7 RISK THEME 4: PUBLIC HEALTH

This risk is focused on the potential impacts of chemicals used as part of the HFS process and potentially hazardous materials such as BTEX and radionuclides that may require treatment and/or disposal.

Preventing contamination: Origin knows what it pumps into the ground and measures and isolates what comes out in pipelines or double lined ponds where needed, so any hazards can be understood and risks mitigated. Ensuring there is no contamination of the natural environment is the surest method to ensure public health risks are minimised or eliminated.

Minimising impacts on people: We aspire to positively impact our host communities, improving medical infrastructure is one aspect of this aspiration. Moreover, the environment in the Beetaloo is ideal for minimising potential impact on people and communities given the very low population density of the region and the flexibility this affords in terms of avoiding any existing human populations during development.

7.1 Background

Origin has been successfully developing and operating unconventional gasfields since the 1990s, and conventional gas fields for much longer. The human and environmental health impacts of conventional and unconventional gas are effectively identical from a processing and transport perspective. In our decades of experience, Origin's employees and contractors and partnering landowners have not suffered environmental health impacts as a result of living and working in close proximity to gas wells, pipelines and other infrastructure. This statement reflects the highly effective regulation and operating practices of the gas industry, conventional or unconventional, to control risks to public health and safety.

Despite a strong track-record in terms of performance, the unconventional gas industry has been targeted by those who oppose it through the spread of misinformation about its impacts upon health. This has been highly damaging to industry's reputation internationally and in Australia. It has eroded public confidence and may threaten future new developments if a dialogue about potential health impacts, based upon scientific and medical facts is not forthcoming.

Importantly, the public's concerns need to be heard and answered by independent experts, which in Origin's view requires Government leadership. Origin also supports greater focus on understanding and managing the mental health impacts that can arise for stakeholders during large-scale projects.

7.1.1 Process for management of environmental health impacts

The environmental health impacts associated with the development of unconventional gas within the Beetaloo would require assessment in accordance with the Health Impact Assessment Guideline (Commonwealth Government of Australia, 2001) using the principles outlined in the enHealth Environmental Health Risk Assessment (EHRA) guideline (enHealth, 2012) .

The determination of potential impacts of a development on public health is a standard component of an environmental impact assessment. Detailed health impact assessments (HIA) are generally undertaken in the early stages of project planning in order to predict and facilitate avoidance of potentially negative health impacts (enHealth, 2012). EHRA's are a tool used within a HIA, to assess the health risks (i.e. adverse health impacts) from contaminant exposures in the broader process of health impact assessment (enHealth, 2012).

Potential health exposures from shale gas development will be assessed using the risk framework described in Figure 40. Initial assessments of individual and cumulative activities on receptors will be based upon a screening of risks using conservative default exposure parameter estimates and comparison with published health-based guidelines (enHealth, 2012; Commonwealth Government of Australia, 2001). Where the initial conservative screening assessment highlights a potential risks to public health, a detailed risk assessment using site specific values will be undertaken to increase the accuracy of the assessment (i.e. change from a conservative screening assessment to a site specific assessment).

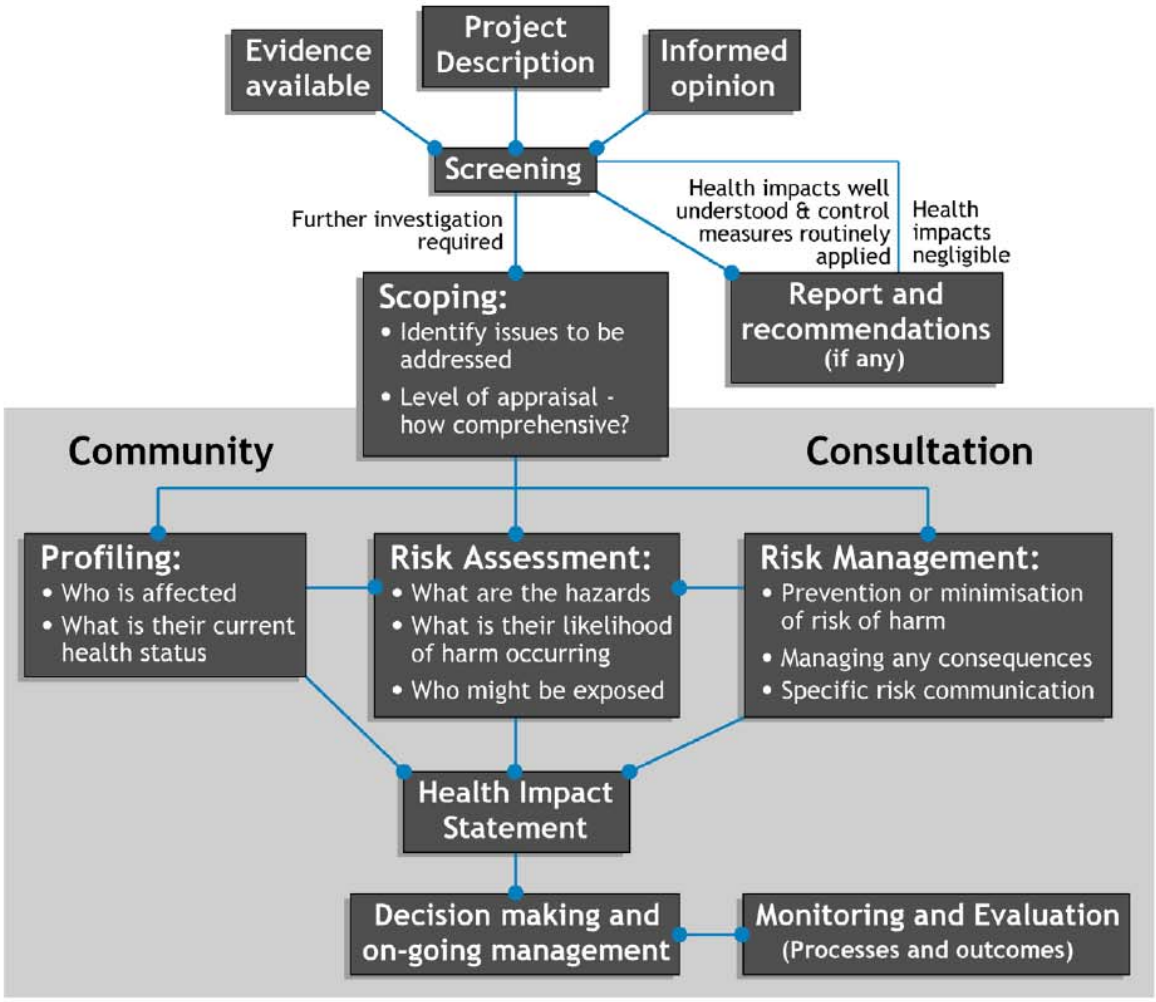


Figure 40. Health impact assessment framework for identifying, assessing and mitigating potential health risks.

The EHRA assessment will be fundamentally underpinned through an assessment of the following components:

1. the source of potential pollutants.
2. the physical pathway of the pollutant from a source to receptor.
3. the receptors present within the study area.
4. the level of exposure of a pollutant to a receptor (where exposure is a function of contaminant dose, duration, timing, frequency and consistency).

The assessment will include a range of contaminant sources and pathways from various gas development activities, including emissions to air, water and land.

Where an exposure is identified during the risk assessment, the hierarchy of controls will be applied to reduce the potential risk of exposure to an acceptable level (Figure 41). A first preference is to eliminate the use/generation of a specific contaminant (e.g. a specific chemical), or substitute the chemical or equipment with a lower risk alternative. Where this is not feasible, engineering controls are applied to prevent the migration of a pollutant away from the source (e.g. double-lined tanks, bunds around tanks, flares, chemical scrubbers etc.). Administration and PPE controls are the lowest preferred option and not considered appropriate to rely upon to manage risks to public health.

