South Australian Multiple Land Use Framework

'Response to South East Submissions'

Report

12 September 2016

SOUTH
AUSTRALIA

Government
of South Australia

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Contents

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1 Introduction

A draft *South Australian Multiple Land Use Framework* (draft Framework) was released for stakeholder engagement between 12 November 2015 and 18 December 2015[1]. In total, 58 submissions were received through the yourSAy website, by mail and email. 29 submissions supported the draft Framework while 20 submissions opposed the draft Framework. Nine submissions discussed specific topics but were unclear as to whether they supported or opposed the draft Framework.

Following stakeholder engagement, the cross-agency Reference Group prepared three reports in response to submissions received. The first, which was released on the yourSAy website on 8 April 2016 (yoursay.sa.gov.au/decisions/yoursay-engagements-south-australia-s-multiple-land-use-framework/outcome) was the '*What we heard*' Report. This report analysed the submissions, identified common themes and provided a selection of comments on each theme from submissions received; however, it did not address any of the questions or comments provided in submissions.

The '*Submission Recommendations and Response to Comments*' Report[2] summarises recommendations from submissions regarding proposed changes to the draft Framework and also provides responses to non-South East matters.

This report (the *'Response to South East Submissions'* Report) provides responses to the key questions and concerns raised by 12 submissions regarding fracture stimulation operations. Responses have been divided into various themes, which are outlined in sections 2.1 – 2.12 of this report.

2 Response to South East concerns

Of the 58 submissions received, 12 submissions raised numerous concerns about fracture stimulation in the South East, particularly in relation to possible impacts to aquifers, property values, tourism, employment, insurance, amenity, occupational health and safety, ability to farm, health of stock and the national vendor declaration as well as the efficacy of legislation and the government agencies that manage them. In light of the range of concerns raised in the submissions on these topics, this report has been prepared.

To date, no fracture stimulation has occurred in the South East, nor has there been any proposal received by the State Government for fracture stimulation in this region. Should a proposal be made, due process under the *Petroleum and Geothermal Energy Act 2000* (PG&E Act) will be followed, which

[1] *Note - 11 individuals/organisations sought and were offered time extensions to lodge their submissions in the New Year.*

[2] *Available to download from yoursay.sa.gov.au/decisions/yoursay-engagements-south-australia-s-multiple-land-use-framework/outcome*

includes a legislative requirement for the company to engage with the community, consider all submissions on the specific proposal and demonstrate how the risks will be minimised or avoided.

Many of the issues raised in the submissions relate to unconventional shallow coal seam gas exploration and production (commonly occurring in New South Wales, Queensland and in the US), which is an entirely different process, with potentially greater landscape impacts than the processes that currently occur in the Cooper Basin or would apply in the South East for exploration of deep shale and tight sandstone (should a proposal be lodged and considered by the State Government).

The State Government acknowledges there are risks and potential impacts associated with petroleum exploration and production activities including hydraulic fracturing, and this is one of the reasons the industry is well regulated, in order to ensure these risks are managed.

2.1 Stakeholder engagement

If a company proposes to undertake fracture stimulation, under the PG&E Act a comprehensive and extensive public consultation process is required to be undertaken, demonstrating how all potential risks to social, natural and economic environments can be managed to meet community expectations for net outcomes. This process requires extensive consultation with stakeholders including land owners, cultural heritage and native title groups, community groups and government agencies. This of course includes the management of potential risks to water resources.

The Department of State Development (DSD) carefully assesses each project application on its merits to ensure that only environmentally sustainable projects are granted land access. The State Government only considers granting approvals when community concerns have been adequately addressed, and all significant risks are effectively managed to protect:

- the natural environment (including the water resources of the region)
- social environments
- enterprises that are also land users.

As with drilling and well operations, it is an offence for any such activity, including fracture stimulation to cause aquifer contamination and adversely impact on land owners.

Under the PG&E Act, approval will only be granted once the community is adequately satisfied that all risks to the environment, other land users and the water resources are manageable. The PG&E Act also states that companies must make sure potentially affected people, enterprises and organisations are provided with all the relevant information necessary to reach informed views before any approvals can be made.

The development of an Environmental Impact Report (EIR[3]) and Statement of Environmental Objectives (SEO[4]) in accordance with the PG&E Act requirements provides all potentially affected stakeholders (including farmers, landholders, communities, environmental groups, traditional owners, including Aboriginal landholding bodies, native title holders and claimants, other Aboriginal organisations, concurrent licensees and more) with the right to be consulted and to raise any issues and concerns (including those associated with other uses of the land) well ahead of land access. In addition, the required notice of entry to land process provides opportunity for landowners (which incorporates many land users) to negotiate proper land access conditions and any commercial terms for such access, including compensation for: any deprivation or impairment of the use and enjoyment of the land; damage to the land; disturbance to business or other activity lawfully conducted on the land; and any consequential loss incurred as a result of the entry to land.

The notice of entry to land process provides the landowner with rights to dispute entry and to seek resolution on terms of entry through the Minister acting as a mediator (and by policy, through the appointment of a knowledgeable, independent and highly regarded person). As a last resort, failing to have this resolved to the satisfaction of both parties, the matter may be referred to the Warden's Court (the mining court).

The obligations for PG&E Act licence holders to compensate landowners underpin the position of power given to landowners (including farmers) under the PG&E Act. Strict monitoring, reporting and regular maintenance based upon recognised, leading-practice industry standards are imposed on licensees to demonstrate compliance with regulatory requirements.

It is an offence under several Acts in South Australia for any activities, including fracture stimulation operations, to cause aquifer contamination and adversely impact on potentially affected people, the natural ecosystems or enterprises. The significant penalties associated with these provisions provide strong drivers for industry to prevent and avoid any contamination, regardless of the PG&E Act application process.

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[3] *An Environmental Impact Report documents and assesses all potential risks from proposed activities in any project.*

[4] *The SEO outlines the objectives to meet with respect to different aspects of the environment, how potential impacts will be avoided or managed, and how achievement of compliance with the objectives will be assessed and measured (www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance). The SEO must be prepared with consultation from stakeholders to ensure that concerns raised are adequately addressed.*

2.2 History of fracture stimulation operations in South Australia

Up to the end of 2015, 842 wells have been fracture stimulated in the South Australian portion of the Cooper Basin with no evidence of adverse impacts on aquifers within the Great Artesian Basin and other shallower aquifers. Fracture stimulation has been safely used in both conventional and unconventional wells in South Australia's Cooper Basin since 1969.

International evidence and the experience in South Australia since 1969 demonstrate that fracture stimulation can occur in our oil and gas fields without harm to social, natural and economic environments.

Successive State Governments and their co-regulatory agencies have concluded that these historical activities have been successfully undertaken with no significant impact on the environment or other land users.

2.3 Deep unconventional gas versus coal seam gas

It is important to understand the difference between operations to develop natural gas from unconventional shallow coal seam gas (CSG) reservoirs in Queensland and New South Wales (which have stirred community concern in the South East of South Australia) and the operations used to develop natural gas in deeply buried unconventional shale, siltstone, and tight (low permeability) sandstone reservoirs in South Australia (including the South East).

