**INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS, AUSTRALIAN NATIONAL CHAPTER**

PO BOX 7634, CLOISTERS SQUARE, PERTH, WA 6850 WWW.IAH.ORG.AU

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Committee Secretary
Senate Select Committee on Unconventional Gas Mining
PO Box 6100
Parliament House Canberra ACT 2600

**Dear Select Committee**

Thank you for the opportunity to make a submission to the Select Committee on Unconventional Gas Mining. It is our understanding that the Select Committee is to inquire on the adequacy of Australia's legislative, regulatory and policy framework for unconventional gas mining including coal seam gas (CSG) and shale gas mining.

The International Association of Hydrogeologists (IAH) is a scientific and educational organisation for scientists, engineers, water managers and other professionals working in the fields of groundwater resource planning, management and protection. Our mission is to further the understanding, wise use and protection of groundwater resources throughout the world. The IAH has a world-wide membership of several thousand individuals, with over six hundred in Australia.

We would be pleased to discuss or clarify any of the aspects of our submission with the Select Committee.

If you have any further queries on the content of our submission, please contact Lange Jorstad, Vice-President, IAH Australia or Alan Wade, Chairperson, Communications Sub-Committee.

Yours Sincerely

**Lange Jorstad** **Alan Wade**
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## Introductory Comments

IAH Australia (IAH) recognises that activities such as Unconventional Gas development impacts groundwater. Decisions on the development of unconventional gas should be determined by the acceptability of impacts. The acceptability of impacts is driven by the capacity to accurately identify them, communicate them clearly, enforce the development and operating standards to ensure the impacts are managed, if necessary have appropriate tools to off-set the impacts and rigorous close out approaches to ensure long term impacts are within the identified limits.

This submission by IAH focusses on the impacts of unconventional gas developments on groundwater. It does not intend to cover all aspects of the terms of reference, only those related to groundwater. The opinion expressed in this submission is a collective position of IAH Australia, and may not reflect the individual opinions of specific members.

IAH Australia supports, through this submission, a legislative, regulatory and policy framework to ensure that the appropriate scientific investigations are undertaken to adequately assess the risks of each proposed Unconventional Gas project. There must be comprehensive baseline studies, impact assessment (including cumulative impacts and risk assessment), appropriate linkage between the different scientific disciplines and that the findings are transparent. In addition, the regulatory framework should ensure consistent standards, the appropriate level of expertise is involved in reviewing and scrutinising impact assessments, and have with the power to require supplementary work if necessary.

## The importance of Groundwater in Australia

Groundwater is one of Australia's most important natural resources. This is the driest inhabited continent on Earth. Surface-water resources are limited over vast areas and glacial ice is non-existent. Groundwater is a major source of water for urban areas, agriculture and industry.

Numerous townships, farms and mines are totally reliant on groundwater. In recent years, the estimated total water consumption in Australia has been on the order of 15,000 Gigalitres (GL) per annum (equivalent to approximately 30 Sydney harbours). Approximately one third of this water, roughly 5,000 GL per annum (i.e. approximately 10 Sydney harbours), is reported as sourced from groundwater. Despite its importance, groundwater is often undervalued and poorly understood. This may in part be due to its nature as a complex, hidden resource that is difficult to conceptualise.

## Risks to Groundwater from Unconventional Gas Projects

The perception of the risks of unconventional gas developments are extensive (Attachment 1). Many of these "risks" have a low demonstrated likelihood of occurrence. The IAH believes that rather than making general alarmist statements, governments and proponents must make a greater effort to analyse and quantify the likelihood and consequence of impacts from Unconventional Gas projects. The risk analysis should be carried out systematically and use information that can be verified. The IAH believes the key groundwater risks include, but are not limited to:

- Large declines in groundwater levels, if significant depressurisation is required, leading to reduced access for existing groundwater users, reduced water for the environment or subsidence at the ground surface.
- Contamination of aquifers from activities conducted at the surface. For example, leaks from storage ponds or fuel storages.
- Cross contamination of aquifers by poorly constructed wells.