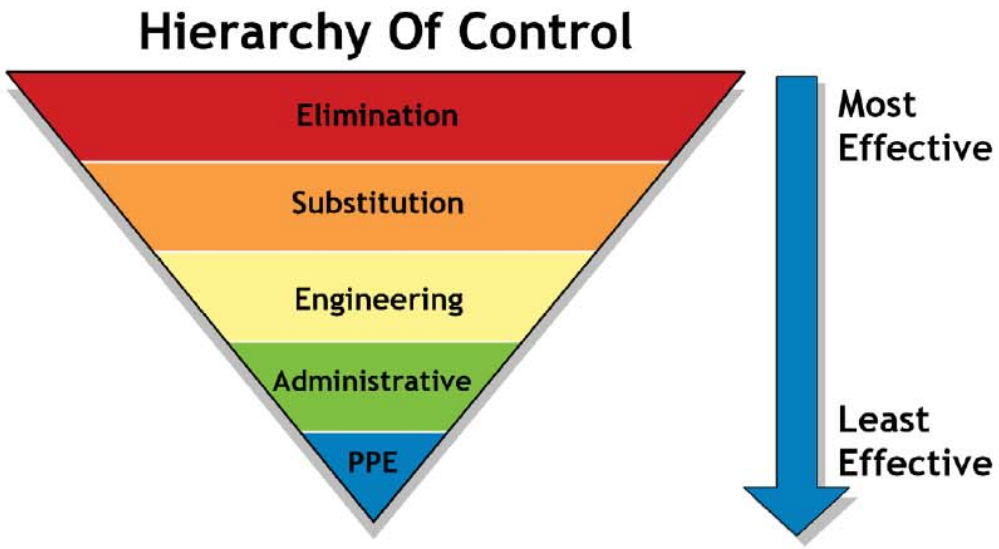


Figure 41.. Hierarchy of controls for controlling a potential hazard.

7.1.2 Existing research into health impacts

Origin is continually reviewing published research into potential environmental health impacts from unconventional gas development. There is a growing body of research focussed on the major unconventional gas developments around the globe, including North America and Australia. One such recent paper seeks to provide a summary of the previous relevant research, "Environmental Health Impacts of unconventional natural gas development: A review of the current body of evidence" (Werner, 2015). This research concludes that "*...there is a lack of highly relevant evidence of direct health outcomes caused by the activities of UNGD [Unconventional Natural Gas Development]*". This aligns with Origin's view that the potential for health and environmental risks can be and are safely managed by unconventional gas developers. Further, we note that the regulators of the unconventional gas industry in both the US and Australia have not had cause to halt the production of unconventional gas as a result of systemic environmental health impacts.

Werner (2015) goes on to also conclude that "*...absence of evidence does not mean evidence of absence*" and calls for further research work to be undertaken to help answer the public concerns. Origin would support clear, Government backed long-term research into environmental health impacts to address public concerns.

Numerous studies have been undertaken into localised health concerns, both in the US and Australia. Looking at the recent Australian examples provides some insight to the phenomenon of reporting of an issue not matching the scientific or medical findings.

Surat Basin, QLD

In 2013 rural residents near Tara in Queensland, raised concerns in the media and with Origin about the presence of a black sticky residue falling on cars and buildings. Dubbed "black rain", the claim was that nearby gas pilot well activity was the cause and that it was contributing to alleged health impacts. Detailed investigations subsequently determined the source of the black sticky material was related to organic material from insects (lerps) and was not connected to the gas industry.

In relation to complaints received from Tara residents, a Queensland Health study undertaken in 2013 found that:

"*The available evidence does not support the concern among some residents that excessive exposure to emissions from the CSG activities is the cause of the symptoms they have reported.*" (Queensland Health "Coal Seam Gas in the Tara region: summary risk assessment of health complaints and environmental monitoring data", March 2013.)

NSW

The NSW Chief Scientist and Engineer, Mary O'Kane, conducted a comprehensive review of CSG-related activities, focusing on human health and environmental impacts.

Professor O'Kane's report (O'Kane, 2014) found that many of the technical challenges and risks posed by the CSG industry can be managed through careful designation of areas appropriate for CSG extraction; high standards of engineering and professionalism in CSG companies; comprehensive monitoring of CSG operations with ongoing scrutiny of collected data; a well-trained and certified workforce; and applying new technologies as they become available.

Origin asserts that these requirements are already features of the CSG industry in Queensland, and that health and environmental issues associated with any shale development in the Northern Territory would be subject to the same stringent checks and controls.

Longitudinal workforce studies into the long-term health of petroleum industry workers, undertaken by Monash University, show that petroleum industry workers have better health on average than the general Australian community and are less likely to die of a number of diseases - including cancer, heart and respiratory conditions (Monash University, 2013 Health Watch – The Australian Institute of Petroleum Health Surveillance Program 2013).

Within the body of research, numerous papers note that there is a lack of comprehensive population-based studies to underpin the conclusions.

Origin considers it important that public health research is Government-backed in order to achieve the necessary independence from the industry that has impacted the credibility of previous studies. Research work into health impacts in the Northern Territory would be most effective if commenced well ahead of any large scale development, to allow clear baselining of prevalent health status and assessment of the subsequent impact of the industry's development and operation.

Origin also recommends the establishment of environmental baselines (e.g. air quality, water quality etc.) and ongoing monitoring to ensure there is visible and accessible data to inform stakeholders about environmental performance and any changes over time in the associated health risks.

7.2 Hazardous materials: drilling and fracking chemicals, hydrocarbons and BTEX, radioactive substances

There may be a risk that chemicals used during the drilling and hydraulic fracturing process are harmful to humans and livestock. Further, there may be a risk that those chemicals come into contact with humans or livestock via groundwater or atmospheric pathways. While the overall concentration of harmful chemicals in the water is low, the actual amount of chemicals can be significant and may pose a threat to the environment if not properly managed.

There may be a risk that hydrocarbons associated with the extracted gas come into contact with humans or livestock via groundwater or atmospheric pathways. This may include aromatic hydrocarbons such as benzene, toluene, ethylbenzene and xylenes (BTEX), which have featured prominently in some risk assessments relating to petroleum and unconventional gas extraction, although BTEX is less likely to be a prominent feature of gas extracted from shale deposits. The use of BTEX in drilling and fracking fluids is prohibited in the Northern Territory.

There may be a risk that radioactive materials from underground come into contact with humans or livestock as a result of the drilling or hydraulic fracturing process.

Response and controls

Origin has demonstrated that hydraulic fracturing can be conducted safely without impacts to humans or livestock.

Origin does not use BTEX in its drilling and hydraulic fracturing fluids and applies significant controls to prevent inadvertent contamination of those fluids with BTEX.

BTEX exposure will be mitigated through:

- *Low levels of BTEX within flowback water mitigating potential impacts from spills.*
- *Containment of shale gas within pipelines will mitigate public and livestock exposure.*

Radiation exposure risk associated with gas developments in the Beetaloo are low as only low levels of naturally occurring radioactive materials are present in the source rocks of the area.

The containment of all materials injected or produced from the well bore, and their isolation from groundwater and the surface environment, during all stages of exploration and development activities is ensured through the detailed engineering and design process addressed in Chapter 4.2 and Chapter 13. The processes that ensure containment and isolation are effectively identical regardless of whether the material is inert and harmless (e.g. fresh water), an explosive risk (e.g. methane), a potential acute health risk (e.g. dilute hydrochloric acid), or a potential chronic health risk (e.g. radiation exposure).

Ensuring robust well integrity, monitoring, and storage and handling procedures and checks are in place are the best means of minimising the risk that any hazardous materials come into contact with humans or livestock. Using the processes outlined in Chapter 4.2 and Chapter 13 there is no realistic scenario where contamination could occur without Origin becoming aware and having an opportunity to intervene and remediate.

7.2.1 Chemical additives for hydraulic fracturing

As discussed in Chapter 4.3.1, the use of additives is a highly regulated process within Australia. Any hazardous chemical or dangerous good used for HFS is governed by the following legislation:

- NT Petroleum (Environment) Regulations.
- National Industrial Chemicals Notification and Assessment Scheme (NICNAS).
- NT Dangerous Goods Act 2012.
- Work Health and Safety (National Uniform Legislation) Act.
- Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act.

All additives undergo a rigorous screening process to ensure it meets Origin's technical expectation as well as its environmental and regulatory requirements. It is typical for additives to be screened for BTEX and PAH (polycyclic aromatic hydrocarbons) by an accredited laboratory.

