/library/a-review-of-current-and-future-methane-emissions.

Lazard (2016) Levelized Cost of Energy Analysis 10.0. Accessed at https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/.

Lewis Grey Advisory (2016) Projections of Gas and Electricity Used in LNG Public Report, 18 November 2016.

McConnell D (2016) FactCheck: Have eight of Australia's 12 most emission intensive power stations closed in the last five years? Accessed at https://theconversation.com/factcheck-have-eight-of-australias-12-most-emission-intensive-power-stations-closed-in-the-last-five-years-65036.

McConnell D (2017) Our power grid is crying out for capacity, but should we open the gas valves? The Conversation, 21 February. Accessed at https://theconversation.com/our-power-grid-is-crying-out-for-capacity-but-should-we-open-the-gas-valves-72355.

McGlade C and Ekins P (2015) The geographical distribution of fossil fuels unused when limiting global warming to 2°C. *Nature*, 517(7533), 187-190.

Moore et al. (2012) Unprecedented Mass Bleaching and Loss of Coral across 12° of Latitude in Western Australia in 2010–11. *PLoS ONE,* 7(12): e51807.

NOAA (National Oceanic and Atmospheric Administration) (2017) Global Analysis - Annual 2016. Accessed at: https://www.ncdc.noaa.gov/sotc/global/201613.

Parliament of Australia (2008) Matters relating to the gas explosion at Varanus Island, Western Australia. Accessed at http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Completed_inquiries/2008-10/wa_gas_08/report/index.

Parliament of Australia (2011) The development of Australias coal seam gas resources. Accessed at http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/BN/2011-2012/CoalSeamGas.

Perkins S and Alexander L (2013) On the measurement of heat waves. *Journal of Climate,* 26: 4500–4517.

Pétron et al (2012). "Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study." *Journal of Geophysical Research,* 117(D4).

Pétron G, Karion A, Sweeney C, Miller BR, Montzka SA, Frost GJ, Trainer M, Tans P, Andrews A and Kofler J (2014). "A new look at methane and nonmethane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin." *Journal of Geophysical Research: Atmospheres,* 119(11): 6836-6852.

Queensland Government (2009) Consultation paper. Domestic Gas Market Security of Supply. Accessed at http://www.parliament.qld.gov.au/Documents/TableOffice/TabledPapers/2009/5309T930.pdf.

RenewEconomy (2015) Renewables clean up at Chile energy auction, including 24-hour solar. Accessed at http://reneweconomy.com.au/renewables-clean-up-at-chile-energy-auction-including-24-hour-solar-10549/.

RenewEconomy (2016a) Murdoch, Coalition go in guns blazing against wind and solar. Accessed at http://reneweconomy.com.au/murdoch-coalition-go-guns-blazing-wind-solar-74901/.

RenewEconomy (2016b) World's biggest solar + storage projects planned for Australia. Accessed at http://reneweconomy.com.au/worlds-biggest-solar-storage-projects-planned-australia-95528/.

RenewEconomy (2016c) W.A. plans Australia's biggest solar+storage micro-grid in Onslow. Accessed at http://reneweconomy.com.au/w-plans-australias-biggest-solarstorage-micro-grid-onslow-39857/.

RenewEconomy (2017a) Victoria seeks to build country's biggest grid-scale battery storage. Accessed at http://reneweconomy.com.au/victoria-seeks-to-build-countrys-biggest-grid-scale-battery-storage-42518/.

RenewEconomy (2017b) Australian wind farms to compete with gas to provide grid stability. Accessed at http://reneweconomy.com.au/australian-wind-farms-to-compete-with-gas-to-provide-grid-stability-62697/.

Reputex (2017) ARTICLE: A cost curve for abatement & energy storage in the Australian power sector. Accessed at http://www.reputex.com/research-insights/a-cost-curve-for-emissions-reductions-energy-storage-in-the-australian-power-sector/.

Saddler (2016) South Australia's electricity price woes are more due to gas than wind. Accessed at https://theconversation.com/south-australias-electricity-price-woes-are-more-due-to-gas-than-wind-62824.

Santos (2016) Media Release: Asset Review Outcome. Accessed at https://www.santos.com/media-centre/announcements/asset-review-outcome/.

Schneising O, Burrows JP, Dickerson RR, Buchwitz M, Reuter M and Bovensmann H (2014). "Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations." Earth's Future: 2014EF000265.

Schwietzke S, Sherwood O, Bruhwiler L, Miller J, Etiope G, Dlugokencky E, Michel S, Arling V, Vaughn B, White J, and Tans P (2016) "Upward revision of global fossil fuel methane emissions based on isotopic database," *Nature,* 538: 88-91.

SMH (Sydney Morning Herald) (2017) Firms queue up to build South Australian battery storage. Accessed at http://www.smh.com.au/business/energy/firms-queue-up-to-build-sa-battery-20170403-gvcrz6.html.

South Australian Government (2016) Government's electricity supply contract to drive innovation in renewables. Accessed at http://www.premier.sa.gov.au/index.php/tom-koutsantonis-news-releases/911-government-s-electricity-supply-contract-to-drive-innovation-in-renewables.

The Advertiser (2017) Fire at Torrens Island Power Station. Accessed at http://www.adelaidenow.com.au/news/south-australia/fire-at-torrens-island-power-station/news-story/c105f9b15c3cbd78a7d6cb3080c69401.

The Age (2002) Coroner blames ESSO for Longford Disaster. Accessed at http://www.theage.com.au/articles/2002/11/15/1037080898920.html.

The Age (2017) Energy Crisis: Wholesale power prices have doubled since carbon tax was introduced, The Age 9 March 2017.

The Australian Pipeliner (2016) The Moonie Oil Pipeline 1963. Accessed at https://www.pipeliner.com.au/2016/03/16/the-moonie-oil-pipeline-1963/.

The Climate Institute (2015) Paris climate agreement: Now it's time for Australia's real work to start. Accessed at http://www.climateinstitute.org.au/articles/media-releases/paris-agreement.html.

The Guardian (2017) Queensland's electricity price spikes far worse than South Australia during 'crisis'. Accessed at https://www.theguardian.com/environment/2017/feb/11/queenslands-electricity-price-spikes-far-worse-than-south-australia-analysis-shows.

Trenberth KE (2012) Framing the way to relate climate extremes to climate change. *Climatic Change*, 115: 283–290.