The potential risk of Unconventional Gas projects impacting on groundwater also varies significantly depending on the type of proposed project and local hydrogeological conditions. For example, some shale gas and tight gas projects will target very deep formations (>2,000 m), where aquifers used to supply agriculture, urban use or the environment may be separated by hundreds of metres of low permeability material from those target formations. The risk to groundwater in this instance is mostly due to well integrity and surface activities. Other unconventional developments, such as coal seam gas projects may target relatively shallow aquifers (<1,000 m) that are closer to regionally significant aquifers. The risks in this case are greater and would need more thorough consideration.

## Key elements – development and approval stage

***Baseline data:*** The collection of long term, spatially consistent groundwater level / pressure, hydraulic property and water quality data is critical to understanding how groundwater systems work. Only with this data can the impacts of long term resource projects including unconventional gas be better understood. Data collection, even by governments, is often focussed on the short term. When costs are to be managed, it is often difficult to justify longer term data collection exercises when the need for the data is not immediately apparent. The value of long term datasets is delivered when you need the data! For groundwater, there is also a mismatch in the mechanisms for funding long term monitoring. Often the focus is on groundwater resource use for agriculture and town supply use and funded from "water management" budgets. In reality, the data is often necessary to understand major resource development impacts such as unconventional gas.

Aquifer testing to evaluate hydraulic properties must be a part of every baseline assessment. Groundwater models used to calibrate to baseline conditions and subsequently evaluate impacts must take into account actual aquifer properties evaluated from aquifer testing within the potential area of impact.

The IAH supports:

- Science based programs such as the bioregional assessment program (or similar) to develop baseline scientific knowledge of prospective unconventional gas development areas
- The work of the Commonwealth Office of Water Science to standardize baseline information requirements, at a national scale

Key opportunities for government in collecting baseline data:

- Enhancing statewide monitoring networks to provide critical spatially consistent hydraulic property data and long term water level/pressure and quality data. In developing and funding such ongoing programs, consideration of how the resource sector, as a beneficiary of the collection of this data, can contribute to the costs. Where this does not occur already, this could include investment of resource based Commonwealth and state revenue into groundwater and aquifer property monitoring infrastructure.
- Expansion of the bioregional assessment approach (or similar) to all states of Australia
- Commonwealth and state governments to work toward uniform nation-wide regulations on the baseline data requirements for unconventional gas developments. Where possible, the regulations should support the systematic commencement of water level/pressure and quality data at the outset of exploration.
- Publication of the data collected in easy to access and use formats.

Key opportunities for proponents include:

- Investing in comprehensive baseline water quality and water level / pressure data collection programs as part of the initial phases of exploration. This includes baseline surveys of existing groundwater users (including environmental uses) in the proposed development area to create a "before exploration" dataset.
- Undertaking comprehensive hydraulic property studies on the development zones, low permeability materials separating the development zone from aquifers that are used for groundwater extraction and/or support environmental values, and the aquifers in use themselves.

**Cumulative impact assessment** – Project proponents must be required to evaluate cumulative impacts, i.e. the impacts of their project combined with existing and approved projects in the same groundwater basin. This is standard practice overseas to address cumulative impacts in areas where there is potential overlap of impacts (e.g. in the Oil Sands of Alberta, Canada). The necessary information to populate the models should be publically available (e.g. rates of groundwater extraction from existing and approved projects).

There is also a potential role for government to develop the capacity to assess the cumulative impacts of several resource developments within connected groundwater systems with their own

models. Such models are complex. They require skilled resources to develop and to maintain. However, they are critical to developing an independent representation of how multiple projects will compound impacts.