Shallow CSG is very different to the deep unconventional gas resources that have been targeted in the South East of South Australia. In general, shallow CSG resources are prone to be near shallow, multiple-use water resources at depths less than 1,000 metres below surface, with only 5-10% of the wells requiring fracture stimulation. In general, shallow CSG reservoirs need first to be dewatered before water-free gas will flow from the coal seam to enable commercial gas production. Dewatering entails a range of volumes of groundwater being produced as a by production of petroleum and mining operations that is required to be managed in environmentally sustainable ways. The management of water produced from CSG reservoirs can result in fresh water supplies being made available for multiple use, the water being safely injected back into the aquifers or allowed to evaporate within fenced-off and lined ponds. Please refer to sections 2.4 – 2.5 of this report for further information on the regulatory framework and risk assessment and management.

All forms of managing water production from coal seams are required to protect air, soil and groundwater from contamination. Deep gas trapped in unconventional reservoirs in South Australia are generally at depths greater than 2,500 metres below surface and conceptually require fracture stimulation to produce natural gas at commercial flow rates of gas. Restricting fracture stimulation to gas-saturated unconventional reservoirs can be expected to result in little co-production (with gas) of associated (deep-sourced) formation water.

Shallow potable aquifers of the Gambier Limestone and Dilwyn Formation in the South East of South Australia are generally at depths no more than 500 metres below surface and hence, well above and segregated from deeper (>2,500 metres) formations that that are targeted for natural gas in unconventional reservoirs.

The main sealing units in the Limestone Coast are the Eumeralla Formation, Laira Formation and upper Sawpit Shale, which in total provide approximately 2,000 metres of separation (including natural impermeable barriers) from the aquifer units, which prevents natural upwards migration of fluids and gases.

The exploration for, and production of natural gas in unconventional reservoirs in the South East does not include (nor is it expected to include) shallow coal seam gas (CSG) because no such shallow CSG resources are recognised as prospective for gas production in the South East. Shallow CSG typically involves a large number of shallow wells drilled in a semi-grid like pattern and connected by gas gathering flow-lines, and hence may raise community concerns about the aesthetics of the area, tourism impacts, impacts on housing prices and difficulties created for surface logistics for pre-existing or future alternative land use – including agricultural land use (due to the high density of land disturbance due to extraction wells).

Significantly fewer surface drilling locations and gas gathering flow-lines are required to produce natural gas from high pressure, deep gas resources (as targeted in the South East), as compared to requirements to produce from low pressure, shallow CSG resources.

Also, multiple wells can be drilled from a single drilling pad into a deep natural gas resources, greatly reducing the surface footprint of production wells and associated gas gathering flowlines and pipelines. It is expected that, if developed in the South East, the footprint for the development of natural gas in deep unconventional reservoirs would be similar to that previously used for production of natural gas from conventional reservoirs at Katnook with up to tens of development wells drilled from multi-well pads.

Any natural gas or oil exploration or production well is always only a temporary land use, as each well has a limited production life after which the land can be restored to pre-existing or future alternative land-use, including agricultural land use. Previous petroleum production activities in the South East at Katnook Gas Field and the Ladbroke Grove Gas Field have been conducted in compatible, contemporaneous co-existence with various agricultural activities without deleterious effects.

2.4 Regulatory framework

In the South East of South Australia there has been no fracture stimulation to date, nor has there been any proposal to government for fracture stimulation in this region of the state. Should a proposal be made, the process pursuant to the PG&E Act will be followed to demonstrate how all significant risks will be avoided (including those identified through public consultation required under the PG&E Act) and how community concerns will be effectively managed. Only after the due process of the PG&E Act is complete (including public consultation and considering all input from co-regulators) will a determination be made to preclude or allow leading practice fracture stimulation to be undertaken in the South East.

The existing regulatory framework for upstream petroleum industry in South Australia, administered by DSD through the PG&E Act, continues to ensure the protection of natural, social and economic environments, including public health. Further information on guidelines and policies can be found at www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance/guidelines_and_policy.

DSD regulates in close consultation and under existing administrative arrangements with Department of Environment, Water and Natural Resources (DEWNR) and the Environment Protection Authority (EPA), PIRSA, SA Health and Safework SA. All activities regulated under the PG&E Act are also subject to the provisions of other state environmental regulation such as the *National Parks and Wildlife Act 1972*; the *Natural Resources Management (NRM) Act 2004*; the *Work, Health and Safety Act 2012*; the *Environment Protection Act 1999; Dangerous Substance Act 1979* and its regulations; *Dangerous Substances Regulations 2002* and *Dangerous Substances (Dangerous Goods Transport) Regulations 2008*. This in turn creates another layer of protection in addition to the best practice regulatory regime under the PG&E Act and in cases of proposed mineral development, the *Mining Act 1971* (Mining Act).

Assessments for the development of South Australia's natural energy and mineral resources are informed by technically competent and experienced regulators using the best available science and engineering information with the aim of ensuring only environmentally sustainable projects are provided with land access. In other words, where a project cannot demonstrate that it can be undertaken in a manner which will comply with the regulatory requirements (i.e. to be environmentally sustainable) then approval for that project will not be granted.

2.4.1 Petroleum Geothermal and Energy Act

The PG&E Act forms the one window to government for the industry, through the SEO as a regulatory instrument under the Act. The requirements of other relevant Acts are incorporated into DSD's approval and compliance monitoring processes.

The protection of the environment is a very high priority for all South Australians. The PG&E Act defines the environment to include:

- land, air, water (including both surface and underground water), organisms and ecosystems
- buildings, structures and cultural artefacts
- productive capacity or potential
- external manifestations of socials and economic life
- the amenity values of an area.

The definition of environment is consistent with the *Environment Protection Act 1993* definition, and is broad to ensure that potential impacts on all natural, social and economic aspects of the environment are identified, considered, and appropriately addressed through the environmental assessment and approval provisions of the PG&E Act.

Therefore if local road infrastructure was identified as potentially inadequate for the level of traffic expected associated with an activity, or damage to roads was a potential impact, these would need to be considered and addressed by the licensee in the EIR and SEO.

The role of the regulators who administer the PG&E Act and relevant co-regulations is to provide assurance to the community that the design and execution of regulated activities will achieve the approved objectives of the relevant SEO. The aim of all forms of relevant co-regulation, and the aim of all of PG&E Act processes are to foster the utmost trust that the combination of robust co-regulatory processes provide necessary safeguards from any potential risks associated with activities regulated under the PG&E Act, including all unconventional gas operations.

The current South Australian petroleum regulatory framework has recently been endorsed as one of the top three resource regulatory regimes in the world by international mining and energy law expert Dr. Tina Hunter for shale and tight gas. Dr. Hunter has been quoted that it was one of only three – Western Australia, South Australia and the UK's Department of Energy and Climate Change - that she recognized as competent regulators:

"In my view they are professional and have the necessary experience and processes to implement best practice in the regulation of unconventional natural gas".