UNFCCC (United Nations Framework Convention on Climate Change) (2017) Paris Agreement - Status of Ratification. Accessed at http://unfccc.int/paris_agreement/items/9444.php.

US Department of Energy (2010) "CBM Gas Separator".

Vast Solar (2017) What sets us apart. Accessed at http://www.vastsolar.com/what-sets-us-apart/.

Vithayasrichareon, Riesz and MacGill (2015) Impact of High Variable Renewable Generation on Future Market Prices and Generator Revenue. Accessed at http://ceem.unsw.edu.au/sites/default/files/documents/PES%20APPEEC%202015%20-%20Revenue_withoutdiffMPC.pdf.

WRI (World Resources Institute) (2015) INSIDER: Understanding the Paris Agreement's Long-term Goal to Limit Global Warming. Accessed at http://www.wri.org/blog/2015/12/insider-understanding-paris-agreement%E2%80%99s-long-term-goal-limit-global-warming.

Image Credits

Cover photo: "Gas processing plant" by Flickr user John Carney licensed under CC BY-NC 2.0.

Page 5: Figure 2: "How Hot?" by Flickr user Ian Sanderson licensed under CC BY-NC-ND 2.0.

Page 12: Figure 3 "Where Adelaide's Electricity Comes From" by Flickr user Michael Coghlan licensed under CC BY-SA 2.0.

Page 18: Figure 5 "Montara Oil Spill - August 25, 2009" by Flickr user SkyTruth licensed under CC BY-NC-SA 2.0.

Page 27: Figure 7 Google Earth photo of Gladstone Curtis Island LNG.

Page 32: Figure 8 "Gasfield, Tara, QLD" by Flickr user Lock the Gate Alliance licensed under CC BY 2.0.

Page 39: Figure 9 "Gemasolar solar thermal power plant, Spain" by Flickr user Beyond Coal & Gas Image Library licensed under CC BY-NC 2.0.

Page 43: Figure 11 "Eoliennes/ Wind Turbines" by Flickr User Denis-Carl Robidoux licenced under CC BY-NC 2.0

Page 45: Figure 12 Used with permission of Debbie Prosser via The Plains Producer.

Thank you for supporting the Climate Council.

The Climate Council is an independent, crowd-funded organisation providing quality information on climate change to the Australian public.

CLIMATE COUNCIL

facebook.com/climatecouncil

twitter.com/climatecouncil

info@climatecouncil.org.au

climatecouncil.org.au

The Climate Council is a not-for-profit organisation and does not receive any money from the Federal Government. We rely upon donations from the public. We really appreciate your contributions.

DONATE climatecouncil.org.au/donate

Appendix: Research to support Lock the Gate's submissions on the concept of a 'social licence to operate' for fracking in the NT

What is a social licence to operate (SLO) and is there an industry endorsed definition of the concept?

1. The concept of a social licence (**SLO**) originally comes from within industry.[1] The term was reportedly first used in 1997 by an executive of Placer Dome, a large mining company.[2] It is now used widely by a range of stakeholders (e.g. NGOs, research institutions, and governments) and in numerous industries.[3]

2. Despite its pervasiveness, the concept is not subject to a clear or single definition.[4]

3. An SLO is distinct from a *legal* licence to operate, the latter coming in the form of specific government approvals. An SLO is intangible and goes beyond legal formal requirements that industry (e.g. mining, energy) are required to comply with.[5]

4. Broadly speaking, an SLO can be understood as being granted when a company (or industry) has 'the approval and support of the local community'; this concept of an SLO is 'widely accepted by the [mining and energy] sector'.[6] SLOs are widely viewed in the global resources sector as 'a vital component to successful operations'.[7]

5. Bice identifies that the key stakeholders who are the 'social licensors' for the Australian mining industry include, but are not limited to:

   > *affected local communities, NGOs and community organisations, other companies operating within the same industry or geographic region, governments, local businesses, landholders and Indigenous groups, regulators and industry bodies.*[8]

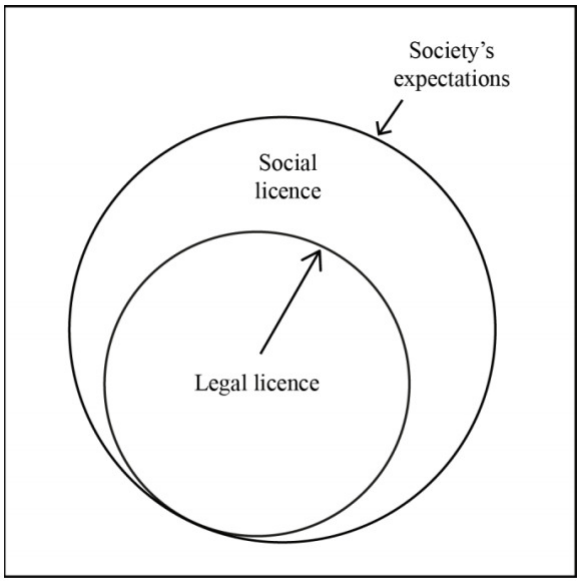
   It is likely that the SLO 'licensors' for fracking in the NT are likely to be similarly comprised.

---

[1] Williams and Walton, *The Social Licence to Operate and Coal Seam Gas Development: A literature review report to the Gas Industry Social and Environmental Research Alliance (GISERA)*, March 2013, CSIRO, 2, citing others.
[2] Justine Lacey, Richard Parsons and Kieren Moffat, '*Exploring the concept of a Social Licence to Operate in the Australian Minerals Industry'* (CSIRO, October 2012, EP125553), 1.
[3] J Lacey, Parsons and Moffat, above n 2, 1.
[4] See, e.g., Lacey, Parsons and Moffat, above n 2; Bice, SJ, 'What gives you a social licence? An exploration of the social licence to operate in the Australian mining industry' (2014) 3(1) *Resources* 62 at 63.
[5] See, e.g., Lacey, Parsons and Moffat, above n 2, 4.
[6] Dan Haigh, 'Building a social licence to operate in the natural resources sector' (2013) (August-September) *Position* 34; Ernst & Young, *Business risks facing mining and metals 2013-14* ("*Business risks 2013-14*"), 7, available at http://www.ey.com/Publication/vwLUAssets/Business_risks_facing_mining_and_metals_2013%E2%80%932014_ER0069/$FILE/Business_risks_facing_mining_and_metals_2013%E2%80%932014_ER0069.pdf (specifically in relation to the metals and mining sector).
[7] Bice, SJ, 'What gives you a social licence? An exploration of the social licence to operate in the Australian mining industry' (2014) 3(1) *Resources* 62-80, 63, citing another.
[8] Bice, above n 7, 68.