IAH supports:

- Modelling of cumulative groundwater impacts, not just the impacts of the project being proposed.
- The use of concepts such as "cumulative management areas", such as the Surat basin in Queensland and the resultant cumulative modelling exercise administered by the Queensland Government with funding provided by industry.

Key opportunities for government include:

- For state governments to develop cumulative impact models for prospective basins within their state, and work with adjacent states where a resource may cross state borders.

Key opportunities for proponents include:

- The development of cumulative impact models as part of project approval process to enable better evaluation and communication of impacts from their development in consideration of adjacent developments.

**Risk-based assessment:** A significant gap in the development of unconventional gas projects is the sophistication of risk based models to understand and quantify the impacts of a development. Consistent, detailed quantification of the likelihood and consequence of changes caused by a development proposal are critical to inform the approval process. They are also critical in the communicating the impacts of a proposal in a consistent and transparent way.

The IAH supports:

- The use of the Independent Expert Scientific Committee (IESC) to provide consistent oversight of the science used in proposals.

Key opportunities for government include:

- Expansion of the IESC by the Commonwealth government to include all Australian unconventional gas projects.
- Development of consistent nationwide guidance on risk assessments for unconventional gas projects.

Key opportunities for proponents include:

- Presentation of development proposals with a comprehensive evaluation of risks to better enable decision making.

## Key elements - Regulatory approaches and the resources to implement them

**Overarching legislation:** State regulations provide a framework for the development of unconventional gas proposals. The individual regulatory approaches can vary. This can provide challenges to industry to meet specific requirements in moving from state to state, and create different outcomes across state borders.

The majority of the States and Territories have well developed groundwater management policies and well trained staff in the relevant water management organisations that implement these policies for current groundwater projects. It is the view of the IAH that additional resources, including qualified hydrogeologists, are required by the State and Territory Governments to make sound decisions and oversight of Unconventional Gas projects, particularly if large scale development proceeds.

In recent years there has been significant advancement in legislative, regulatory and policy frameworks governing unconventional gas and other resource projects around the world. This builds on both successes and failures. Australia should build on the experience of other governments rather than reinvent the wheel. We have included a selection of references from Europe and the United States that may be useful to the Committee.

**Gas Well Integrity:** A specific area where consistent regulation and appropriate resourcing to ensure it is delivered is well integrity. Well integrity is considered a key risk factor for Unconventional Gas projects. Well "integrity failure can cause adverse changes in groundwater levels, flow rates and flow directions and can also lead to changes in groundwater quality" (Department of Environment, 2014). There is emerging evidence that faulty wells rather than hydraulic fracturing represent the greatest risk to shallow groundwater resources from Unconventional Gas projects (e.g. Darrah, et al, 2014).

It is critical to ensure that gas wells are designed, constructed and decommissioned in accordance with relevant international best practice and verified by independent experts. Ongoing monitoring and maintenance is required to ensure well integrity is maintained during the life of each well. Environmental bonds (or similar) need to be adequate to cover potential legacy issues with abandoned wells or insolvent well owners.

**Community engagement:** The IAH understands that there are many factors that influence a projects social licence to operate. At a broad scale the IAH believes a contributing factor to the erosion of the Unconventional Gas industry social licence to operate is a lack of transparency related to fracking, risk to groundwater resources and surface and groundwater pollution. The IAH believes that improvements to the existing legislative, regulatory and policy frameworks must address the need for community consultation and involvement in the process of project approval.

IAH supports:

- Consistency in the regulation of key aspects of unconventional gas developments, such as well integrity.
- Resourcing to adequately verify standards for well integrity are being met.

The opportunities for Governments are:

- Development of national standards for key aspects such as well integrity.
- Continued integration and/or clear explanation of regulations within states to ensure a clear and consistent approach to the unconventional gas industry.
- Increased emphasis on community engagement within the proposal process.

The opportunities for proponents are:

- As part of regulatory approval processes, increase the level of engagement with stakeholders within and around the proposed development area.