The use, storage and handling of chemicals associated with HFS are undertaken in accordance with the National Code of Practice for the storage and Handling of Workplace Dangerous Goods (National Occupation Health and Safety Commission, 2001). Risks associated with the use, storage and handling of chemicals are assessed and included in the Environmental Plan of each activity. Stimulation activities are short in nature (days) and are restricted to defined lease boundaries with appropriate offsets to sensitive receptors. A summary of standard chemical storage and handling risk mitigation practices include:

- Rigorous assessment of chemicals to use low-toxicity or non-toxic additives where possible.
- Designated lease areas where activities are to occur.
- Fencing and appropriate signage of lease areas to prevent livestock and community access.
- Use of designated chemical storage areas, bunding and signage within the lease.
- Chemical volumes onsite are kept to a minimum with chemicals removed from site at the completion of an activity.
- Minimal open handling and mixing of dangerous goods by personnel.
- Use of Personal Protection Equipment (PPE); Gloves, protective clothing, particulate filters etc.

A further risk assessment, modelled on Queensland requirements, to cover an expanded gas development within the Beetaloo is currently underway. This detailed risk assessment process is being undertaken in accordance with Australian guidelines for human health and environmental risk assessments and addresses the following:

- A qualitative assessment of the human health and environmental risks to the receiving environment associated with the injection of hydraulic fracturing fluids into the target formation.
- A qualitative assessment of the potential risks to aquatic terrestrial and human health toxicity associated with the process of hydraulic fracturing and the management and storage of flow back fluids above grade.
- A quantitative assessment of the potential risks to aquatic, terrestrial, human receptors associated with the management and storage of flow back fluids.

Where risks to livestock or people are identified through risk assessments, additional controls are implemented.

7.2.2 Benzene, toluene, ethylbenzene and xylenes (BTEX)

As per current NT regulations, no BTEX materials are included as additives in the drilling and/or HFS operations.

Water chemistry results from flowback fluids at Amungee NW-1H show that there are trace levels of BTEX detected during flow back, as per Table 24. Due to the very low levels of BTEX encountered in the water sample and volatility of the compound, the potential exposure to livestock and humans through contact with water (for example a spill) is anticipated to be extremely low.

	BENZENE	ETHYL-BENZENE	TOLUENE	XYLENE (m & p)	XYLENE (o)	XYLENE TOTAL	SUM OF BTEX
DATE	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
11/09/2016	<1	<2	<2	<2	<2	<2	1
1609/2016	3	<2	3	4	<2	4	10
29/09/2016	4	<2	3	<2	<2	<2	9
05/10/2016	7	<2	6	<2	<2	<2	15
07/10/2016	3	<2	3	<2	<2	<2	6
22/10/2016	4	<2	3	<2	<2	<2	7
25/10/2016	3	<2	<2	<2	<2	<2	5
23/12/2016	3	<2	<2	<2	<2	<2	5
26/12/2016	2	<2	<2	<2	<2	<2	<2
28/12/2016	2	<2	<2	<2	<2	<2	<2
30/12/2016	2	<2	<2	<2	<2	<2	<2

Table 24. Amungee NW-1 BTEX sampling results for HFS flowback fluids.

7.2.3 Naturally occurring radioactive materials (NORM)

NORM occur, to some extent, in almost all rocks and minerals. Radioactive elements such as uranium, thorium and potassium and any of their decay products, such as radium and radon, are examples of NORM. Exposure to naturally occurring radiation is responsible for the majority of an average person's yearly radiation dose and is therefore not usually considered of any special health or safety significance.

The source rocks in the Proterozoic Roper Group of the Beetaloo (i.e. the Velkerri and Kyalla formations) are relatively enriched in NORM, but in absolute terms they still occur at very low concentrations and have commensurately low radioactivity and radiation hazard levels. Origin undertook x-ray fluorescence (XRF) analysis on drill cuttings at regular intervals (average of 5m) while drilling in the Beetaloo, these data provide an accurate estimate of approximately 100 elements (including Uranium, Thorium and Potassium) present in the formation being drilled. These data have been analysed internally and by third party experts ("Radiation Professionals"; Appendix 8) and confirm that activity levels are sufficiently low that the cuttings are exempt from regulation – they are just 'rock' as far as environmental hazard and health hazard is concerned. This analysis considered the maximum observed concentrations, not just average values or statistically likely value, and it is considered unlikely that this risk level will increase in other areas of the basin based on our geological understanding.

In addition to testing and analysis of cuttings, Origin has undertaken detailed water and gas chemistry testing to understand the type and concentration of any water and gas borne radionuclides in HFS flowback fluids and gas. The assessment concludes:

- Based on the most active sample (12.5 uSv for 1 litre of water), to exceed 1 mSv/year would equate to 80 litres of water being consumed in one year. It is very unlikely that this amount of active water could be consumed by a member of the public.
- Results from the analysis of the gas sample indicated Radon levels of 225 Bq/m3. The Potential Alpha Energy Concentration (PAEC) in this sample was calculated to be 1.001mJh/m3, which could result in an effective dose to an exposed person, of 1.4 mSv/year, however, the exposure risk can be disregarded in well-ventilated or open air situations due to the very short half-life of the Radon progeny and the fact that the Radon would mix and dissipate quickly in clean air. Hence, there is considered no increase in radiation exposure risk to the community members as a result of shale gas development in the Beetaloo.

The observed radionuclide levels within flowback and gas samples observed from Amungee NW-1H are at the lower end of those observed in US shale developments (Kibble et al., 2013). Management of NORMs within the oil and gas industry has well established controls. A number of standard treatment technologies will be assessed as a part of the project pre-feasibility and design phase. It is likely that standard water treatment technologies, such as ion exchange water treatment or reverse osmosis, could be utilised to reduce NORMs levels if required.

7.3 Mental health and wellbeing

There may be a risk that the mental health and wellbeing of persons could be affected by an unconventional gas project. These factors could include increased costs of living associated with changing property values, access to social services, business failures, increased traffic, effects on the natural environment and concerns about the amenity of the local area.

Response and controls

Origin recognises that changes associated with unconventional gas development could affect the mental health and wellbeing of individuals, both positively and negatively. There is a current lack of data to inform about these potential impacts and Origin will undertake work to monitor this aspect of health and wellbeing to inform any controls required to support the community and individuals.

Research on health impacts to date has focused on environmental and physical health risks and impacts, leading to strong regulation and best practice by the industry. However, Origin's view is that more work is needed to fully understand the mental health impacts that the industry can bring to its stakeholders, including landowners, local communities and businesses, traditional owners, employees, contractors, families and others. Origin's experience is that the environmental health risks are highly regulated and controlled, but the mental health risks are not well understood.

7.4 Diesel fumes

There may be a risk of emissions from plant and equipment, such as diesel fumes from drilling equipment and pumps and from off-site increases in road traffic.

Response and controls

The risks to public health posed by the combustion of fuels is considered extremely low and consistent with other industrial, mining and agriculture activities. All activities associated with HFS (including diesel emissions) will be assessed using the framework providing in the Health Impact Assessment Guidelines (Commonwealth Government of Australia 2001).

Increased emissions associated with development scenarios can be accurately projected and the effects on people and communities modelled and minimised through good planning. Origin would expect such modelling and planning to be a condition of approval following an EIS process, if a development is proposed in the future.

7.5 Physical safety

There may be a risk that physical safety may be compromised by factors associated with hydraulic fracturing including road transport accidents and seismic activity.

Response and controls

Safety is Origin's first priority. Origin and will assess safety risks and the necessary controls thoroughly as part of any formal project impact assessment to inform the design and planning of activities. All daily activities would follow Origin's stringent safety risk assessment processes to ensure hazards are identified and eliminated as far as possible. Everyone working at and for Origin has the authority to stop the job for any safety concern.

Increased risk of road transport accidents is likely to be an outcome of any increase in development in many parts of the NT. However, along with an increase in traffic will come the opportunity to reduce road transport risks through improved transport infrastructure. Detailed modelling of traffic movements would be included in any project proposal and require approval of various agencies.