6. Stakeholder expectations can relate to 'social and environmental impacts of a company's operations', the potential for benefits that will flow to the local communities and the region, and the expectations of local communities as to 'how [a] company engages with local citizens'.[9]

7. The SLO has been described as the difference between what the law requires of businesses and what society requires of businesses: the SLO filling the gap when society's expectations are greater than the requirements imposed by law.[10] This view is illustrated by the following diagram:[11]



8. Gunningham, Kagan and Thornton, in 2004, described a social license as:

> *demands on and expectations for a business enterprise that emerge from neighbourhoods, environmental groups, community members, and other elements of the surrounding civil society. In some instances the conditions demanded by "social licensors" may be tougher than those imposed by regulation, resulting in "beyond compliance" corporate environmental measures even in circumstances beyond where these are unlikely to be profitable.*[12]

9. Two other descriptions of the SLO that may be useful include the following:

> *As originally conceived, the notion of a social licence to operate reflects the idea that society is able to grant or withhold support for accompany and its operations; with the extent of support being dependent on how well a company meets societal expectations of its behaviour and impacts. A social licence is tacit, intangible and context specific. It needs to be earned and is dynamic, as people's experiences and perceptions of an operation shift over time.*[13]

[9] Williams and Walton, above n 1, 2.
[10] Preston, The Hon Brian J, 'The adequacy of the law in satisfying society's expectations for major projects' (2015) 32 *Environmental and Planning Law Journal* 182 at 182-3.
[11] Preston, above n 10, 183.
[12] Neil Gunningham, Robert Kagan and Dorothy Thornton 'Social Licence and Environmental Protection: Why Businesses Go Beyond Compliance'(2004) *Law and Social Inquiry* 307 at 308.
[13] Williams and Walton, above n 1, 1.

and

> *The term 'social licence,' or 'social licence to operate,' generally refers to a local community's acceptance or approval of a project or a company's ongoing present. It is usual informal and intangible, and is granted by a community based on the opinions and views of stakeholders, including local populations, aboriginal groups, and other interested parties. Due to this intangibility, it can be difficult to determine when social license has been achieved for a project. Social license may manifest in a variety of ways, ranging from absence of opposition to vocal support or even advocacy, and these various levels of social license (as well as, of course, the absence of social license) may occur at the same time among different interested parties.*[14]

10. Although earning an SLO requires some level of stakeholder acceptance, an SLO does not require *universal* agreement and acceptance.[15]

11. Notable qualities of SLOs are that they are:[16]
    (a) tacit
    (b) intangible
    (c) context specific; and
    (d) continually under negotiation.[17]

12. CSIRO research published in 2013 reported on a series of interviews conducted with minerals industry representatives in Australia. Industry representatives typically understood concepts of community and stakeholder 'approval', 'acceptance' and 'support' as being central to an SLO. Some industry representatives also identified 'permission' or 'consent' to operate as part of the SLO.[18]

13. Also notable is the 2004 World Bank Group 'Extractive Industries Review' (**EIR**) definition of an SLO which 'has been influential within the mining industry'. Bice states that this definition is 'not well-consolidated, with criteria for a social licence appearing sporadically throughout the two-volume report'. However, Bice finds that the EIR:

> *defines a "legitimate" social licence to operate as being granted when free, prior and informed consent of indigenous peoples has been practiced and where key stakeholders have access to transparent information.*[19]

---

[14] Brian Yates and Celesa Horvath, *Social License to Operate: How to Get It, and How to Keep It*, (2013 Summit Working Papers, Pacific Energy Summit), 2-3, at http://www.nbr.org/downloads/pdfs/eta/PES_2013_summitpaper_Yates_Horvath.pdf. This definition appears to have been adopted by the member for Mount Gambier, Mr Troy Bell MP, in his submission to the South Australian Inquiry into Unconventional Gas (Fracking) in the South East of South Australia: *Inquiry into Unconventional Gas (Fracking) in the South East of South Australia Final Report*, Tabled in the House of Assembly and ordered to be published 29 November 2016, 6-7, available for download at https://www.parliament.sa.gov.au/Committees/Pages/Committees.aspx?CTId=5&CId=175.

[15] Lacey, Parsons and Moffat, above n 2, 3.

[16] Williams and Walton, above n 1, 3.

[17] Lacey, Parsons and Moffat, above n 2, 3.

[18] Lacey, Parsons and Moffat, above n 2, 4.

[19] Bice, above n 7, 68. Santos' 2015 Sustainability Report identifies transparency to stakeholders and shareholders as 'an integrate part of maintaining our social licence to operate': *Santos Sustainability Report 2015* (2015), 33, 36, at https://www.santos.com/media/3312/2015_sustainability_report.pdf.

14. Bice has also extracted examples of how Australian mining companies define their SLO, including the following:

> *For society to grant us our "licence to operate", we must demonstrate to our host communities and governments that we can, and will, protect the value of their environmental and social resources and that they will share in our business success.*[20]

15. Bice notes, however, that although it was common for companies to 'front-end position' the importance of 'earning and maintaining' an SLO, 'none actually defined the "licensing criteria"'. Further, '[t]he ways in which companies believe they can gain and maintain their social licence to operate are consistently linked to their definitions and conceptualisations of sustainable development'. This typically reflected 'the Brundtland tradition of addressing intergenerational human needs, now and into the future', with 'key issues areas covered within the reports' content tend[ing] to be generalised to fairly high levels such as labour or employment, social and environmental issues'.[21]

16. An SLO is not only granted by local communities; the 2013 CSIRO report noted that there can be multiple SLOs, each associated with different stakeholder groups.[22] The same report also acknowledges that an SLO may be needed at a broader scale, such that the relevant community that grants the SLO might include not just local community members but members of the relevant State or, impliedly, Territory, or members of the entire nation.[23]

17. The SLO has been modelled as having three levels, with four elements, as demonstrated in the table below:[24]

Table 2.1 Four factors constituting three levels of SLO (after Boutilier and Thomson 2011)

