Presentation to 2017 Fracking Inquiry

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PURPOSE

- To discuss potential sources of contamination of the Tindal aquifer occasioned by a shale gas industry through all stages from Exploration to Completion and beyond
- To position potential sources of contamination on a Risk analysis matrix
- Primarily of relevance to Terms of Reference 1.

Potential risks of hydraulic fracturing

Unconventional Gas: Presentation by Damien Barrett CSIRO to Community Meetings Darwin & Katherine 21/22 November 2013

- Surface transportation spills
- Well casing leaks
- Connectivity through rock fractures
- Drill site discharge
- Wastewater disposal
- Retention pond release

Largest risk:

- Wastewater disposal
- High epistemic uncertainty
- High flow back volumes
- Large number of wells

Rozzell and Reaven (2012) Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale. Risk Analysis, 32, 1382-1393

Well Casing Leaks-introduction

- For a gas industry to have no lasting effect on the several sustainable industries and permanent communities that rely on the Tindal aquifer, the wells to extract the gas must maintain integrity into the distant future, where "distant future" is defined as 100 years.
- Gas Industry processes have as their objective to establish and maintain Well Integrity by the application of cement to seal the space between the casing and the surrounding geological structure.
- In order to place the EVENT (as defined previously) on the LIKELIHOOD Axis it is necessary to know, or have an estimate of, the number of wells in a production gas field.
- The notes below derive a figure for the maximum number of fracked wells in the Betaloo basin as between 27,000 and 54,000 (Nutwood Downs/multi-well pads method) and 1260 (Frogtech/single well pads method).
- The discrepancy highlights the ease of generation of conflicting information relevant to the gas industry.

The Environment

- The seal is exposed to an environment is characterised by:

1. MECHANICAL SHOCK
2. VIBRATION
3. THERMAL SHOCK
4. MOISTURE
5. SALT
6. PRESSURE DIFFERENTIAL
7. TEMPERATURE DIFFERENTIAL
8. EARTH MOVEMENTS

Life Cycle/Failure Mechanisms

My understanding of the life cycle of a gas well and the conditions to which the critical metal to cement seal is exposed:

- **Inject the cement**: Cleanliness and metal surface priming is essential for good uniform adhesion, but not possible in situ; complete metal-cement contact over entire casings length is essential but difficult, maybe impossible. Void testing is carried out. I assume there are tolerances on acceptable void sizes and tests for variation in quality of bonding.
- **Perforate the horizontal casing**: As many explosive shocks as there are stages resulting in relative movement between the two rigid materials, steel and cement. In practice the perforation channels penetrate the shale 6-18 inches. During the fracking process the induced fractures emanate out from these channels

Life Cycle/Failure Mechanisms (contd.)

- **Frack the shale in stages**: Thermal shock as the fluid at surface temperature encounters the lower casing at subsurface temperature, resulting in relative movement. The casing will expand as 10,000 psi pressure is applied. The rate of application of the fracking fluid pressure must be controlled to avoid hydraulic hammer.
- **Gas flow:** Fracking fluid expelled by the initial gas flow, including acid to clear the perforations; some fluid escapes into capillaries between casing and cement; as flow proceeds proportion of fluid associated with the shale increases as does the salinity and content which may include radio nuclides, heavy metals and the products of the perforation explosions. It is not known if the gas flow is turbulent or laminar ie is the frequency, and associated vibration, generated by the gas flow white noise or single frequency?
- **Plug the casing:** At some juncture in the life cycle of the well the gas flow is assessed as not commercial. The well is plugged ie cement is injected into the producing casing and the shale bed sealed off. Gas continues to be released and pressure builds up

A Structural Engineer's View

- A structural engineer would describe the casing/cement combination as an extended composite structure comprising a very long steel tube as the inner component and an outer component of a cement layer nominally 2.5cm thick.
- The steel tube has been inserted down a hole in the ground and the cement is applied from the top and expected to surround the steel and bond to it all the way to the other end.
- Both materials are rigid and have different modulus of elasticity. There would be a concentricity tolerance allowing for some variation in thickness.
- Any factor which causes differential movement between the two bonded layers will lead to weakening and eventual rupture of the bond. There are several such factors identified in the previous slide, including shock, vibration, thermal differentials, internal and external mechanical stress.
- Moisture either by capillary effect or under pressure will find its way into any crack between casing and cement and if saline will accelerate corrosion.
- The consequence is migration path(s) for the gases and other materials released from the shale to the overlying aquifer and to the atmosphere. The predicted Impact is to render the aquifer unsuitable for its current and projected use in support of sustainable industries, established communities and the environment

Waste Water Disposal -Retention Pond Release

- Waste water is returned to the surface after a fracking operation. As well as the initial fracking additives it is highly saline and may contain heavy metals and radionuclides.
- Since 13th November 2013 industry responses to questions on the management of produced water have included:

1. Retention/Evaporation ponds--Risk of inundation and overflowing during a Wet season downpour
2. Road transport to a disposal facility-- A producing gas field of many thousands of wells implies 25 million/10,000 equals 2500 tanks per fracked well in transit along the Stuart Highway.
3. Deep Well injection—US experience not encouraging; Incomplete knowledge of aquifers, particularly connectivity between aquifers, indicates precautionary principle
4. Reverse Osmosis—Expensive, power hungry, centralised, residue disposal

Waste Water Disposal -Retention Pond Release

When considered in the context of the development and production stages of a gas field and given that human error is a factor , these methods attract "risk ratings" of highly probable

The consequences should be rated as "High" noting that the Tindal aquifer is already contaminated, a situation which justifies a zero tolerance to further contamination.

Risk and Consequence of Well Casing Leaks & Waste water spillage

The probability of EVENTS under examination, that of:

- Well casing leaks, when taken over a period of time starting with exploration and beyond the production phase of a gas field
- Waste water spillage during the exploration and productive phases of a gas field

are rated at 100%

The CONSEQUENCES to the eco-system of communities, industries and environment which briefly shared its space and resources with the gas industry are SEVERE and, in some cases, IRREVERSABLE.

Seventh Generation Principle

- The gas industry has proposed to exploit methane bearing shale deposits which are overlaid by a social, economic and environmental eco-system which is both established and sustainable.
- This presentation has set out to demonstrate that such a project being of relatively short duration and exploiting a non-renewable resource would entail an unacceptable risk of severe consequences to the existing and future enterprises and communities.
- I ask the Panel to accept this conclusion, and in judging it be mindful of the seventh generation principle of the Iriquois Nation.