The availability of emergency medical services to local residents and visitors to the area would be improved by the presence of a gas development. In southwest Queensland the provision of industry funded CareFlight services has facilitated dozens of evacuations of injured people every year since 2011 – individuals and families have benefited in the most vital way possible through this service.

7.6 Cumulative risks

There may be cumulative risks associated with some or all of the risks identified above.

Response and controls

Origin acknowledges that cumulative risks need to be understood and assessed as part of any formal project impact assessment.

The cumulative risk associated with the foregoing issues, and potentially others, would be assessed thoroughly using a detailed project description.

8 RISK THEME 5: ABORIGINAL PEOPLE AND THEIR CULTURE

This risk is focused on the potential for gas development in the NT to disrupt traditional practices and/or adversely impact the wellbeing of Aboriginal communities.

Working with Traditional Owners: Our host Traditional Owners tell us that they want their voices heard, that they want to understand what activities are proposed, and they want to be able to make the decision whether to support such activities. Origin is striving to build a partnership that will allow us to work together for mutual benefit for the long term. We have worked closely with our host Traditional Owners who play a role in the planning and location of our activities. No activity has taken place without explicit consent of the Traditional Owners.

The belief of the Traditional Owners we consult and work with is that gas development can coexist with their communities, and importantly provides real, intergenerational economic and social opportunities that allow their young people to be trained and employed without having to leave their Country.

8.1 Background and context

Aboriginal Peoples in the Northern Territory are the traditional custodians of land and through various legislated provisions the beneficial landowners of some 50% of the NT. As such, for extractive businesses operating in the NT they are a core constituency and a focal point for *social performance* work. The recognition of Aboriginal legal rights at a general level, and the explicit recognition of ethnographically identified, land connected Aboriginal groups on the lands and waters on which extractive companies seek to operate, is a central tenet for working in the NT. Beyond requirements of the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) (ALRA), the *Native Title Act 1993* (Cth) (NTA) and at common law, for reasons of self-interest, it also makes complete sense for extractive businesses to forge local level agreements with relevant custodial Traditional Owners.

Agreement making with land connected Aboriginal Peoples is now common place in Australia, the British Commonwealth 'settler states' and increasingly elsewhere. Much of this evolving competence was developed in the NT following the promulgation of the ALRA in 1976. The four statutory land councils in the NT are amongst the most competent, experienced and better resourced anywhere, and the NT government is highly attuned to working collaboratively with Aboriginal custodians and their representatives. Through several decades of experience in the NT and Australia, agreement making processes have evolved and agreements now form a critical part of the thinking, planning, operation and closure activities of many extractive projects and operational assets.

Agreement processes represent a giant step beyond what is often referred to as 'corporate social responsibility' (CSR). Local level agreements are fundamental to obtaining and sustaining the land access vital to extractive operations, to protecting the interests of land connected Aboriginal groups and enabling approvals and consents to be granted.

Agreements deliver benefits directly to affected Traditional Owners who host activity on their land and empower decision-making about how benefits should be used within communities.

They also empower Traditional Owners to sanction poor behaviours, if they occur, by extractive business employees and contractors working on their lands. In an international context, such agreements exemplify the concept of Free, Prior Informed Consent (FPIC). The University of Queensland publication *"Why agreements matter"* (Ali *et al.*, 2016) provides a comprehensive and up to date discussion of agreement making between extractive businesses and land connected peoples.

Agreement making implementation should not be confined to any single part of a business. Agreements include commitments on such things as land use, environmental management, cultural heritage protection, site security and access protocols, procurement and employment. The process of planning, making and implementing agreements is the 'business of the whole business' and requires the understanding, prioritisation and efforts of everyone. Agreements provide for both business and Traditional Owner accountability, with mutual performance indicators that cover all stages of development, from exploration through to project planning and operations, including closure and post-closure.

It is difficult for an extractive business, with its scientific, engineering and operational focus, to understand Aboriginal Peoples' spiritual and cultural relationships with land and waters. Agreement making forces an extractive business to think in the realm of Aboriginal custodians. Businesses can learn through agreement making to define behaviours that makes sense to Traditional Owners and for businesses to see land and land connected Aboriginal interests differently. The new learnings inform the content and delivery of cultural induction courses, in which the maintenance of culture and strong cultural heritage protection messages are core curricula. Beyond the improved organisational and employee comprehension that ensues, standard operating procedures such as *ground disturbance permits* and *chance finds procedures* ensure mistakes do not occur.

An agreement with Aboriginal custodians secured under common law contract, recognised under appropriate legislative provisions, provides for the strongest possible recognition and protection of Aboriginal custodial interests. That said, agreements have not consistently delivered positive outcomes for Aboriginal peoples. A recent analysis of the impact of major native title agreements in Western Australia, published by Curtin University and the University of WA (Quicke *et al* 2017), explores this and finds that the governance architecture of agreement implementation is essential for success and should be given prime consideration in agreement making. The competence of respective extractive businesses and Aboriginal groups and their advisors in making agreements is a major factor in ensuring good governance is understood and implemented.

8.2 Land ownership

There may be a risk that hydraulic fracturing or the associated activities will disrupt traditional practices that connect Aboriginal landowning groups with their country and underpin recognition of their ownership of that land

Response and controls

In addition to legislated requirements, comprehensive and transparent agreement making with land connected Aboriginal groups can include specific provisions for the protection and honouring of cultural values and practices associated with land connection and ownership.

8.3 Benefits

There may be a risk that the development of the industry will occur without short and long term benefits flowing to local Aboriginal communities

Response and controls

Comprehensive agreements with affected Aboriginal communities can ensure they have access to short, medium and long-term benefits, formally negotiated and agreed.

8.4 Culture, values and traditions

There may be a risk that the above and/or below ground disturbance associated with drilling and hydraulic fracturing or as the result of seismic activity caused by hydraulic fracturing or reinjection of water will have an adverse impact on Aboriginal culture, values and the traditions that connect landowning groups with their country and sustain community cohesion

Response and controls

In addition to legislated requirements to protect cultural heritage, comprehensive and transparent agreement making with Aboriginal Traditional Owners can include specific provisions for how cultural values and practices are protected.

8.5 Community wellbeing

The development of the unconventional gas industry may have an adverse impact on the wellbeing of Aboriginal communities

Response and controls

Impacts on existing (baseline) and changing wellbeing in Aboriginal communities can be carefully monitored. The sparsely populated nature of the region will remain largely unchanged, allowing traditional and hybrid livelihood activities to continue. Wellbeing indicators can be carefully monitored and normal government social welfare and other interventions in collaboration with the developer can be deployed to ensure there is no decline in wellbeing.

8.6 Aquatic and terrestrial ecosystems

The development of the unconventional gas industry may have an adverse impact on aquatic and terrestrial ecosystems important to Aboriginal culture

Response and controls

Robust environmental monitoring and management can ensure there is no adverse impact on aquatic and terrestrial ecosystems and Aboriginal culture.

Origin has a proven history of affording time to understand Aboriginal culture, engaging with Traditional Owners, learning the significance of areas and avoiding impacts. During the first five years of Origin's development in the Surat Basin, Origin walked over 30,000 km with Traditional Owners.

The flexibility in locating infrastructure means that if significant sites are identified, Origin will design infrastructure to avoid impacting these sites.

8.7 Cumulative risks

There may be cumulative risks associated with some or all of the risks identified above

Response and controls

Social impact assessments are run through iterative and cumulative scenarios to ensure to ensure all risks are comprehensively considered.

9 RISK THEME 6: SOCIAL

This risk is focused on a range of potential impacts on people and communities, which could be either beneficial or negative depending on how they are identified, assessed and managed.

Working with communities: Origin is committed to working and living in host communities in a way that supports value being shared. We acknowledge that we are often perceived as visitors and we aim to be described as being a good community citizen who, overall, positively contributes to a community's health and well-being.

A Social Impact Assessment for any proposed development would be critical in addressing potential social issues. Origin commits to using social data to identify, assess and manage impacts in conjunction with the host community and the Northern Territory Government. We are committed firstly to listening to communities to understand their aspirations, interests and concerns, and we know from development in other jurisdictions that communities consider participation and self-determination to be crucial (rather than being told what we can do to their benefit). Our Social Impact Assessment processes, and all that follows, will be centred on the aspirations of the community and Territorians more broadly.