Level and Label	Description	Role in Determining SLO Levels as Described in Thomson & Boutilier Pyramid Model
1. Economic legitimacy	The perception that the project/company offers a benefit to the perceiver.	If lacking, most stakeholders will withhold or withdraw the SLO. If present, many will grant an acceptance level of SLO.
2a. Socio- political legitimacy	The perception that the project/company contributes to the wellbeing of the region, respects the local way of life, meets expectations about its role in society, and acts according to stakeholders' views of fairness.	If lacking, approval level of SLO is less likely. If both this and interactional trust (2a & 2b) are lacking, approval level is rarely granted by any stakeholder.
2b. Interactional trust	The perception that the company and its management listens, responds, keeps promises, engages in mutual dialogue, and exhibits reciprocity in its interactions.	If lacking, approval level of SLO is less likely. If both this and socio- political legitimacy (2a & 2b) are lacking, approval level is rarely granted.
3. Institutionalised trust	The perception that relations between the stakeholders' institutions (e.g., the community's representative organisations) and the project/ company are based on an enduring regard for each other's interests.	If lacking, psychological identification is unlikely. If lacking but both socio-political legitimacy and interactional trust are present (2a & 2b), most stakeholders will grant approval level of SLO.

[20] Bice, above n 7, 69, citing BHP Billiton's 2007 sustainability report.
[21] Bice, above n 7, 70,
[22] Lacey, Parsons and Moffat, above n 2, 8.
[23] Lacey, Parsons and Moffat, above n 2, 8-9.
[24] Williams and Walton, above n 1, 4.

An SLO for the CSG industry: a unique context?

18. The 2013 GISERA literature review specifically considers the role of the SLOW in the CSG industry, in particular in South East Queensland. It notes that:

> *Coal seam gas development in SE Queensland presents a different context to that of most mining developments in Australia, particularly in terms of the cumulative effects of having multiple operations in the region, the co-location of CSG wells on productive agricultural land and the extensive distribution of gas extraction industry and activity.*[25]

19. For this reason, the authors suggest that in the CSG industry, 'a social licence might be more usefully understood as relating to the CSG industry as a whole, rather than in terms of an individual company's operations'.[26]

20. This appears to have been taken on board in the final report of the South Australian Fracking Inquiry, with a central point of the committee's final report being that the unconventional gas *industry* did not have an SLO in the south east of South Australia:

> *This has been made starkly apparent by widespread opposition from the local community. This is not vehement or violent opposition; it is peaceful and determined opposition, and it is occurring in spite of there having previously been a convention gas industry in the South East which has undoubtedly provided significant benefits including employment to the local community.*[27]

21. Williams and Walton have considered how the SLO concept might be applied in the context of the CSG industry in south eastern Queensland.[28] They note that the context for CSG development in SE Queensland 'is considerably different from that of most mining operations in Australia to date'. Distinguishing factors identified include that:[29]

    (a) communities are affected by the cumulative impacts of multiple sites operated by multiple companies, raising the question 'as to how meaningful it is to consider the idea of a social licence in relation to an individual company';

    (b) 'extraction sites occur in close proximity to productive agricultural industry';

    (c) extraction activities can occur relatively close to a capital city;

    (d) there is a diversity of stakeholders with different 'experiences, expectations and perceptions' of the industry, which requires stakeholder analysis to understand the range of different perspectives; and

    (e) the perception that regional activity booms are temporary and that relationships with and benefits for communities will be short-lived.

[25] Williams and Walton, above n 1, 1.
[26] Williams and Walton, above n 1, 1.
[27] *Inquiry into Unconventional Gas (Fracking) in the South East of South Australia Final Report*, above n 14, 7.
[28] Williams and Walton, above n 1, 15.
[29] Williams and Walton, above n 1, 12-13.

What does an SLO look like?

(i) Who is an SLO obtained from/where is an SLO 'located'?

22. Whereas in the past an SLO could be earned by obtaining support from a local community leader, in recent years the mining and energy industry has accepted that obtaining an SLO requires 'a whole-of-community' approach. This is attributed by Dan Haigh to the influence of social media, whereby *'individuals are increasingly turning to social media and the internet for information…*'and *'[t]hanks to social media, [SLO] issues now go viral'*.[30] Haigh identifies a range of relevant interest groups when it comes to earning SLOs, including:[31]
    (a) residents;
    (b) farmers;
    (c) special interest groups;
    (d) sports clubs;
    (e) schools;
    (f) health service providers;
    (g) local businesses;
    (h) government authorities;
    (i) NGOs; and
    (j) governments at all levels.

23. However, in terms of where an SLO is 'located', or who needs to grant it, CSIRO's 2013 research found that the majority of industry respondents participating in the research described the SLO as existing within a local community. The following quote from a respondent interview included in that paper illustrates this:[32]

> *…the most important people, as far as social licence to operate, are the people who live near the operation, and are potentially impacted from an environmental or social perspective*

(ii) How is an SLO obtained? – Trust is critical

24. The relationship between a company (or industry) and stakeholders is critical in order to earn an SLO. Important factors include:
    (a) trust;
    (b) openness;
    (c) accessibility; and
    (d) mutual respect.[33]

    Of these, trust appears to be the most critical ingredient.

25. One study of community perspectives on the development of the LNG industry in the Surat basin concluded that 'trust is the only consistent predictor o-f

[30] Haigh, above n 6, 34.
[31] Haigh, above n 6, 34-5.
[32] Lacey, Parsons and Moffat, above n 2, 8.
[33] Williams and Walton, above n 1, 6.

acceptance and approval of the industry'.[34] Other factors identified of importance in that study were:

(a) whether 'perceived impacts on natural and economic capital were lower than expected'; and

(b) the extent and quality of contact between the company and community members'.