## Key Aspect - Open and transparent information sharing

The IAH recognises that the communication of information around unconventional gas developments is complex and can be fraught with difficulties. There needs to be a wider recognition that Unconventional Gas projects can coexist with existing industries and can have beneficial outcomes for regions and the country as a whole. Factors that could be considered to address this issue include broader tools to enable the impacts to be managed, greater community involvement in both the front end (e.g. scoping) and back end of impact assessments (e.g. hearings) and overall improving the way information is communicated to better equip communities to participate in decision making. This includes addressing contentious issues such as fracking and the associated concerns over pollution issues.

Even in a tightly regulated environment with good science and communications driven by the regulations and paid for by project proponents, there is potential for the risks of projects to be distorted by the perceived biases of proponents and opponents of unconventional gas. In addition to the requirements of project proponents that are specified by the legislative, regulatory and policy framework, the IAH suggests that the resources be put aside to either appoint a national scientific panel or augment the IESC to improve Unconventional Gas governance. The IAH believe that the committee should be tasked with verifying compliance with legislation and regulations and making recommendations for ongoing improvement of the regulatory environments. This would add a layer of rigour and credibility to the development and approval process.

IAH supports to the idea that all research, baseline monitoring, impact assessment and cumulative impact studies conducted by Unconventional Gas developers, State agencies,

academic institutions and other scientific research organisations should be made publicly available to help build transparency and confidence in the process.

IAH Supports:

- Continued open sharing of data

Opportunities for Governments and Industry include:

- Expansion of the IESC by the Commonwealth government to include all Australian unconventional gas projects.
- Making technical information "plain English"
- Better communicating risks and associated management options.

Opportunities for proponents include:

- Making technical information more readily available and easy to understand using "plain English".
- Better communicating risks and associated approaches to management that reflect the concerns of the stakeholders.

# Attachment 1: Incident rates associated with Unconventional Gas

In a recent article in the journal of the Australian Academy of Technology and Engineering, Professor Craig Simmons outlined the public concerns that are related to the technical risks associated with Unconventional Gas projects (Simmons 2015):

- potential contamination of groundwater from fracking chemicals and released methane;
- leakage of methane gas and its impact on climate change;
- potential toxicity of the 600+ chemicals used and risks to operators and local residents;
- waste disposal and containment of fracking materials;
- fracking-induced minor earthquakes and land-stability issues
- environmental damage and pollution caused by many thousands of vehicle trips to gas wells to deliver water and chemicals, as well as surface spills and land clearing;
- competition and tension among alternative land uses, including farming;
- a new industry with many uncertainties and unknowns;
- large scale and significance of production projects;
- long production timeframes;
- cumulative impacts of multiple projects or wells and difficulty managing them;
- immature science, regulation, compliance and monitoring;
- weaknesses in public consultation;
- water issues managed outside normal water allocation processes; and
- piecemeal (partial) approval processes when a whole-of-landscape 'systems' approach is required.

This is a relatively long list of issues, however issues that are at least similar face all major mining and construction projects in Australia. Professor Simmons reported that "In general, there is an emerging consensus in international reports. They do record documented cases of environmental impact, including groundwater contamination and induced seismicity in other phases of the unconventional gas and oil production and development cycle, although these are more common in shale gas than in coal seam gas production".

The following breakout box (Simmons 2015) documents incidents that have been recorded in Texas. The incident rate (0.1 per cent of wells drilled in Texas) is low and are mostly associated with surface activities and waste disposal.