Development opportunities: We commit, through any development, to providing sustainable, long-term employment and training opportunities, and also opportunities for entrepreneurial Territorians to start businesses and lead a regional economic expansion. There is also the potential for other direct benefits, through a royalties for regions scheme and industry led improvements in transport and telecommunication infrastructure.

9.1 Background and context

Social impact is the uncertainty and effects experienced by people arising from business activities close to where they live and work. The impacts can be negative or positive and can change quickly as business activities evolve. When businesses assess potential social impacts, they consider socio-economic and socio-political context, project scope and scale, regulatory requirements and their own self-interest in doing no harm and understanding how they interact with the immediate social and biophysical landscape and broader society.

Social impact assessment (SIA - an integral part of Environmental Impact Analysis in NT legislation) as deployed by established extractive businesses involves field-proven, robust methodologies for assessing and mitigating risk to *receptors* ('economic, cultural and social conditions' as stipulated in the Inquiry Terms of Reference). Applied iteratively with *social risk assessment* (SRA - defined as risk to the business arising from social interactions), business-driven SIA extends beyond the regulatory risk assessment applied to a permitting gateway; as part of business planning it considers *project*- and *business-related* risk over the entire projected life of an asset. The language of *project*- and *business-related* risk is important; *project* risks arise during evaluation, construction and commissioning; *business-related* risks are longer term, associated with the subsequent full-life of the business.

Mitigating project risks can potentially exacerbate business risks (for example, expedient siting of ancillary infrastructure to save construction costs could create a future hazard when population dynamics in a locality change), so risk and scenario assessment should be run through both life-cycle lenses.

SIA and SRA work off a *likelihood* and *consequence* methodology that seeks to equilibrate all project-related risks to a common denominator for rigorous decision making. SIA and SRA are applied continuously, iteratively and cumulatively at all stages of project development, including exploration, extraction, production, decommissioning and extractive site rehabilitation, provide a self-reinforcing control of mutual protection and benefit for businesses and host communities alike. Intertwining SIA and SRA in this way means the self-interest of the business drives consideration for and risk protection of host communities.

Social performance is how extractive sector businesses manage social impact and all interactions (positive and negative, material and intangible) with affected stakeholders; it concerns asset-level behaviours and activities involving direct and local social interactions. Away from the immediate surrounds of an operating asset, corporate-led activities aimed at broader stakeholder interaction expand a business's managed interaction with all people and institutions who are affected by and have an interest in the business's plans, actions and activities.

For effective *social performance*, businesses need to understand the likely trajectory of local development, with or without their presence, and how to work within it. An early critical step in this is to compile a socio-economic knowledge base and situational analysis (usually called a socioeconomic baseline in legislated provision; e.g. Appendix 3). This can be regularly updated to track changes and attempt to determine which are occurring due to the presence of business and which are happening anyway.

It is forecast that upon completion of the exploration program Origin will initiate the next requirement which is a more advanced and relevant social understanding of likely and potential impacts of a development project on the community/region's social fabric. These assessment will begin to define and prescribe appropriate and acceptable behaviours across the whole of the business – that is all employees and contractors. This is best achieved through properly constituted local induction courses, comparable to behavioural safety training. Such courses oblige personnel to listen, reflect and discuss the consequences of poor behaviour, and applies to all the workforce, not just non-locals and those in specialist roles. The curriculum for local induction courses should be determined and delivered by local people based on what is important to them, as well as business and government stipulated behavioural requirements.

Social performance is also addressed along functional department lines. For instance, Human Resources needs to give concerted attention to employing local people, linked into local education options that enhance 'employability'. Procurement needs to provide for scaffolding local service and supply on an escalating trajectory, and link it to expanding the indirect and induced economy.

Infrastructure and Asset management can design and manage business assets and ancillary infrastructure in a way that provides for maximum civic access, as deemed safe and appropriate. Maintenance and Operations staff can mentor local young people as trainees and foster their development as skilled workers and employees. Occupational Health and Safety can recognise and enhance the natural tendency for employees to take learnt safe behaviours home; such as wearing seat belts, drug and alcohol self-management and measures to reduce injury and disease. Management can consciously recognise that securing social, and particularly local, support for their business is a fundamental role for management and dedicates a serious amount of time to it.

Technical elements of *social performance* work are the remit of specialists. Depending on circumstance, this work can include:

- socioeconomic situational analysis and scenario planning.
- scoping regulatory Environmental and Social Impact Assessments.
- undertaking social risk assessments.
- community liaison, monitoring, reporting and communication.
- delivery and governance of local level agreements.
- delivery and governance of Corporate Social Responsibility (CSR) and philanthropic activities.
- cultural heritage protection and management.
- the management of local concerns, issues, grievances and achievements.
- management of compensation for damage, resettlement and economic displacement.
- human rights due diligence.
- dealing with the challenges of in-migration and local population movement.
- interface with Indigenous and land connected peoples.
- addressing local 'resource curse' issues such as inflation and economic leakage.
- being responsive to gender considerations, minorities and marginalised people.
- dealing with community health issues, including control of communicable diseases, and
- working to improve local civic and fiscal governance.

The Social Risk Themes listed in the Issues Paper (namely *housing and rent, insurance, health services, education, infrastructure, livelihoods, long-term benefits, community cohesion, crime, employment, business* and *cumulative risk*) all fall within the sub-disciplines above and for each project make their way into context-specific, carefully designed management plans.

The description provided above serves to illustrate that *social performance*, as a new professional discipline in the extractive sector, is evolving in its broad-based competence and governance architecture to the levels achieved in other business functional areas. Business safety performance and financial performance are models for success.

The elevated attention to *social performance* has happened in response to dramatic changes in societal expectations of industry in the past two decades. While governments still issue legal permits, and maintain regulatory control and manage taxation and royalty streams, people living local to extractive assets increasingly have greater control over their own destiny. This means that instead of relying solely on sovereign legal entitlement, businesses must also secure a 'social license to operate', a form of 'social contract' that derives from a developer's ability to work with communities and stakeholders and demonstrate to them that it is in everybody's best interest to develop and exploit a natural resource.

Social performance governance architecture (Figure 42) is a tightly connected hierarchical set of business policies, standards, management plans and standard operating procedures used to manage *source* and *pathway* behaviours; coupled with reporting and auditing procedures to affirm whether they are working.

When part of a management system that includes defined *social performance* competencies and role accountabilities, the variation (risk) in outcome is dramatically reduced. This approach places firm control over what is otherwise a seemingly complex and dynamic social system, and also removes the temptation to engage in the false comfort of off-setting or charitable deeds. It ensures that *social performance* focus is on protection from harm and building long-term stakeholder participation and opportunity.

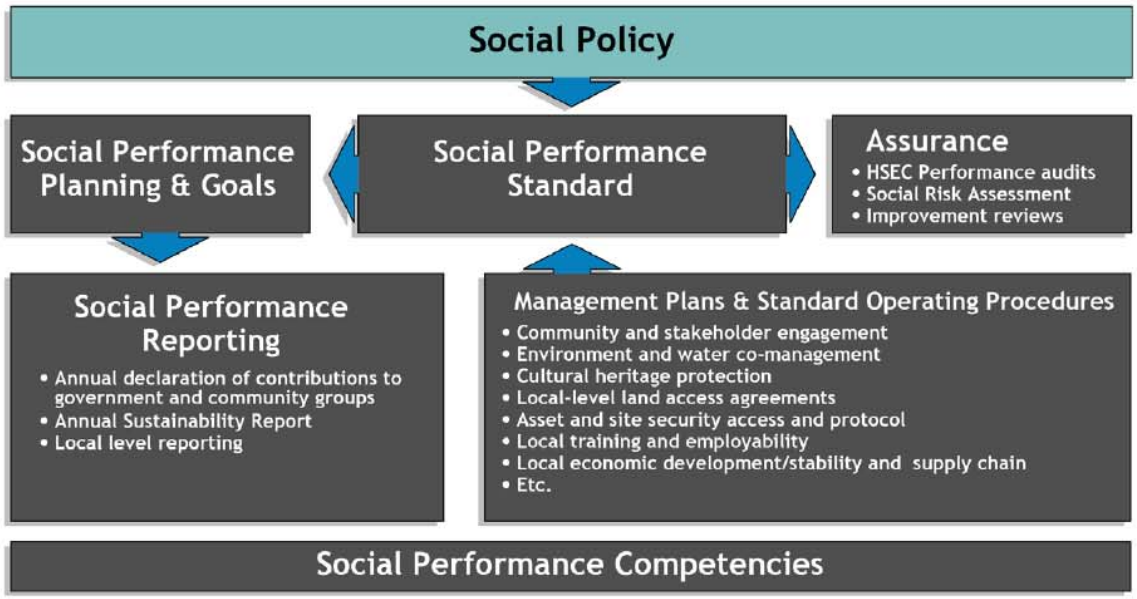


Figure 42. Example of Social Performance Governance Architecture.