However, for both of these additional factors, trust was also seen as a mediating factor.[35]

26. Similarly, the 2014 CSIRO publication, *Australian attitudes toward mining: Citizen survey – 2014 results*[36] found the following:[37]

> *The results suggest that:*
>
> - *trust in the industry is a strong predictor of acceptance of industry. Put another way, the industry's social licence is facilitated by the level of trust that the Australian public have in it*
> - *procedural fairness in the way that industry engages the public is a strong positive predictor of trust in the industry*
> - *the more that Australians feel the benefits of mining are distributed fairly, the higher their level of trust in the industry*
> - *the more faith that people have in Australia's governance capacity to ensure mining companies do the right thing, the more they accept the industry*
> - *but, perceptions of governance capacity is a stronger positive predictor of trust than it is of acceptance – trust is a critical vehicle for achieving social licence*
> - *procedural and distributive fairness, and governance capacity, are all strongly positively related to each other – more of one leads to more of the others.*

27. Importantly:

> *these results indicate that building trust and acceptance of industry (i.e., a social licence) requires more than just the actions of either industry or governance alone – a social licence is dependent on these important parts of the mining industry working together.*[38]

Further:

> *From this data then, we can see that the Australian public are more accepting of the mining industry in Australia when industry and governments work together to build trust in the industry – holding a social licence to operate is, therefore, the responsibility of governments*

[34] Williams and Walton, above n 1, 6.
[35] Williams and Walton, above n 1, 6, citing another.
[36] Moffat, K., Zhang, A. and Boughen, N., *Australian attitudes towards mining: Citizen survey – 2014 results* (2014, CSIRO Australia), 14, at https://publications.csiro.au/rpr/download?pid=csiro:EP146276&dsid=DS1. .
[37] Moffat, Zhang and Boughen, above n 36, 14.
[38] Moffat, Zhang and Boughen, above n 36, 15.

> *and industry working together with communities to promote effective, constructive, and mutually beneficial relationships.*[39]

28. Notably:

> *[c]ompanies frequently underestimate the importance of relationship building with a community and the length of time required to do that, and/or they overestimate the quality of the relationships that they have with a community.*[40]

29. EY (2013-14) state that '[c]ommunities should be consulted from the outset, even from pre-exploration, to identify and eliminate potential issues'[41] Similarly, Haigh identifies the need for companies to 'engage early and openly with local communities to identify and respond to community concerns and complaints before they develop into conflicts'.[42] This aligns with research suggesting that trust and dialogue are critical elements of an SLO.

30. Williams and Walton emphasise this need for 'community engagement and participatory processes' in order for an SLO to be earned, with the SLO 'dependent on a relationship that is meaningful, and able to deliver dialogue capable of leading to outcomes that are mutually beneficial'.[43]

31. Williams and Walton also identify a 'public participation spectrum' that describes a continuum of stakeholder/community engagement, with give levels of engagement which each involve a greater level of community/stakeholder engagement and impact:
    (a) inform;
    (b) consult;
    (c) involve;
    (d) collaborate;
    (e) empower.[44]

32. Finally, it is important to note that an SLO is not static or permanent; it does not simply need to be earned once at the outset of an industry and/or project but needs to be maintained over the life of that industry/project.[45] Further, 'it can be lost almost instantly'.[46] Haigh notes that it is imperative that companies respond 'quickly and meaningfully' to concerns over, for example, 'air quality, water rights, noise levels, heavy vehicle traffic, house prices, use of public land, preservation of historical sites, access to recreational areas and other legitimate environmental, cultural and social issues' because such issues 'can quickly escalate'.[47]

---

[39] Moffat, Zhang and Boughen, above n 36, 15.
[40] Williams and Walton, above n 1, 5-6.
[41] EY, *Business Risks 2013-14*, 5, above n 6.
[42] Haigh, above n 6, 35.
[43] Walton and Williams, above n 1, 6.
[44] Williams and Walton, above n 1, see Table 3.1 at 7-8 for descriptions of each of the levels of public participation.
[45] See, e.g., Haigh, above n 6, 35.
[46] Quote from industry participant quoted in Lacey, Parsons and Moffat, above n 2, 7.
[47] Haigh, above n 6, 35.

What would happen if fracking commenced in the absence of an SLO?

(i) SLO's are acknowledged as critical for smooth industry operations

33. According to Botilier and Thomson:

> *An SLO is arguably indispensable for companies operating within certain jurisdictions, chiefly those classified as representative democratic societies where having an SLO is generally needed for political support and thus real operating licences.*

(ii) What does an SLO provide and what might happen in the absence of an SLO?

34. Yates and Horvath propose that an SLO is important to companies because it:

- *provides a proponent with legitimacy for its presence and actions from a local community's perspective;*
- *provides regulators with a level of comfort that a proponent is acting responsibly;*
- *minimises the risk of costly delays in regulator approvals due to opposition;*
- *assures shareholders and investors that a company is managing social risks and other risks associated with its projects and activities;*
- *enhances trust by demonstrating to regulators and other stakeholders that the company is genuinely striving for good performance; and*
- *protects a company's reputation in times of crisis.*[48]

35. Risks of operating in the absence of an SLO include, for example:[49]
    (a) reputational damage;
    (b) premature closure of an operation;
    (c) interruptions to operations, including protests (which delay projects and therefore could in turn increase overall costs);
    (d) industrial disputes; and
    (e) the need for regulatory intervention.

36. In terms of industry's perspective (although notably this is the metals and mining sector, rather than energy), Ernst & Young (now EY) rated the SLO fourth in its top ten risks to the metals and mining sector in 2013-14.[50] The report said the following of the SLO:

> *Social licence to operate has crept up the list to fourth position as activists become more powerful and vocal through the use of social media around concerns over climate change, competition for water and the impact mining has on communities.*[51]

37. The same report also notes the following factors as increasing the importance of obtaining an SLO in the metals and mining sectors. Many of the identified factors

[48] Yates and Horvath, above n 14, 3.
[49] See, e.g., Haigh, above n 6, 35; Lacey, Parsons and Moffat, above n 2, 6.
[50] Haigh, above n 6, 34; EY, *Business Risks 2013-14*, above n 6, 5.
[51] EY, *Business Risks 2013-14*, 5, above n 6.

are also likely to also to be relevant to the energy industry, including the following:[52]

(a) *'The community and governments are developing a more sophisticated understanding of mining and metals activity and its potential impact'*

(b) *'Social medial is also empowering stakeholder both en masse and within smaller community groups'*

(c) *'Community groups have a greater awareness of their rights and are prepared to defend them using social media and other channels'*

(d) *'bad media and reputational damage suffered by one company can, in turn, result in collateral damage for the whole industry'*

(e) *'stakeholders are turning to the courts'* to address perceived issues with projects that have been approved

(f) In light of *'[g]lobal climate change concerns and increasing regulation [which] mean that fossil fuel reserves may not be able to be exploited…',* investors may be wary of optimistic resource assessments by resource companies if these assessments *'don't take into account global climate change policy and the implications of a low-carbon future'* (this comment was made specifically in relation to coal production).