2.4.2 Mining Act

The key objectives of the Mining Act is to regulate and ensure compliance with the exploration and mining of the state's mineral resources, in a manner that seeks environmental excellence, land access and community engagement and economic growth. COAG has agreed that all governments will ensure that regulatory processes in their jurisdiction are consistent with the following principles:

- triple bottom line assessment
- sustainable legislation
- effective consultation with stakeholders
- proportionate government actions.

The Mining Act underwent a major review in 2010, with amendments commencing on 1 July 2011. The amendments ensure the Mining Act is consistent with these COAG principles. The review of the Mining Act also brought in performance (or risk) based regulation and a range of new compliance tools to achieve leading practice regulation (www.minerals.statedevelopment.sa.gov.au/exploration/exploration_activities).

2.4.3 Role of the EPA

The EPA regulates off site activities associated with exploration under the *Environment Protection Act 1993*, for example the transport of waste from the lease site against waste transport and disposal requirements. The *Environment Protection Act 1993* and its associated policies applies to companies or individuals undertaking petroleum production activities.

The EPA works with DSD to provide advice through their SEO and EIR process and is listed as a mandatory referral agency within the Petroleum and Geothermal Energy Regulations 2000.

Based on identified environmental risks of proposed activities, proposals are reviewed by EPA technical experts in the fields of water quality, air quality, waste, radiation or site contamination. Assessment of the environmental risks associated with the activities, and the appropriateness of the proposed mitigation measures are considered. Advice is then provided to DSD for consideration and inclusion in the proposal.

Above certain thresholds, an authorisation (licence) from the EPA is required to undertake activities. These thresholds are set out in Schedule 1 of the *Environment Protection Act 1993* – categories that may be applicable are:

- petroleum production or storage
- discharges to marine or inland waters
- chemical works and chemical storage facilities
- waste or recycling depots
- fuel burning.

This licence sets conditions under which the company is permitted to undertake their activities. These conditions may include monitoring and reporting requirements, based on the environmental risk associated with the activities being undertaken.

It is important to note that if a company or individual does not meet these threshold criteria, they are still required to meet the requirements of the relevant Environment Protection Policies, the General Environmental Duty (Section 25 of the Act) and other requirements such as incident notification requirements. In addition, the general offences under the Act (with maximum penalties of $2m for actual / potential serious environmental harm) apply.

DSD and EPA meet regularly to ensure that regulatory approaches are effective and efficient. In contrast to interstate regulatory processes, the PG&E Act mandates a clear role for early public participation and engagement in identifying potential risk of a proposed activity, and the environmental outcomes to be achieved set by the government in approving an SEO. In addition, public reporting on compliance is required under the PG&E Act.

2.5 Risk assessment and management

The objectives of the PG&E Act and Mining Act and their Regulations are to ensure that all risks to the health and safety of the community and to the natural, social and economic environments are either completely avoided, or managed and reduced to a level that is as low as reasonably practicable and acceptable to the community.

To date in South Australia, potential residual risks of fracture stimulation have been determined to be low risks in relation to the necessary protection of social, natural and economic environments. However, industry deploys leading practice risk control measures as per legislative requirements and as part of their operations, will assess the potential risks in relation to local circumstances.

Experience in the fracture stimulation of more than 840 wells in the Cooper Basin in South Australia has enabled a clear general understanding of potential residual risks associated with fracture stimulation. A non-inclusive list of potentially affected social, natural and economic environmental factors follows and is discussed in the proceeding sections of this report:

- impacts on:
    - water resources
    - soil
    - native vegetation and native fauna
    - potentially affected enterprises
    - landscape and heritage features
    - air
    - the health[5] and wellbeing (including traffic and noise) of potentially affected people and enterprises.

The Environmental Impact Report (EIR), approved SEO and approved State Government Environmental Impact Classification (Significance Test) for fracture stimulation in the Cooper Basin in South Australia (www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance/environmental_register) provide a guide to the assessment and management controls required to reduce the above-listed risks to acceptable residual risks for fracture stimulation in the Cooper Basin.

The State Government acknowledges there are risks and potential impacts associated with petroleum exploration and production activities including hydraulic fracturing, and this is one of the reasons the industry is regulated to ensure these risks are properly managed.

[5] *A Health SA's Health Impact Assessment is part of developing an Environmental Impact Report and Statement of Environmental Objectives.*

Risk assessment as required under the PG&E Act is a rigorous process[6] that considers both the probability of an adverse impact event occurring and the consequence of that event (which may be trivial or significant). Possible impact events consider the potential source (e.g. contaminant in chemicals used in fracture stimulation), the pathway or mechanism (e.g. surface spillage) that may lead to impact on a receptor (e.g. users of the near surface aquifer, etc.).

The impacts that are addressed through regulatory processes focus on those that may have a significant consequence (i.e. those that may impact other users of natural resources, or ecological communities) and those that require regulatory control (i.e. those that require the proponent to put in place an engineered control mechanism). Where there is significant uncertainty in a particular risk (either due to significant uncertainly in the probability or consequence), a precautionary approach applies.

Some controlled and uncontrolled risks perceived by individuals may be of such low probability or low consequence as to be not a credible significant risk based on known science and/or engineering data – either controlled or uncontrolled in the context of leading practice risk management processes and technologies.

Regulatory standards are and will be set based on evidentiary science and necessary engineering capabilities that are appropriately proportionate to the potential risk, and will be reviewed with experience. The effectiveness of mitigation strategies needs be demonstrated for widespread deployment. Trials of prospective, evolutionary risk mitigation are restricted to locations where receptors to risk are minimal while measurement and monitoring are deployed to establish the efficacy of innovative risk management processes and technologies. Further information on fracture stimulation, risks and their management is provided in section 2.8 of this report.

2.6 Water use and management

The draft Framework does not have the power or the ability to allow changes to current water allocations or regional natural resources management plans.

Water use must be taken in accordance with principles set out in the relevant regional natural resource management plan and water allocation plan. In the South East, the Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area (www.naturalresources.sa.gov.au/southeast/water-and-coast/water-allocation-plans/lower-limestone-coast):

- protects the water resource
- establishes the rules for managing, taking and using prescribed water
- provides security and equity to users

[6] *Refer to AS/NZS standard 31000:2009* Risk Management – Principles and guidelines *for an outline of this process (note ISO 31000:2009 supersedes AS/NZS 4360:2004).*

- balance the capacity and sustainability of the region's water resources and the needs of the environment
- takes into account any potentially detrimental effects on the quality or quantity of water resources from taking or using water
- identifies how water will be allocated and the amount of water available for allocation.

Water allocation plans provide the Minister for Sustainability, Environment and Conservation the ability (among other things) to grant allocations from the confined aquifer for the purpose of petroleum and carbon dioxide production. However, the water allocation plan limits this allocation to water taken as a byproduct of petroleum or carbon dioxide production (known as co-produced water or produced formation water). Water used in unconventional gas production, including for the drilling process or for use in fracture stimulation, is not co-produced water.