The *social performance* capabilities described above may be partly or fully developed, so government policy and regulatory oversight should target management system competency, rather than attempt to 'list check' a multitude of potential social issues. The focus should be on management capability in eliminating social impacts and risks and enabling local people to participate fully in the oversight of business activities and the opportunities that arise. The *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) and the *Native Title Act 1993* (Cth) regimes are good examples of this approach; they provide for the central participation of land connected Aboriginal people and the institutions most affected by proposed and actual development, an appropriate balancing of power, procedural fairness and for government to be the 'insurer of last resort'.

Recent changes to petroleum regulations in the NT, including the *Schedule of Onshore Petroleum Exploration and Production Requirements (2016)* set up similar requirements for hydrocarbon developers to work with other (Aboriginal and non-Aboriginal) stakeholders when preparing and submitting environmental and social performance plans.

The Inquiry TOR social risk sub-themes of *Housing and rents, Insurance, Health services, Education, Infrastructure, Livelihoods, Long term benefits, Community cohesion, Crime, Employment, Business, amenity* and *Cumulative risks*, along with other apparent and emergent risk sub-themes, can be adequately mitigated by the *social performance* management approach described. Importantly, the management systems approach is adaptive to emerging circumstance, a vital consideration when working in social landscapes.

Managing the many individual risks (uncertainties) that can be associated with a major resource development, including those that are listed in the Issues Paper as well as others, needs to be undertaken within a comprehensive management system. This approach and an expanded discussion of elements noted in the Issues Paper is presented in a following section. The following explicit responses to the 'Values' and 'Risks' listed in the Issues paper need to be read and understood by reference to the full discussion above.

9.2 Housing and rents

There may be impacts on local housing, which may decrease or increase rents and house prices as a result of an increased population.

Response and controls

Along with other potential inflationary and 'resource curse' risks listed, closely monitored and regularly updated 'baseline' assessments of housing prices and rents can determine if unacceptable deviation from normal trends is occurring. The developer and government can then proactively design moderating responses and, if necessary, collaboratively intervene to ensure housing stock pressures do not exceed acceptably thresholds.

During the development of the APLNG project, impacts on housing were a significant issue and we have learnt from this experience. Whilst we took steps to house the construction workforce in temporary accommodation and ensure housing was secured for locals, there was extensive land and accommodation development by third parties which became available post peak construction. Looking back, there was a shortage of housing at peak construction, and a surplus of housing afterwards which has impacted investors and locals alike. Origin has learned the need to work closely with regulators, local government and the local community to collaboratively address housing to ensure supply and demand can be more closely matched, and will take that approach into its development in the Northern Territory.

9.3 Insurance

There may be a risk that there will be an increase in insurance costs and liabilities of landowners, occupiers, and traditional owners.

Response and controls

Insurance costs can be closely monitored and where detriment is identified, compensatory measures can be implemented.

We take steps to minimise impacts on landholders, occupiers and Traditional Owners. We compensate for losses, and do not expose them to our commercial risks. Insurance costs can be closely monitored and compensatory measures implemented if required. In Queensland, we're not aware of our stakeholders' insurance costs increasing, and in any event our compensation policy would address any increase in costs.

9.4 Health services

There may be impacts on the local health system (hospitals, health services etc) as a result of an increased population, including that there may be increased health services in remote communities as a result of industry's presence.

Response and controls

Careful management of employee and supplier residential options can ensure there is a spread of any new residency across the region to achieve a healthy balance of service provider and recipients. Collaboration between government and the developer can ensure enough new resources are allocated to health service providers to maintain adequate levels of service.

9.5 Education

There may be an impact on the local education system as a result of an increased population.

Response and controls

As above, for education providers.

9.6 Infrastructure

There may be an impact on infrastructure, such as roads, as a result of increased traffic.

Response and controls

Additional traffic associated with development scenarios can be accurately projected and the effects on traffic infrastructure modelled. Existing infrastructure in remote parts of the NT is not intensely utilised; meaning any modelled 'choke points' or improvement options can be proactively tackled by a combination of infrastructure development and logistics behaviours enforced by developers and road traffic authorities.

9.7 Livelihoods

There may be an impact on peoples' livelihoods

Response and controls

Impacts on existing (baseline) and changing livelihoods can be carefully monitored. The sparsely populated nature of the region will remain largely unchanged, allowing traditional and hybrid livelihood activities to continue. Other livelihoods in a growing cash economy can be carefully monitored and normal government social welfare and other interventions in collaboration with the developer brought to bear.

9.8 Long term benefits

There may be a risk that the development of the industry will occur without short and long term benefits flowing to the local community.

Response and controls

Unconventional gas field development occurs over a long time period, with incremental 'ramp up' over years to decades. This means induced economic effects and benefits can take place at a measured pace and can be carefully controlled by the developer and government working together to ensure that short- and long-term benefits accrue.

9.9 Community cohesion

There may be an impact on community cohesion and resilience, particularly in relation to fly-in, fly-out workers.

Response and controls

Developers and governments working collaboratively can agree and 'construct' hybrid employment and supply models that mix and match Fly-in Fly-out, Drive-in Drive-out and locally domicile options for work crews and supply chain activities. Economic, well-being and community cohesion at all employee/supplier home-bases can be monitored closely and the mix of domicile options dynamically adjusted if issues arise.

9.10 Crime

There may be an increase in crime.

Response and controls

Community security and safety can be managed proactively under formally agreed protocols between the authorities, community leaders and developers.

Developers must establish site access and exclusion protocols that acknowledge local people and local authorities as 'ears and eyes' and custodians of civic order. After all, local people are just as interested as extractive businesses in preventing unlawful and antisocial behaviours by marginalised individuals. Similarly, the Environmental Department should involve local people and Traditional Owners as custodians of the local landscape in environmental understanding and management. Land restitution, life-of-asset planning and post-closure land use aligned to local perspectives is central to this thinking.

9.11 Employment

There may be an impact on local employment and skill levels.

Response and controls

Developers can favour local training and employment under agreement with governments and service providers, providing a positive local impact. Such requirements can be made a condition of permitting and local level agreements.

In other jurisdictions we have developed apprenticeship programs in the regions and are exploring partnerships with schools and other educational institutions to ensure regional capacity building, which underpins long term positive employment outcomes.

9.12 Business

There may be an impact on local business opportunities.

Response and controls

Developers can favour local service and supply under agreement with governments and service providers, providing a positive local impact. Such requirements can be made a condition of permitting and local level agreements.

Regardless of obligations imposed by regulators, we aspire to maximising regional and local buy, meaning we buy goods and services locally to the greatest extent possible. In a development scenario we would work with government and the local business community with a view to building capacity for locals to support our activities, especially during the harvest or operational phases of development.

9.13 Amenity

There may be a risk that the amenity of persons living on the land will be adversely impacted by hydraulic fracturing and its associated activities.

Response and controls

Locations of active well placement can be agreed that are not near residential and/or living and recreational areas. This is something we already do in other Australian jurisdictions through involving landholders in the design of our infrastructure on their land.

9.14 Cumulative risks

There may be cumulative risks associated with some or all of the risks identified above.