38. In EY's 2016-17 assessment, SLO remained number four in the top ten risks.[53]

39. EY has also identified its top ten risks for energy and power companies. This list does not specifically include SLO, however it does include at number six 'managing planning and public acceptance risk'.[54]

40. Santos' 2015 Sustainability Report[55] quotes the Santos Chair as saying the following:

> *For me, maintaining our social licence to operate is central to our long-term success – without the support of our shareholders, governments and the community, we will not be able to deliver on Santos' significant potential.*[56]

41. In South Australia, the Fracking Inquiry similarly recognised the importance of a SLO, recommending that:

> *Without social licence, unconventional gas exploration/development should not proceed in the South East of South Australia. The committee found that social licence to explore/develop unconventional gas does not yet exist in the South East of South Australia.*
>
> *…*[57]

---

[52] EY, *Business Risks 2013-14*, 5, above n 6, 27-9.
[53] Report available here: http://www.ey.com/Publication/vwLUAssets/EY-business-risks-in-mining-and-metals-2016-2017/%24FILE/EY-business-risks-in-mining-and-metals-2016-2017.pdf.
[54] See here: http://www.ey.com/gl/en/industries/power---utilities/turn-risk-and-opportunities-into-results--power-and-utilities---the-top-10-risks.
[55] *Santos Sustainability Report 2015* (2015), at https://www.santos.com/media/3312/2015_sustainability_report.pdf.
[56] *Santos Sustainability Report 2015*, above n s55, 3.
[57] *Inquiry into Unconventional Gas (Fracking) in the South East of South Australia Final Report*, above n 14, 11.

A relationship between making submissions to the Inquiry Panel on an SLO and making submissions on the regulatory framework applicable to fracking

42. Industry has identified the SLO as a qualitative rather than a quantitative concept, and one that has unclear, immeasurable boundaries.[58] Further, there is acceptance of this as being part of the very nature of an SLO, with recognition that attempts to standardise the concept being risky: *'such standardisation would not allow for flexibility or the ability to adapt to the needs of different communities or contexts'.*[59] However, Justice Preston, Chief Justice of the NSW Land and Environment Court, has argued that there are numerous ways to improve legal processes in order to reduce the size of the gap between the expectations of society and the law, arguing that this is 'the preferable means of satisfying society's expectations'.[60] In summary, the suggestions raised by Preston J were:[61]

    (a) improving public participation during the application stage for projects;

    (b) improving consideration of the social impacts of projects at the assessment stage;

    (c) ensuring that the approval stage takes public participation into account and 'adequately reflects the assessment of the application', with conditions of approval adequately mitigat[ing] adverse social and environmental impacts, and … not trade off unlike social benefits and burdens'; and

    (d) ensuring that 'at the implementation stage, there is … adequate monitoring and adaptive management … ongoing community engagement, and adequate enforcement'.

43. Recognising that supporting industry to obtain an SLO can be supported by improved legal requirements, the South Australian Fracking Inquiry recommended, among other things:

> *A review of the Petroleum and Geothermal Energy Act 2000 and relevant regulations would be appropriate, with particular consideration given to:*
>
> - *…*
> - *the development and integration of formal guidelines for community engagement and consultation to assist with negotiation processes and achievement of social licence;*
> - *...*[62]

[58] Lacey, Parsons and Moffat, above n 2, 5.
[59] Lacey, Parsons and Moffat, above n 2, 5.
[60] Preston J, above n 10, 200-201.
[61] Preston J, above n 10, 200-201.
[62] *Inquiry into Unconventional Gas (Fracking) in the South East of South Australia Final Report*, above n 14, 11.

CONSULTATION AID

EP(A) 173 & EP(A) 194 – Armour Energy Initial Consultations

Tuesday 02 October, 2012 @ Borroloola

1. What is this meeting all about?

This meeting has been called to:

1. explain what a petroleum exploration permit is;
2. tell you about an Application for petroleum Exploration Permit (EP(A)) which a company called 'Armour Energy Pty Ltd' (Armour Energy) has lodged over your country (EP(A)s 173 & 194);
3. explain what say/rights Traditional Owners (TOs) have in relation to EP(A)s 173 & 194;
4. talk about how companies look (*explore*) and drill for oil and shale gas;
5. identify and discuss the potential environmental and social impacts of oil and gas exploration and production;
6. discuss whether TOs would like to make a decision about whether or not to proceed with consultations for EP(A)s 173 & 194; and
7. give you a chance to meet Philip McNamara – the CEO of Armour Energy.

2. What is an Exploration Permit or 'EP'?

An Exploration Permit or EP is a licence to look for oil and gas that is issued by the Northern Territory Government under a law called the *Petroleum Act*.

The holder of an EP has a number of rights including:

1. to access country within the permit area with any vehicles and equipment that are necessary for exploration;
2. to carry out a technical works programme or 'explore' for petroleum within the permit area;
3. to extract from the permit area an amount of material necessary to establish the presence of petroleum through sampling and testing; and
4. to use the water resources of the permit area for domestic use and exploration.

An exploration permit lasts for 5 years with the possibility of two 'renewals'. Therefore, the company can spend up to 15 years of looking for oil and gas.

3. What say/rights do Traditional Owners have over EP(A)s 173 & 194?

Under the Aboriginal Land Rights (Northern Territory) Act 1976 (the "Land Rights Act" or "ALRA" as it also known), Traditional Aboriginal Owners (TOs) have control over development on their country. Oil and gas producing companies who want to explore on Aboriginal land must ask permission of Traditional Owners and must accept their decision.

You are identified as Traditional Owners of this land. This meeting is being held so that Armour Energy can talk to you about their work and what they would like to do on your country. You will then need to decide if you want to the NLC to talk with them some more about this to negotiate an 'Agreement' on your behalf or not.

Today, you are not being asked to agree to exploration for and production of oil and/or gas. You are only being asked if you want the NLC to have further talks (negotiations) with Armour Energy in order to make an Agreement.

If you don't want to have exploration or oil and/or gas production on your country, or if you don't want the NLC to have further talks with Armour Energy, then you may say NO at today's meeting.

If you say **NO** at this meeting, then Armour Energy must go away for 5 years before they can ask again for permission to explore the part of the land to which you have said no.

If you say **YES** at this meeting, then the NLC will sit down with Armour Energy to talk and negotiate to try to reach a fair agreement for exploration and production of oil and/or gas. These agreements also work to protect your sacred sites and environmentally important areas on the land to which you have said yes to oil and gas exploration. Part of the negotiation process includes a site survey of the tenement to 'block out' sacred sites and other culturally important areas that TOs want protected.