No water is available for allocation from the unconfined aquifer in the Lower Limestone Coast Prescribed Wells Area for the purpose of petroleum production, nor can a new allocation be issued by the Minister under the Lower Limestone Coast Water Allocation Plan for the purpose of petroleum production for water that is not co-produced water from the confined aquifer. Where no water is available for allocation for the purposes proposed, in prescribed areas, the proponent will need to purchase a water allocation from another licensee, subject to any requirements of the relevant water allocation plan, including hydrogeological assessment.

In addition, authorisations to take water for a particular purpose without a licence can be granted by the Minister for Sustainability, Environment and Conservation under section 128 of the *Natural Resources Management Act 2004*. For the purposes of petroleum exploration only, there is currently a state-wide Ministerial authorisation in place.

Volumes of water required to be taken for petroleum exploration are minimal and will not impact on the availability of water for other users. An exploration well has a 'one-off' requirement of 1 to 2 megalitres of water in total, depending on the depth of the drill. The water is used mostly for making up fluid (mud) used in the well drilling and cement used in the well casing process. Similarly, water used to drill a water well for irrigation does not require a water licence. Other exploration water needs may include camp services, pump testing, and fracture stimulation that is part of the exploration process.

For these reasons, the taking of water for petroleum exploration anywhere in the state is authorised without a licence, under section 128 of the *Natural Resources Management Act 2004*. In the case of fracture stimulation activities, about 1 megalitre per stimulation stage (i.e. fracture stimulated zone) is required. Typically in Australia, a single, vertical exploration well program for fracture stimulation entails an average of 4 stages (thus, 4 megalitres of water). This equates to about two Olympic swimming pools or the volume required to produce 4.3 tonnes of wheat.

More stages are typical in horizontal production wells. For example, a US horizontal shale well on average will use ~15 megalitres of water[7]. Between 15-50% of the fracture stimulation fluid tends to be recovered during flow-back and as produced waters[8]. The fracture stimulation fluid that is flowed back is contained in fenced-in or otherwise isolated lined ponds for evaporation or collected in the gathering system for appropriate disposal at an approved offsite location.

As part of petroleum development, companies must use water sources in ways that minimise all negative impact on other water users, including water required for agricultural and environmental needs.

2.7 Baseline studies

Prior to any well operations being undertaken such as fracture stimulation, appropriate baseline studies must be undertaken. As part of these baseline studies the existing overall health of the environment needs to be evaluated. In relation to the South East region, the current widespread impacts on the shallow unconfined aquifers (Gambier Limestone) from longstanding industries and agricultural practices will need to be identified and accounted for.

In the case of the South East, ensuring protection of the surface aquifers entails protection from both potential cross-flow from deep hydrocarbon reservoirs and any potential cross-flow between the unconfined aquifer and the deeper confined Dilwyn aquifer.

2.8 Fracture stimulation, risks and their management

Fracture stimulation is just one technology already well regulated under the PG&E Act that has been performed in this state safely, and without harm, over the last 45 years.

One submission questioned whether fracture stimulation activities were legal in South Australia as the PG&E Act did not mention the words ‘fracking’ or ‘hydraulic fracture stimulation’, nor a description of these activities. Section 10(3) of the PG&E Act defines regulated activities to include *‘all operations and activities reasonably necessary for, or incidental to, that activity’* and goes on to provide as an explicit example in section 10 (3)(c) *‘the injection of water or some other substance into a natural reservoir in order to enhance production of petroleum or another regulated substance’*. A *‘natural reservoir’* has been defined in the PG&E Act as a *‘part of a geological structure (including one that has been artificially modified) in which petroleum or some other regulated substance has accumulated; or which is suitable for the storage of petroleum or some other regulated substance.’*

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[7] *Engineering Energy: Unconventional Gas Production, Final Report: ACOLA, pg. 58*
acola.org.au/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf

[8] *Engineering Energy: Unconventional Gas Production, Final Report: ACOLA, pg. 57*
acola.org.au/PDF/SAF06FINAL/Final%20Report%20Engineering%20Energy%20June%202013.pdf

Fracture stimulation or hydraulic fracturing is a technology used in the exploration and production of petroleum and other regulated resources under the PG&E Act and as such is a regulated activity under the Act.

Risks and their management

The main potentially significant risks of contamination of aquifers associated with fracture stimulation that are additional to conventional drilling are:

- significant cross-flow of fracture stimulation fluids, oil and/or gas (including methane) or deep saline groundwater to shallow potable aquifers due to inadequate well construction
- significant release of fracture stimulation fluids and chemicals to potable surface aquifers due to a spill or breach at the surface leading to downward leakage
- worker exposure to chemicals and silica used in the fracture stimulation process.

In general, these risks are similar to those of managing conventional drilling and production activities, and are addressed in the existing approved EIR and SEO.

Based on current technology and geological data (including thousands of metres of sealing rock between these aquifers and the potential petroleum reservoir fracture stimulation targets), the risk of fracture propagation at depths below 2,500 metres leading to fracture stimulation fluids contaminating shallow aquifers is unrealistic.

Research into petroleum field development led by Durham University in the UK[9] indicates that there is a less than 1 per cent chance of a stimulated fracture propagating upwards for more than 350 metres, and that the maximum recorded distance of such a stimulated fracture is less than 600 metres. These figures have been confirmed by data from the Cooper Basin in South Australia. Fracture stimulation design will dictate the actual vertical and horizontal extent of fracture propagation in the specific case, dependent on the rock characteristics at the specific location, but will always be within these maximum possible engineering limits.

The small volumes of chemical that remain in the fracture stimulated reservoirs cannot realistically migrate upwards to aquifers used by people and industries from the fracture stimulated intervals due to many overlying natural aquitards and low permeability rocks adjacent to, but unaffected by the fracture stimulation. Hence, the small volumes of chemicals pumped into, and not flowed back from fracture stimulated intervals are expected to remain in the fracture stimulated petroleum reservoirs indefinitely.

In South Australia, recognised, leading-practice, industry standards are used for all upstream petroleum operations, in order to manage all potential risks in ways that meet community expectations for

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[9] *"Hydraulic fractures: How far can they go?" Richard J Davies, Simon Mathias, Jennifer Moss, Steinar Hustoft and Leo Newport, Marine and Petroleum Geology (November 2012)*

outcomes. No petroleum projects are allowed to commence unless it can be demonstrated to regulatory authorities that these standards can and will be met.

2.8.1 Aquifers

Overall, the risks of contamination of aquifers by fluids (whether they be drilling or fracture stimulation fluids) will predictably be very low, given the small volumes of chemicals used compared to the large volumes of water present in the aquifer, and most importantly, the multiple engineered containment barriers between the chemicals and the aquifer that prevent any significant contamination from occurring. Water and sand make up around 97 to 99 per cent of the fracture stimulation fluid. Added chemicals make up about 1 to 3 per cent. Fracture stimulation fluid mixtures are designed to be compatible and toxicologically safe for use in the petroleum-saturated reservoirs that constitute the fracture stimulation targets.