**INCIDENCE RATES**

**Groundwater Contamination**

Incident rates* for groundwater contamination calculated from data chiefly in US EPA (2015), Groundwater Protection Council (2012) and Texas Railroad Commission files (State oil and gas regulatory agency) (2015).

| | |
|---|---|
| Waste management and disposal | .0003 |
| Production and on-lease storage | .0003 |

| | |
|---|---|
| Casing failure | .0002 |
| Drilling and completion | .0003 |
| Fracking stimulation | 0 |
| Site development | 0 |
| Spillage of frack water and chemicals | 0 |
| Surface spill volume/volume of fluids handled | .0007 |
| Subsurface blowouts with possible leakage to subsurface | .0004 |

** Number of incidents of groundwater contamination per number of fractured wells drilled. This excludes the 57 legacy well incidents in the Texas/Ohio data set from US Groundwater Protection Council (2012) (see below).*

Data sets from the US Groundwater Protection Council (2012) are available for the incidence of groundwater contamination from oil and gas operations in states such as Texas (1993–2008) and Ohio (1983–2008). The Incident rate was .00179 – 396 incidents in drilling of 221,092 wells (85 per cent in Texas). It is estimated that 65 per cent of incidents occurred on the site of or associated with hydraulic fracturing.

*Principal Causes of incidents (percentage of incidents)*

- Waste management and disposal: 28 per cent (57 of 75 incidents from legacy wells with disposal sites that were outlawed in 1969)
- Production and on-lease storage and transport: 26 per cent
- Drilling and completion (including cement isolation problems): 22 per cent
- Orphan well-related: 18 per cent
- Casing failure: eight per cent
- Stimulation (including hydraulic fracturing): nil

*Note: more than one incident could occur on the one site.*

Water use and management are important parts of the unconventional gas production cycle. Water management includes the use of water injected and the flowback of the injected water as well as the produced waters from the fractured formation. Large volumes of water are typically produced. Increasing evidence suggests that improper handling of flowback and produced waters contributes to the majority of the environmental impacts in the hydraulic fracturing cycle.

Data from the US Groundwater Protection Council reveal a 90 per cent reduction in incidents from regulated wells in Ohio over the period 1983–2007 – presumably through increased regulation and compliance measures as well as improvements in technology, engineering, understanding, expertise and experience.

**Induced Seismicity**

Induced seismicity is caused mostly by change in pore fluid pressure in the subsurface in the presence of faults with specific properties and orientations. The factor that appears to have the most direct correlation in regard to induced seismicity is the net fluid balance – the total balance

of fluid introduced into or removed from the subsurface. A report by the US NRC in 2012 documented the incidence of induced seismicity in the US. Of 35,000 wells, there were eight induced seismicity events. The maximum magnitude of 'felt events' was 4.8 on the Richter Scale. It concluded that the re-injection of co-produced water into aquifers, and associated pore pressure increase, is the dominant mechanism – not the hydraulic fracturing phase of the production process.

## References

Darrah, T.H., Vengosh, A., Jackson, R.B., Warner, N.R. and Poreda, R.J. 2014. Noble Gases Identify the Mechanisms of Fugitive Gas Contamination in Drinking-Water Wells Overlying the Marcellus and Barnett Shales. Sept.15, 2014, Proceedings of the National Academy of Sciences, USA.

Department of Environment, 2014. Bore integrity, Background review, Commonwealth of Australia 2014.

Harrington N and Cook P, 2014, Groundwater in Australia, National Centre for Groundwater Research and Training, Australia.

Simmons, CT (2015) Massive challenges, but we must meet them, Focus – Journal of the Academy of Technology and Engineering, Australia

Selected Existing Resources

European Commission

https://ec.europa.eu/energy/sites/ener/files/documents/Study%20to%20support%20the%20definitio n%20of%20a%20CBA%20methodology%20for%20gas.pdf

https://ec.europa.eu/jrc/sites/default/files/reqno_jrc70481_unconventional_gas_potential_energy_market_impacts_in_the_european_union.pdf

https://ec.europa.eu/energy/sites/ener/files/documents/2012_unconventional_gas_in_europe.pdf

United States

http://www.rff.org/rff/documents/RFF-Rpt-StateofStateRegs_Report.pdf

http://www.rff.org/centers/energy_and_climate_economics/Pages/Shale_Maps.aspx#maps