After this agreement has been written, it will be discussed with you at another meeting. This second meeting will allow you to make a final decision on whether you accept the agreement and allow Armour Energy to do their exploration; or whether you wish to say **NO**. If you say no at this second meeting, then Armour Energy must go away for 5 years before they can ask again for permission again to explore the part of the land to which you have said no.

What happens if we say yes to the agreement and agree to exploration?

It is very important that you understand that if you decide to give consent to exploration you are also giving consent to production of oil and gas on this land. Oil and gas production may not happen, but it will happen if Armour Energy finds enough Oil and Gas (resource) in the ground to make it economic to produce oil and/or gas from this land.

The rules for Aboriginal (ALRA) land are different from the rules for native title land. To summarise this difference on Aboriginal land, TOs have a right to say 'yes' or 'no' to petroleum (oil & gas) exploration. This is called a **veto right** because TOs have the right to

veto exploration and that means that exploration and mining cannot occur if the TOs don't want it to occur.

4. The Land

EP(A)s 173 & 194 are over **Aboriginal Land** and include the entire Garawa Aboriginal Land Trust (ALT), that is covered by the Aboriginal Land Rights (Northern Territory) Act 1973 (ALRA). EP(A) 173 covers the northern part of the Garawa ALT and EP(A) 194 covers the remaining southern portion of the Garawa ALT, i.e. EP(A) 194 includes all of the land in the Garawa ALT that is not covered by EP(A) 173 and *vice-versa.*

5. Who is the company?

The company which has applied for EP(A)s 173 & 194 is called 'Armour Energy Pty Ltd'. Armour Energy is a publically traded Company listed on the Australian Stock Exchange since April 2012 Armour Energy was established principally for large-scale shale gas exploration in Northern Australia. Armour Energy's CEO and Managing Director, Mr Philip McNamara is their representative and he is here today to talk with TOs about EP(A)s 173 & 194 . This is a good chance for you to talk with him and ask questions about the company's plans for EP(A)s 173 & 194.

6. What is shale gas?

Shale gas is also known as **'natural gas'.** Scientists believe that natural gas is created when the ancient remains of algae and other plants and animals are placed under lots of pressure over millions of years deep under the earth's crust. When the plant and animal matter break down they can become gas, which gets trapped within shale rock. The deeper underground the plant and animal matter are, the higher the pressure they are placed under and therefore the higher the chance of finding natural gas.

7. How will Armour Energy explore for shale gas?

(A) Initial Stage – Geological mapping & other fieldwork activities

- In the first and second years of exploration, Armour Energy will be concerned with demonstrating the quality of any potential gas shales by geological fieldwork, sampling, and by acquiring drill core samples. Armour Energy may fly, drive or walk over country looking for rocks that point to gas. The company will probably take rock samples and send them away to a laboratory for analysis. This type of work is known as "reconnaissance" work within the Oil and Gas industry.

Ground surface geological mapping has very limited environmental impact.



Airborne Survey – flying over country and using special equipment to look for signs of gas



Taking rock samples



Walking across country

(B) – Intermediate Stage – Seismic surveys

After doing their reconnaissance work, Armour Energy will focus on seismic acquisition by undertaking seismic surveys. Seismic surveys use trucks with sounding equipment. These will be driven through single lane tracks, sending sound waves down into the earth that are used to create pictures on a computer screen to show where oil and gas may be found.



Clearing an area for the placement of seismic lines



Installing seismic receivers



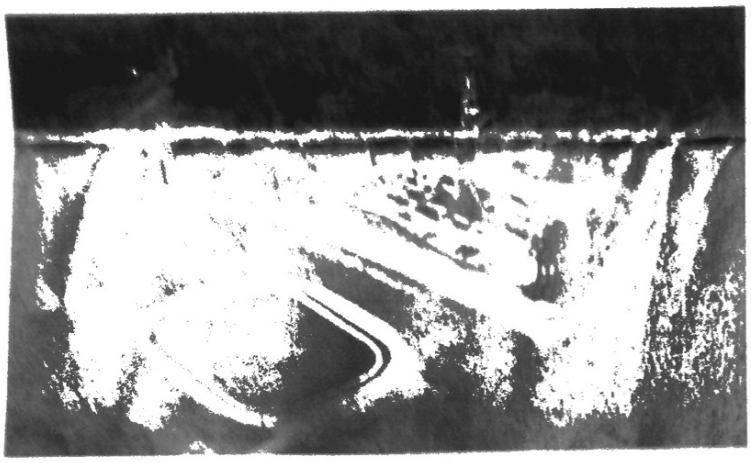
Equipment used for seismic surveys – recording truck



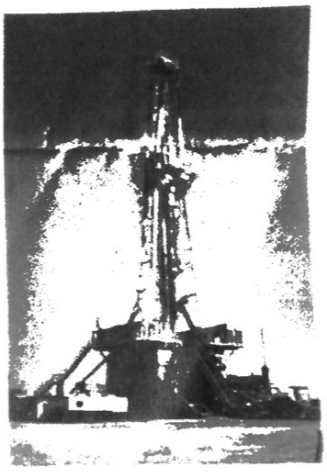
Equipment used for seismic surveys – seismic vibrators

(C) Advanced Stage *Drilling test wells & hydraulic fracturing*

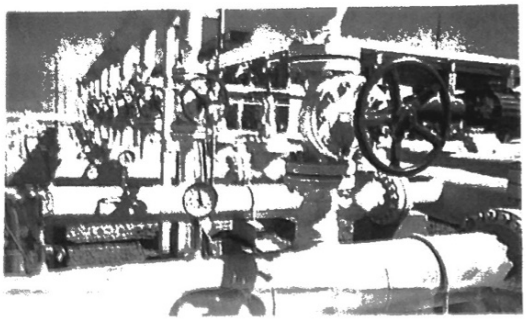
If Armour Energy find signs of potential for oil or gas in the first few years of exploration, they will want to drill vertical test wells. A drill pad for a test well is **a little bit smaller than a football field**. The well would be lined with a steel pipe and cement to try to prevent gas from escaping into ground water. Armour Energy could drill many holes from the one drill pad. These holes could be shallow (up to a few hundred metres) or they could go down deep underground, up to several kilometres below the surface. Armour Energy may build a processing plant in the EP area, taking core samples, fluid samples and other materials for evaluation and further refining if necessary.