2.8.2 Fracture stimulation additives

Guar gum or similar substances that modify the viscosity (thickness) of water and other chemical additives are added in low concentration to enable proppants, typically sand or ceramic beads, to be carried from the surface to the underground zone to 'prop' the newly created fractures open and prevent them from closing up after pressure is released. This allows gas otherwise trapped in the unconventional reservoir to flow through the induced fracture system to the production well.

Some commonly used chemical additives, and their uses, include[10]:

- guar gum (a food thickening agent) used to create a gel that transports sand through the fracture
- bactericides, such as sodium hypochlorite (pool chlorine) and sodium hydroxide (used to make soap), used to prevent bacterial growth that contaminates gas and restricts gas flow
- 'breakers', such as ammonium persulfate (used in hair bleach), that dissolve hydraulic fracturing gels so those gels do not impede the flow of water and gas
- surfactants, such as ethanol and (cleaning agent) orange oil, used to increase fluid recovery from the fracture by reducing surface tension
- acids and alkalis, such as acetic acid (vinegar) and sodium carbonate (washing soda) to control the acid balance of the fracture stimulation fluid.

A full list of fracture stimulation additives and their chemical constituents used in South Australia's Cooper Basin are publicly available within the Environmental Impact Report for

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[10] *From the CSIRO's What is hydraulic fracturing. Download from: www.csiro.au/en/Research/Energy/Hydraulic-fracturing/a-What-is-hydraulic-fracturing*

Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin)[11].

Just as for many substances commonly used for industrial and domestic purposes, several of the additives in the fracturing fluids (particularly biocides) at concentrations of transport and just after mixing, before degraded and/or further diluted (for example in a petroleum reservoir or a swimming pool) have relatively high toxicity. The State Government is committed to best practice regulation of the chemicals to ensure the protection of the environment.

The avoidance of a release or spill is a standard objective of regulation for the transport and handling of all hazardous substances in the state. Waste water disposal is regulated to avoid the following potential risks associated with all industrial and domestic activities, including oil and gas operations:

- discharge of contaminated waters into waterways
- delivery to unsuitable treatment works
- spills due to improper surface handling of wastewater
- salt waste – a by-product of water treatment and salt recovery processes – that may also create a concentrated salt waste stream, which can present an important waste disposal issue, particularly in arid landscapes that are already sensitive to salt load.

2.8.3 Chemicals and human health

The objectives of the PG&E Act and its Regulations are to ensure that all risks to the health and safety of the community and to the environment are either completely avoided, or managed and reduced to a level that is as low as reasonably practicable and acceptable to the community. Potential health impacts to both employees and adjacent communities must be managed effectively and the SEO process seeks to adequately address such risks prior to any approval being granted.

The following extract from a standard SEO illustrates typical provisions for addressing health and safety risks in accordance with the PG&E Act.

[11] *Listing of fracturing additives and constituents provided in Appendix A of the Environmental Impact Report for Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia: www.beachenergy.com.au/IRM/Company/ShowPage.aspx?CategoryId=190&CPID=2937&EID=75598299*

Environmental objectives	Assessment criteria	Guide to how objectives can be achieved
Minimise air pollution and greenhouse gas emissions.	No reasonable stakeholder complaint left unresolved. No unplanned gas releases. Well production diverted to flare as soon as practicable. Well testing curtailed when test objectives are satisfied.	Equipment operated and maintained in accordance with manufacturer specifications. Well flow-back diverted to separator as soon as practicable to minimise gas not being recovered and sent to flare. Flaring during production testing kept to minimum length of time necessary to establish resource and production parameters. Options to connect to gathering network investigated once initial testing is complete and longer term testing is required for reserve definition. Dust control measures (e.g. water spraying) implemented if dust generation becomes a problem e.g. near sensitive sites. Appropriate emergency response procedures are in place for the case of a gas leak. Monitoring of well parameters during testing operations to check for fugitive emissions at the wellbore.
Minimise risks to the safety of the public, employees and other third parties.	Reasonable measures implemented to ensure no injuries or health risks as a result of the activities.	**Fracture stimulation activity** All employees and contractor personnel complete a safety induction prior to commencement of work in the field. All employees and contractor personnel undertake a regular refresher induction. Signage in place to warn third parties of access restrictions to operational areas, with particular warnings when potentially dangerous operations are being undertaken. Contractor equipment has valid certifications, is properly secured and pressure tested prior to commencement of stimulation at each site and trip systems are installed to shut off stimulation pumping

units if pre-set operational maximum pressure is reached.

All appropriate PPE (personnel protective equipment) is issued and available as required in accordance with company operating requirements and applicable standards.

Monitoring undertaken to confirm / ensure that levels of radioactivity are within acceptable limits.

Safety management plans prepared as required for the activity. Permit to work systems in place for staff and contractors as required.

Effective Emergency Response Plan (ERP) and procedures are in place.

Traffic and journey management procedures followed.

General area

Speed restrictions and appropriate signage to reduce speed and increase awareness of hazards for public, employees and third parties.

Fire and Emergency Services Act requirements complied with (e.g. permits for 'hot work' on total fire ban days).

Fire-fighting equipment available as appropriate for location and use.

2.8.4 Prevention of potential contamination of shallow, potable aquifers

The key to preventing potential contamination of shallow, potable aquifers are good industry practices[12] as deployed for all petroleum well construction targeting oil and/or gas in both conventional and unconventional reservoirs in South Australia. Such practices are required by stringently enforced regulations in South Australia by ensuring:

- wells are designed and constructed in accordance with relevant industry standards to meet pressure, temperature, operational stresses and loads
- aquifers are isolated behind multiple casing strings and a competent cement bond and placement is demonstrated
- monitoring programs are implemented (e.g. well logs, pressure measurements, casing integrity measurements and corrosion monitoring) to assess the condition of casing and potential for any cross-flow behind casing
- monitoring of existing bores in close proximity to assess changes in water quality
- if cross-flow is detected, appropriate remediation is undertaken promptly
- isolation barriers are set in place in accordance with applicable standards for the decommissioning of petroleum wells to ensure that cross-flow does not occur
- all fuel, oil and chemicals are stored and bunded in accordance with relevant standards
- adequate spill response/contingency plan in place to ensure any appropriate remedial action is undertaken promptly.

Approval of a comprehensive on-site chemical safety management plan (addressing transport, storage, use and waste) is required before any proposed fracture stimulation would be approved to prevent impacts to workers, the public and the environment. This would include consideration of all chemicals to be used and their potential cumulative toxicity, as is the case for the use of potentially hazardous substances by any industry.

In all cases with good well design, construction and maintenance, the risk of significant (i.e. has an impact on landowners) crossflow between the stimulated reservoir and aquifers can be avoided. In addition, with good work practices all chemicals will also be contained at the surface and disposed of appropriately.