Response and controls

Social impact assessments are run through iterative and cumulative scenarios to ensure to ensure all risks are comprehensively considered. Origin also monitors performance measures, shares them with local stakeholders, will collaborate with local communities to take further action if a need is identified.

10 RISK THEME 7: ECONOMIC

This risk is focused on the potential impacts that may come in conjunction with the likely economic benefits of an onshore gas industry in the NT.

Ensuring net benefits are shared:

Origin's approach to living local and buying local will ensure economic benefits accrue in our areas of greatest activity and impact. There is also the potential, however, to benefit a diverse range of regional businesses from Katherine to Tennant Creek and beyond. Production royalties would also substantially increase and diversify the NT revenue base, without impacting critical existing industries such as cattle export and tourism.

10.1 Background and context

An extractive business's role as a developer is to facilitate the transformation of a natural endowment, which is a publicly owned good, into social or economic benefit for shareholders, governments and host communities. This concept of the transformation of a natural asset to a net benefit should underpin all thinking about the merits or otherwise of onshore gas development.

Every development proposal should be judged on a detailed project description that will be unique for each potential gas field, considering such things as population density, land ownership and use, existing and potential economic diversity, and distance from existing infrastructure and markets. Political and social perspectives are equally important. The utilitarian economic argument of the greatest good to the greatest number of people without inducing harm (negative externalities) should be the yardstick by which all proposals are measured.

In the case of deep, shale gas fields, pre-existing economic claims beyond those of government seem difficult to imagine. Like radio spectrum, the 'asset' essentially did not exist until technological advances 'revealed' it; hence it is a 'public good' and can justifiably be managed and allocated by government. In the case of shale gas, the technology discoveries include new societal and industrial uses for natural gas, the ability to extract and transport it, and the delineation of *in-situ* resource by the combination of technologies of horizontal drilling and hydraulic fracturing. In detail, these technologies can take many forms and are the intellectual property of the individuals and businesses that invent, develop and deploy them; the value resulting from these proprietary technologies is a private good.

Typically, the added economic value generated by extractive industries is high relative to industries such as manufacturing and retailing which essentially recycle existing value by purchasing existing components, inputs and goods, then add marginal value. Extractive businesses and other primary producers create the higher added value at the base of an economic ecosystem because they are recycling a lot less pre-existing economic value.

Once new economic value has been created, literally by bringing it out of the ground and refining it in some way, the challenge is to determine the basis for its distribution. In contrast to private goods, in Australia it is within the remit of government to be the ultimate arbiter of the distribution of economic benefit from public goods. This value distribution issue lies behind most of the political and governance conflicts that arise around natural resource development. In short, the debate relates to which part of the added economic value of an extractive product derives from the in-situ resource and which part derives from the extracting business's competitive capability in delineating, developing, beneficiating and selling product.

Part of the answer to this value distribution dilemma is relatively easy to resolve; this being *direct*, *indirect* and *induced* economic contributions. The salaries and wages paid directly by extractive business to their employees, together with fees for services paid to contractors, make up the *direct* economic contributions of an extractive business. The more of these salaries, wages and contractual payments are paid to locally[9] domicile people and businesses, the greater the direct local economic effect and value distributed locally.

The local employees of extractive business and their contractors also buy goods locally and pay for local services such as education, health services, transportation, accommodation, food and entertainment. Much of this is paid for indirectly through their taxes and other fees paid to governments, which then organise public sector service delivery. Collectively this 'secondary' local spend is known as the *indirect* economic contribution, and the higher it is, the greater the local value distribution.

With greater cash flowing through local economies due to *direct* and *indirect* economic flows, entrepreneurs and other businesses can be attracted into an extractive region, whether to sell to the customers of the service providers to the extractive business, or to take advantage of the better civic infrastructure developed off the back of the extractive business and expand or develop new primary industries. Infrastructure attractors can include better roads, grid electrification, water reticulation, improved telecommunications, skilled workers, training centres and general civic amenity. This *induced* economic effect adds to the *direct* and *indirect* economic contributions to make up an expanded total local economy.

Without detailed economic Input-Output studies and defined boundaries to an area of study it is not possible to predict what the total added economic effect in any one locality will be, however studies in sparsely populated shale gas producing regions in the US (IHS Inc. 2012) indicate total new jobs and economic flow can be as much as 3-4 times the direct contributions and the local distribution as high as 50% of total added economic value. Similar multipliers can reasonably be expected in remote Australia.

The combined share of a project's economic value add that accrues to the various economic actors described above is the major share of the extractive resource's total value. The distribution is determined by commercially competitive, transparent and regulatory conditions where individuals and businesses benefit largely on merit. Under Australian conditions of rule and certainty of law, it is maintained in a state of dynamic equilibrium.

The extraordinary amplifying power of the economic multiplier effect, properly managed, is demonstrated in the publication *Economic impact of shale and tight gas development in the NT* (Deloitte Access Economics, 2015). The high-end and mid-case scenarios described indicate a potential cumulative $22.4 billion increase in the NT's Gross State Product (GSP –essentially the NT-wide added economic value) between 2020 and 2040, with a long-term employment boost of 6,300 full time positions across the NT. The short-term and limited-footprint impact of infrastructure construction aside, the truly remarkable thing is that the upstream surface expression could be as little as several hundred relatively widely-scattered production well locations occupying 1-2 hectares each.

9 The definition of 'local' is open to negotiation in any one location, as is the targeted percentage mix of local and non-local employees, contractors, goods and services. Amongst other factors, these are important elements to be agreed by negotiation between developers, governments and local land owners and residents.

10.1.1 Government revenues

A less easily resolved element of the extractive value distribution dilemma is the amount and mix of 'economic rents' that accrue to various governments and affected land owners. The reason it is difficult to resolve is that extractive projects vary greatly in their 'realised economic value'. This is cannot usually be determined until extractive assets have been operating for many years and many operating and financial variables are gradually understood.

The mix of local, state and territory, and national 'rents' can potentially be set by edict, but need to reflect careful, multilateral consideration of ancillary effects. Aboriginal landowners and custodians in the NT are in a strong position to negotiate beneficial rents (better thought of as compensation and benefits); these come on top of government rents and add to the multilateral consideration. It is not in the scope of this submission to recommend what the most effective mix of government and landowner 'economic rents' might be, however, as a general principle, it is worth noting that money going into individual households of economically active families generally has a higher output multiplier and provides greater benefit than money channelled through governments or other institutions.

10.1.2 Compensation for impairment

*I*n addition to economic value distribution, the distribution of real and perceived impairment to local people and existing property from industrial development is an equally important economic consideration. Project and operational design focusing on *source* and *pathway* should to the greatest extent practicable 'engineer out' any potential causes of impairment or loss. Where this is not possible, such as what often happens with public infrastructure (e.g. a bridge on a vital river crossing), it is important that compensation is paid to those negatively impacted, and equally important that the concept of compensation is properly understood.

Compensation is recompense for loss of something, such as resources, amenity, spiritual wellbeing and livelihood, and requires careful balancing. It may be necessary when project design cannot 'engineer out' impairment. It is also necessary when there is accidental mishap resulting in damage or loss. In the case of non-punitive recompense for planned and unavoidable impact, the amount of compensation should equal the value of the loss. A good compensation process accurately determines the rightful recipients of compensation and then compensates the value of their loss. It should be based on what the 'sufferer' of impact is losing, not what the 'impacter' can potentially offer.

Quantifying compensation is an objective exercise irrespective of who is obliged to provide it, whether business, government, civic organisation or development agency. In most cases, 'like for like' is the desirable basis for compensation; e.g. land of equal value for land lost, or house for house, etc. This can rarely be perfectly achieved and compensation is frequently financial.

10.1.3 Negotiating benefits (as a component of economic value distribution)

In contrast to compensation, 'benefits' are project contributions that transfer value to a host community group as part of the project's total scope. Benefits constitute the extra things that developers can offer as opportunities created by the development, such as employment, civic development assistance, inflated prices for land, business opportunities, cash paid into benefits-receiving trusts, and joint lobbying for financial services. Appropriation for non-industrial purposes (by non-industrial or non-extractive developers) frequently cannot consider such benefits. For instance, a government appropriating land for a conservation estate cannot provide for the same economic opportunities as a major industrial development or a hydrocarbon project.