Example of a drill test well in America

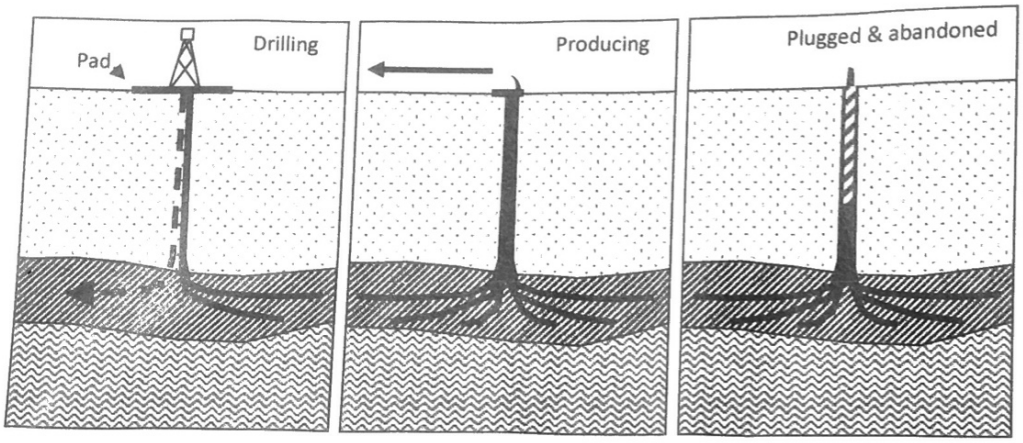


Example of a natural gas well

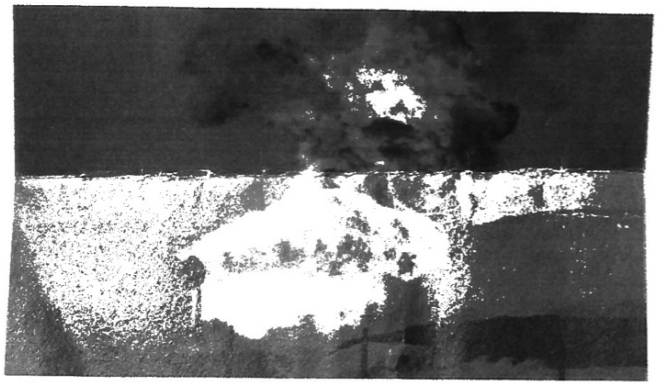


Example of an Oil and Gas Processing Plant

Because gas is trapped in shale rock, Armour Energy would need to fracture (crack open) the rock so that gas can be released and extracted via the drill hole. To do this, a hole would fist need to be drilled *vertically* down to the shale rock zone and then drilling would continue for up to several kilometres *horizontally* through the shale zone and then a mix of water and sand are pumped into the hole at a very high pressure. This high-pressure mixture would help to fracture the rock, opening up cracks and allowing the gas to be released into and extracted via the drill hole. This is called **'hydraulic fracturing'** or as it is more commonly called **'fraccing'**.



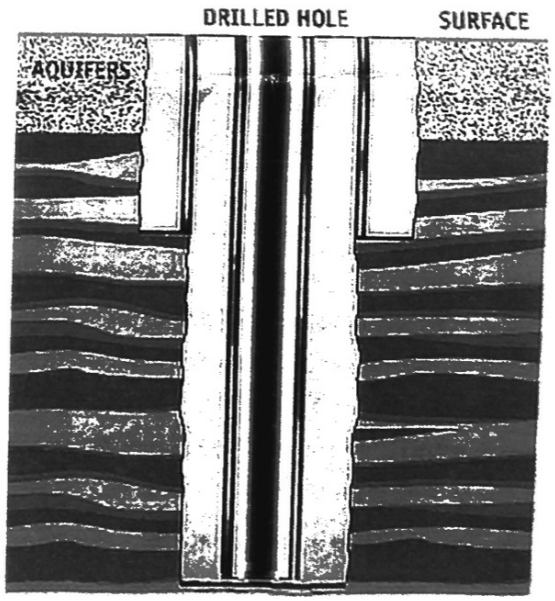
If Armour Energy want to build a well they must also provide the NLC with an engineer's certificate to show that the design of the well is lawful, safe and will not pollute ground water. Any gas found in the exploration phase must be flared (burnt), as shown in the picture below, because it cannot be transported.



8. How will Armour Energy recover oil and gas?

Once a well is drilled, engineers use metal casings to add stability. These casings help keep the well from collapsing in on itself. Each casing is lined with cement walls. Casings get narrower as the well gets deeper. Oil companies use progressively smaller drill bits as the well's depth increases.

When the drilling unit hits oil or gas, engineers must seal the well to prepare it for a production rig using a pair of plugs to seal off the well bore. The bottom plug sits near the deposit. Drilling mud provides the pressure to hold the plug in place while the engineers place a top plug to cap the oil well. Then the well is ready for a production rig to take over.



Armour Energy is not allowed to drill for oil without seeking permission from the Northern Territory Government. The company needs to explain to the Government the exact technique it intends to use to drill and assess the environmental impact their drilling operations will likely have. In addition, drilling must be undertaken in accordance with Commonwealth Laws and Industry Codes of Practice. The Company is not allowed to start taking large quantities of oil unless it applies for a 'Production Licence'. At that stage the Company will have to come back and talk to TOs.

9. What are the potential environmental impacts of oil and gas exploration?

Armour Energy (The Company) must abide by all Australian environmental laws and with the environmental provisions within the agreement that they will have to make with the NLC and TOs. The company is subject to environmental protection and rehabilitation conditions.

Unlike mining, oil and gas recovery does not invlove large excavations or quarries The company must protect groundwater from contamination however there is always a small ***risk of water contamination or a gas leak****. The company will do its best to stop this from happening.*

10. What is the process for TOs decision making?

We need to ensure that a decision to negotiate with the Company (say "Yes") or to veto (say "No") made by the TOs is made:

1. **By the right people who speak for country; and**
2. **In accordance with traditional law and custom.**

If TOs say "Yes" today, the NLC will begin to negotiate an agreement with the company. We will come back to TOs to hold a 'Final Meeting' when a site survey has been completed a fair and reasonable agreement has been reached with the Company that will be present to TOs at this Final Meeting.

If TOs say **"No"** today, EP(A)s 173 & 194 will be placed in moratorium ("put on the shelf") for 5 years. The company is allowed to ask for permission to explore again after 5 years have passed