The potential risk of an uncontrolled flow from a petroleum well is globally well managed, and is a rare event worldwide. Further information can be found in specific EIR and SEO documents, publicly available on the DSD website

[12] *More efficient and effective technologies and methodologies are constantly being pursued by the upstream petroleum sector. "Edible" fracture stimulation fluids (Halliburton's "CleanStim" fluid, which uses ingredients utilized in the food industry) and Halliburton's self-healing cement (cements that can self-heal behind pipe to reduce the potential for cross-flow) are two such recent innovations.*

(www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance/environmental_register).

2.8.5 Well construction

Wells are designed to have multiple layers of steel casing and engineered cement that form a continuous barrier between the well and surrounding rock. Casing and cement are pressure tested for leak-tightness prior to taking further steps in well construction. Cement integrity evaluation tools are used to assess the cement bond to confirm long term integrity of the well construction. This process, which is the subject of continuous innovation by industry, is heavily regulated by DSD and requires that operators adhere to the highest well design standards, including ongoing monitoring of the integrity of each barrier (casing strings) within the well bore. The requirements of DSD are consistent with and in many cases exceed globally recognised best industry practice.

The Information Paper on Abandoned Wells[13] from the NSW Chief Scientist's Independent Review of Coal Seam Gas Activities in NSW states that:

"Cement is a critical component of well construction and thus cementing is a fully designed and engineered process. Cement is used in casing at the time of well construction, in addition to plugging at the time of well abandonment, and less commonly to address production or perforation issues. Cement used for plugging has the purpose of providing zonal isolation, preventing fluid from flowing within the well. Cementing a well casing has two main purposes: to provide zonal isolation between formations and to provide structural support to the well. According to the API (Australian Petroleum Industry), "cement is fundamental in maintaining integrity throughout the life of the well".

"Cementing practice and design has decades of research to underpin it. Special formulations and additives are available to customise cement to individual well conditions, including increased resistance to gas migration, naturally occurring chemical ions, low pH environments, carbon dioxide (CO2), high temperatures, sulphate, and mineral acids. Designs may call for using different cements for casing than for plugging a well. Poor cement jobs, which may result in well integrity failure and potential leaks, are influenced by three main problems: failure to bring the cement top high enough, failure to surround the casing completely with cement, and gas migration in the cement during cement setting. All of these problems can be mitigated through proper cement design and competent execution. Cement is a strong, durable, very long-lasting barrier as long as it is mixed and placed properly".

[13] *www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0009/56925/141002-Final-Abandoned-Well-report.pdf*

The importance of well integrity as a barrier for containment is highlighted by one study[14] that assessed water samples from drinking water bores overlying the Marcellus and Barnett shales in the US. While most samples were found to be gas-rich from natural processes, there were cases where fugitive gas contamination was identified due to an increase in gas contamination over time. Where fugitive gas contamination occurred it was found that leakage was due to poor well integrity (i.e. issues with casing or cement). The data in the study rules out that fracture stimulation or horizontal drilling has created a conduit to connect the deep shale formations to surface aquifers.

Furthermore, the New York State Department of Environmental Conservation in their draft Environmental Impact Statement for horizontal drilling and fracture stimulation[15] demonstrates through their own research that *"no significant adverse impact to water resources is likely to occur due to underground vertical migration of fracturing fluids through the shale formations."*

2.8.6 Risk of well integrity failure

Well integrity failures (loss of fluid containment) are infrequent events. Nonetheless, regulations in South Australia require risk management to both avoid well integrity failures and the monitoring of petroleum wells to enable the detection of leaks within, or from wells at an early stage, before any significant harm is done to surface or adjacent subsurface water resources, air, soil, people or enterprises.

Like most life experiences there is no such thing as zero risk. For example - our use of motor vehicles is made as safe as practical, to meet community expectations for net outcomes. While *"the probability of well failure is low for a single well if it is designed, constructed and abandoned according to best practice"*[16] (1:25,000) throughout the history of well construction and operations, there have been documented failures of casing and cement behind casing.

However, in all documented cases the failures have mainly been attributed to poor coverage of cement (preventable mishaps) within the annulus or annuli between various casing strings, and in some cases between the casing string and the formation that was intended to be isolated. Where industry best practice is applied, *"worldwide industry experience in both conventional*

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[14] *Darrah, T. H., Vengosh, A., Jackson, R. B., Warner, N. R., Poreda, R. J., Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales, PNAS 2014* *www.pnas.org/content/early/2014/09/12/1322107111*

[15] *www.rnrf.org/rrj/featured/nystate.pdf*

[16] *Royal Society & Royal Academy of Engineering, 2012. Shale gas extraction in the UK: a review of hydraulic fracturing. London: The Royal Society and The Royal Academy of Engineering.* *www.raeng.org.uk/publications/reports?q=shale%20gas%20extraction*

and unconventional petroleum resources suggests that well integrity failures are low for both active and abandoned wells".[17]

Not all well integrity failure events pose even theoretical risks to water resources, air, soil, people or enterprises. Some infrequent instances of the failure of internal casing, or the failure of production tubing within other cemented casing, only results in leaks within the well e.g. the well remains under control, neither leaking into surrounding rocks, nor leaking at surface.

It is a requirement under company Well Integrity Management Plans to monitor for events and to respond accordingly when detected. The company must first identify the source of the leak, and depending on the level of risk, may initiate necessary remedial action. In South Australia, DSD requires licensees to report casing pressure monitoring on a quarterly basis demonstrating the integrity of all casing strings including the internal tubing, through which gas is produced to the surface. Licensees also must demonstrate the risk level of any wells found to have abnormal pressure readings and submit activity notifications for remedial action that may be required on wells with an unacceptable risk rating.

There is no evidence to date that suggests fracture stimulation activities here in Australia have led to any serious environmental contamination, harm to the surface and subsurface environments, or impacts to human health.

In North America there have been cases before the courts relating to incidents of contamination and in some cases alleged harm to human health as a result of petroleum related activities, including one case from fracture stimulation. Notwithstanding some of these cases have been disputed and/or subject to appeal, through good regulation ensuring implementation of recognised good industry practice, such incidents are avoidable. Studies and reviews undertaken have shown the risks associated with unconventional reservoir development are low through implementation of: proven well construction and fracture stimulation design; chemical storage; and monitoring techniques.

A study conducted in the US on the Environmental Risk Arising from Well-Construction Failure[18] found that the overall risk of groundwater pollution from a producing well is extremely low and individual barrier-failure rates and well-failure rates vary widely with type of well, geographical

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[17] *Davies, S. Almond, R. S. Ward, R. B. Jackson, C. Adams, F. Worrall, L. G. Herringshaw, J. G. Gluyas. (2014). Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation. Marine and Petroleum Geology, 56, 239-254. earth.stanford.edu/jacksonlab/sites/default/files/mpg2014.pdf*

[18] *Conclusions of Environmental Risk Arising from Well-Construction Failure—Differences Between Barrier and Well Failure, and Estimates of Failure Frequency Across Common Well Types, Locations, and Well Age George E. King, Apache Corporation, and Daniel E. King, WG Consulting Group (November 2013)*

location, and maintenance culture of the operator, as well as with the regulatory regime in place in the respective jurisdiction. The report found that:

- individual well-barrier element failure rates are often one to two orders of magnitude greater than well-integrity failures in which all barriers in a protection sequence fail and pollution can or does happen
- oil, gas, or injection wells have an overall leak frequency ranging from 0.005 to 0.03% of wells in service at this time; however, areas with older wells and surface facilities tend to have higher leak frequencies, while more-recent development areas (such as the Barnett shale in northeast Texas) have lower leak frequencies.

It has been demonstrated in the petroleum industry that, where deficient cement coverage in wells has been detected behind casing, with and without any risks of cross-flow (between rocks at different levels), remedial action can be taken effectively. There have been cases where remedial work known as cement squeezing has successfully isolated the zones behind exposed casing. In the very rare cases where hydrocarbon has entered aquifers, decontamination can be successfully achieved.

2.8.7 Well monitoring

All petroleum wells that are producing or cased and suspended must be monitored by the licensee (under the scrutiny of the state regulator) throughout the term of a license, and decommissioned upon relinquishment of the licence to demonstrate compliance with the regulatory requirements.

In order to ensure protection of potable aquifers and hence other land users' access to that water, the SEO requires that background sampling and analysis of aquifers are undertaken before drilling activities commence. Regular ongoing sampling is then undertaken at appropriate intervals to demonstrate that no contamination is occurring.

Furthermore, prior to the completion of the well, the SEO requires the licensee to demonstrate that cement integrity behind the casing is adequate and meets relevant industry requirements. This is most often achieved through the use of sonic cement bond log tools being run in the hole which measure the cement coverage behind the casing and more importantly the integrity of the cement bond. Operators monitor the containment of wells using high-tech monitoring tools during the fracture stimulation process and ongoing integrity testing.

Recognised industry best practice for facility integrity and safety must be adhered to in well design, construction, maintenance, and monitoring to ensure there will be no loss of containment that may result in contamination of the environment, including water supplies, soils, flora and fauna. In addition, a relentless pursuit of evermore efficient and effective technologies and methodologies is evidenced within the upstream petroleum sector. Edible fracture stimulation fluids and cements that can self-heal behind-pipe potential for cross-flow are two such recent innovations.

Licensees are accountable for consequences should a well failure occur and lead to a breach of the activities SEO, the Act or Regulations. Subject to the Minister's discretion the transfer of water bores from licensee to landowner can be arranged if both parties agree and the land owner is happy to take over liability for decommissioning. Petroleum wells cannot be transferred to landowners.

The licensee is responsible unless a well that is suitable for water production is formally and under an agreement with the landowner provided to the landowner for their use rather than being plugged and decommissioned. There is no requirement to monitor decommissioned wells in the long-term as cement plugs have been placed inside the well which prevent any loss of containment. Once a well is decommissioned the wellhead is cut off and the site rehabilitated in line with the surrounding environment. Further information on DSD's compliance and monitoring can be found at www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance/compliance_and_monitoring.

2.8.8 Flaring

Flaring may occur in the early stages of well production testing before the well is connected to local pipeline infrastructure. Typically the production testing to flare may last anywhere between a week and a few months. Impacts are managed in accordance with the relevant SEO objectives.

2.8.9 Recent drilling in the South East

Beach Energy recently drilled two deep exploration wells, (Jolly 1 and Bungaloo 1), both of which sought to confirm whether or not petroleum liquids rich gas in unconventional reservoirs are present in the lower Sawpit Shale and Casterton Formation between 2,800 and 3,600 metres depth below ground level. Operations in the drilling of Jolly 1 and Bungaloo 1 wells were managed in accordance with all regulations[19].

Beach Energy's exploration drilling comprised conventional oil and gas drilling operations which are routine in South Australia, with thousands of such wells drilled in the state, including over 110 petroleum wells already drilled in the South East of South Australia over the last century. Beach Energy's Jolly 1 is the deepest well in the South Australian Otway Basin and was drilled to 4026 metres. The potential risks relating to the exploration well operations stage of Beach

[19] *In response to concerns raised about drilling at Jolly 1, the drill pipe got stuck while drilling (which is not uncommon) and was subsequently sidetracked, as per standard petroleum practice.*

Energy's Otway Basin program have been adequately addressed through the environmental assessment and approval process under the PG&E Act culminating in the publicly disclosed EIR and approved SEO (www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance/environmental_register).

There were no reportable or serious incidents recorded as defined by the PG&E Act during operations of these two exploration wells. Annual reports for Beach Energy's activities on their tenements (PELs 494 and 495) can be reviewed at www.petroleum.statedevelopment.sa.gov.au/legislation_and_compliance/annual_reports.

In accordance with the requirements of the state's regulatory framework for all petroleum operations anywhere in South Australia, DSD will continue post-drill regulatory compliance audits for these two Beach Energy exploration wells as appropriate.

2.8.10 Lifespan of abandoned wells

The Information Paper on Abandoned wells from the NSW Chief Scientist's Independent Review of Coal Seam Gas Activities in NSW[20] notes the following about abandoned wells:

"While little data exists about the long-term durability (100 – 1000 years) of abandoned petroleum wells, other studies have been undertaken into the degradation of comparable wells that suggest sound integrity over a 1,000+ year period. Yamaguchi (et al) (2013) investigated the long-term corrosion behaviour of cement in abandoned wells under CO2 geological storage conditions by simulating the geochemical reactions between the cement seals over a simulated period of 1,000 years. While alteration of the cement seals was found after a period of time, the alteration length after 1,000 years was approximately one meter, leading to the conclusion that cement would be able to isolate CO2 and upper aquifers over the long-term."

"Cement plug integrity in CO2 subsurface storage was also looked at by Van der Kuip, Benefictus, Wildgust & Aiken (2011). Using estimates for degradation after 10,000 years they likewise came to similar conclusions stating that "mechanical integrity of cement plugs and the quality of its placement probably is of more significance than chemical degradation of properly placed abandonment plugs".

"It is important to note in the foregoing, that the literature on corrosion and cement degradation considers CO2 stored at high pressure to be more aggressive than methane. Therefore, a conclusion can be drawn that if wells are properly designed, installed and maintained, the risk of long-term leakage from CSG wells from both the casing and cement can be considered to be

[20] *www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0009/56925/141002-Final-Abandoned-Well-report.pdf*

minimal, although there is scope for additional research specifically to assess the impact of abandoned CSG wells over extended timeframes."

Although CSG is not the target of unconventional exploration in the South East, the same conclusion can be drawn for the long-term abandonment of unconventional wells in a downhole environment that is of lower pressure (as gas has been depleted from the unconventional reservoir) and less aggressive (methane is not as reactive as carbon dioxide (CO2)).

2.9 Management of a specific abandoned well in the South East

Three submissions discussed a particular abandoned well on a property in the South East, drilled by Australian Groundwater Consultants for Western Mining Incorporated in 1982. The well in question was drilled 20 metres into the unconfined aquifer as an observation well and following exploration was transferred to the landowner, without it being fully decommissioned.

In mid-2013, the owner of the property advised the State Government of the poor condition of the well and government officers attended the property to inspect it. The responsibility for decommissioning of wells rests with the land owner (as outlined in section 144 of the *Natural Resources Management Act 2004*). However, given the circumstances that led to the well being transferred to the land owner and the unsafe and unacceptable condition of the well, the former Department of Manufacturing, Innovation, Trade, Resources and Innovation (DMITRE, now DSD) agreed as a once off, good will gesture, to fully fund the decommissioning of the well. The well was decommissioned in December 2013.

The well in question was never used for or intended to be used for petroleum exploration or production and cannot be compared to current industry practices.

Since February 2014, DEWNR has included a mandatory condition on all water well construction permits requiring that any water wells incidental or ancillary to mining operations or regulated activities under the Mining Act or *Petroleum and Geothermal Energy Act 2000* (PG&E Act) must be decommissioned prior to the relinquishment of the lease or licence under the associated Acts, unless alternative formal arrangements can be made with the owner or occupier of the land on which the well is located subject to approval by the relevant Minister or the Minister's agent.

2.10 Earthquakes and fault lines

There is a thorough understanding of the microseismic activity associated with fracture stimulation in the petroleum industry. Drilling through faults is not new and is common practice in South Australia in the most actively explored basins in the state (e.g. the Cooper, Eromanga and Otway basins).

In accordance with good industry practice, faults are detected via geophysical surveys then drilled through, cased and cemented such that well integrity is maintained, and the environment protected. These practices were described through the consultation process for the Otway Basin Drilling SEO in relation to the risk of aquifer contamination as a result of all drilling, completion or production testing activities.

The PG&E Act and regulations require all potential environmental impacts for the particular activity in the particular location to be well documented and understood through the public EIR and standards for the outcomes to be achieved with respect to management of the activity to avoid and minimise any potential impacts to an acceptable level in the accompanying SEO. Further, should a licensee plan to conduct a particular activity, they must address the specific risks again through an activity notification process and for the case of natural fractures and faults in the vicinity of a proposed well location the potential risks associated with this would be assessed and avoided/managed at this stage prior to receiving activity approval or commencement.

Good-quality modern seismic coverage now exists over the offshore and most of the onshore parts of the basin has resulted in better understanding of the respective geology. Fracture stimulations are designed to fracture only the targeted petroleum-saturated reservoir formations; fracture stimulation operations generate microseismic events that can be recorded with sensitive listening tools and analysed with established scientific methods. Techniques such as micro-seismic are used to monitor fracture propagation during the stimulation process to confirm the fractures generated are as per the design. In addition, if earthquake risk is a reasonable risk relevant to an activity in an area this will need to be considered in the EIR and SEO and managed appropriately for the particular activity on a case by case basis as with all activities regulated under the PG&E Act.

Under the PG&E Act, many petroleum exploration and production activities have been approved and undertaken safely in the South East including geophysical exploration activities, drilling operations, gas pipelines, and the Katnook Gas Processing Facility. There have been over 110 petroleum wells drilled in the South East over the last 100 years, and there have been no leaks observed as a result of earthquakes in the area, nor have there been any cases of injuries or damage as a result of the very low level of seismicity related to fracture stimulation.

The results from one study[21], which assessed thousands of fracture treatments in US shale plays, showed that the largest microseismic event recorded had a measured magnitude of approximately 0.8. This is approximately 2000 times less energy than a magnitude 3.0 earthquake. The magnitude 3.0 earthquake is commonly used to describe deep earthquakes that can be felt at the surface, but still much smaller than an earthquake that could be damaging or harmful.

2.11 Livestock Production Assurance National Vendor Declaration

Five submissions referred to the Livestock Production Assurance National Vendor Declaration (LPA NVD) in relation of petroleum exploration and production in the South East.

Having petroleum wells or pipeline infrastructure in your region or on your property will not change how you complete your LPA NVD. The NVD requires the producer to only declare known or existing

[21] *Warpinski, N. R., Du, J., & Zimmer, U. (2012, January 1), Measurements of Hydraulic-Fracture-Induced Seismicity in Gas Shales, Society of Petroleum Engineers*

contamination events. Producers accredited under the LPA program are however responsible for undertaking a property risk assessment to ensure they are aware of any potential risks of contamination, and must take appropriate steps to manage any possible or known risks (this could include excluding stock from risk areas if necessary). Where activities change on the property, it is the producer's responsibility to update the property risk assessment, seeking input from third parties as required.

A licensee is responsible to address all valid impacts (including aquifer contamination), underpinned by considerable research on the natural, social and economic environment, and demonstrate to DSD that:

- all risks that will adversely affect other users of the land will be avoided
- all concerns from potentially affected people (including land owners, enterprises, cultural heritage and native title groups, community groups, and other government departments) have been adequately addressed.

Notwithstanding the low likelihood of contamination from modern petroleum practices, in accordance with existing SEOs, licensees are required to monitor the environment before, during and after operations for any change in background levels.

Furthermore, numerous pastoral leases and agricultural land in South Australia utilised for livestock continues to co-exist in areas where there is petroleum development, including the Cooper Basin in the far north and the Otway Basin in the South East of South Australia.

2.12 Insurance

The Notice of Entry provisions under Part 10 of the PG&E Act provide for advance notice of any operations and for defined compensation factors between the land owner and licensee.

Furthermore, under the PG&E Act it is a mandatory licence condition that the licensee must have adequate technical and financial resources to ensure compliance with the licensee's environmental obligations. There are multiple checks and balances in the approval for and conduct of regulated activity to provide adequate level of comfort to any affected landowner. In the extremely unlikely event that a licensee becomes insolvent and all the numerous checks and balances in place leave residual rehabilitation or compensable factors to any party affected, the state will assume such responsibility.

3 Next steps

With the completion of the '*What we heard*', the '*Submission Recommendations and Response to Comments'* Report and '*Response to South East Submissions*' Reports, the Reference Group will work through the recommendations provided in the 58 submissions received, liaise with stakeholders if clarification is required and make relevant changes to the draft Framework.

The recommendations from the engagement process will assist in informing changes to this important body of work and we thank you for taking the effort to provide your thoughts on the draft Framework.

Once the Reference Group has completed the integration of submission comments into an amended draft Framework, Cabinet will be asked to consider and endorse the draft Framework. Should Cabinet approve the amended draft Framework, it will then be made publically available on the yourSAy website and will be linked on all relevant state and local government websites. Copies of the draft Framework will be forwarded to all stakeholders and regulators will be provided additional copies for their customer service counters.

Decision makers and stakeholders will be encouraged to consider the guiding principles and key engagement mechanisms for land use and land use change projects.