Historically in Australia the benefits that were distributed locally from extractive projects were determined by government. In the 21st century, however, benefits are liable to involve direct negotiation with local people and their representatives as a more democratic form of total 'rents' distribution. In the NT, the paramount recognition of this principle is in the provisions of the ALRA and the NTA, in which relevant Aboriginal Peoples *rights to negotiate* are enshrined.

While the strongest rights to negotiate with a resource developer lie with ethnographically recognised Aboriginal Land Owners, there is nothing in principle to prevent developers making agreements with other parties, such as pastoralists, local governments, civic society organisations and Aboriginal groups generally. Theoretically, negotiation and agreement making should only consider 'benefits' because, technically speaking, 'compensation' should be calculated on replacement value criteria. In many parts of the world compensation is indeed determined by reference to government schedules. However, some option exists for negotiating compensatory replacement value because some lost value, such as spiritual loss, cannot be determined by reference to a standard yardstick. In some cases where parties have not been able of reach agreement on compensated value, a Court of Law has been asked to declare a compensatory value (e.g. as in Griffiths v Northern Territory of Australia (No 3) [2016] FCA 900 (Timber Creek), described in Aro et al, 2016).

Governments should set their revenue (economic value share) on a common baseline for all resource developers, and with tax and other measures encourage developers to build local economic linkages to the greatest extent practical and commensurate with project circumstance. Other affected parties should be facilitated to negotiate context-specific economic value exchange and protections under existing 'right to negotiate' provisions and contract law. Regulation by the NT Government, including regular audits against agreed self-management standards, and regular review by other agreed parties on operating, environmental, health and safety and social performance should be a condition of permitting and operating.

Extractive businesses with enlightened *social performance* strategies and governance architecture will operate willingly and responsibly under these conditions. Successful extractive businesses will secure competitive resource access ahead of rivals, particularly where host community support and development lead times are the determinant of competitive market positioning.

10.1.4 Risk values (sub-themes) in the TOR and Origin's Beetaloo Project

In a development scenario at Beetaloo, given the low population densities in the region and the long distances that Territorians habitually travel, the deemed area of potentially positive economic and social influence would extend to Katherine and Tennant Creek, as would the extent of potential *indirect* and *induced* negative influence. Potential *direct* negative influence would be confined to a much smaller area. *Indirect* negative effects would relate to issues like project-induced inflation and inequality as some people gained well-paid employment and others did not. Depending on the size of any future project, the 'spill over' effects, positive and negative, could extend as far afield as Darwin. It is simply not possible, nor appropriate, to speculate on possible effects in the absence of a defined project and refined knowledge.

Suffice to say, in the case of any development in circumstances like Beetaloo and the NT generally, developers and governments working collaboratively can agree and 'construct' hybrid employment and supply models that mix and match Fly-in Fly-out, Drive-in Drive-out and locally domiciled options for work crews and supply chain activities. Economic and well-being outcomes at all employee/supplier home-bases can be monitored closely and the mix of domicile options dynamically adjusted if issues arise. This model has worked well elsewhere and is entirely appropriate to the 'economic frontier' conditions that prevail throughout most of the NT.

Indeed, the definition of 'local' for development and opportunity purposes in places like Beetaloo can be deemed to extend many hundreds of kilometres, whereas in more densely populated regions it is appropriate to constrain the definition's geographic extent.

A critical theme of developer and government collaboration and agreement would need to be highly refined NT-wide economic Input-Output studies and scenario modelling to arrive at an optimal mix of government 'rents' and distributions, taking into account affected parties' compensation and benefits, and 'local' employment and supply options for the developer. Experience elsewhere suggest lower rents in return for higher local economic stimulus inputs agreed by the developer result in higher multiplier effects, leading to greater economic diversity and growth over the longer term.

The overarching implication of this discussion is that the Inquiry's TOR Economic impacts risk sub-themes of *Distribution, Property values, Other industries, Energy security, Net impacts, Management* and *Cumulative risks*, along with other apparent and emergent risk sub-themes, can be managed dynamically by collaborative studies, policies, joint resourcing and action plans to be agreed as part of any project approvals and defined timelines.

10.2 Distribution

There may be a risk that any economic benefits will not be shared by the regions that are directly affected by the industry, and/or will not be shared equitably between the gas companies, the government, and the community

Response and controls

Comprehensive regional economic Input Output studies can help model ideal mixes of local, regional, Territory and national service and supply options. An equitable mix of economic factors can be negotiated and agreed as part of project permitting and agreement making.

10.3 Property values

There may be a risk that there will be a decrease or increase in existing property values

Response and controls

Closely monitored and regularly updated 'baseline' assessments of property values in directly affected communities can determine if unacceptable deviation from normal trends is occurring. The developer and government can then proactively design moderating responses and, if necessary, collaboratively intervene to ensure property pressures do not exceed acceptably thresholds.

10.4 Other industries

There may be a risk that there will be an adverse impact on other businesses, such as tourism, fishing, agricultural and pastoral businesses

Response and controls

It is in the interest of developers to ensure a high level of induced economic activity occurs in the regions in which they operate. An equitable mix of induced industry support can be agreed as part of total project scope over the long run.

10.5 Energy security

There may be a risk that energy security in the Territory will be jeopardised if the gas is undeveloped

Response and controls

The long term energy security in the NT could be threatened if gas exploration and discoveries do not add to the resource base available to provide gas for the domestic NT market. Exploring for onshore gas provides greater potential supply diversity than relying entirely on offshore developments.

10.6 Net impacts

There may be a risk that any economic benefits will not outweigh economic detriments

Response and controls

It is in the interest of governments and developers to ensure that broad-based economic benefits prevail, and they collectively need to ensure the natural gas endowment is transformed into social or economic benefit for shareholders, governments and host communities. This can be made explicit and made a condition of permitting.

10.7 Management

There may be a risk that, if not properly managed, any economic benefits will result in 'boom and bust' economic activity.

Response and controls

Unconventional gas field development occurs on a very-long term trajectory, with incremental 'ramp up over several decades. This means economic effects can take place at a measured pace under carefully controlled conditions to ensure that 'boom and bust' economic activity does not eventuate. The development of the existing LNG train in Darwin demonstrates that this can be done.

10.8 Cumulative risks

There may be cumulative risks associated with some or all of the risks identified above.

Response and controls

Social impact assessments are run through iterative and cumulative scenarios to ensure to ensure all risks are comprehensively considered.

11 RISK THEME 8: LAND ACCESS

This risk is focused on the need for adequate protections for existing landholders and land users to ensure the right to amenity from their property is minimally impacted, and that any impacts are appropriately compensated.

Coexistence of resources and agriculture is a proven proposition: Origin understands we are guests of our landholders and communities and strive to build long-term partnerships. We work closely with landholders to understand their business needs and other drivers and listens to their feedback to minimise the impact of our activities on their business. All Origin activity in the Beetaloo has had the full consent of landholders, in addition to the permissions provide under our exploration agreements with Traditional Owners. Origin would support the introduction of an independent body (such as an NT GasFields Commission) to foster coexistence.

Landholder veto: Origin does not support the creation of an onshore gas development landholder veto. Government, not an individual landholder, should have the ultimate right to decide whether the nation's energy resources are developed for the public good. Origin, however, will always work openly and transparently with landholders to agree access conditions that are acceptable to landholders.

11.1 Background and context

The nexus of resource developers and host community interests is their mutual need for land access. Gaining access to land is the foundation of an extractive business's ability to operate; this is where they secure competitive advantage and hence can be expected to apply strategic focus and demonstrate that they have operational advantage over others. In fact, it can be argued that a resource developer's strategic assets are its technology related intellectual property and is its geographic bounded exclusive legal licence to operate; the latter being subject to the developer maintaining its 'social licence to operate'. The actual hydrocarbon resource is a public good.

Extractive developers should reach agreement with affected parties over the terms of access to land. In hydrocarbon development and extraction, except for very small areas of land for production well pads (see Chapter 3.2), this land access can be synchronous and sequential with other land users. Following well closure, all surface infrastructure can be removed and the well pads and logistics corridors completely rehabilitated, or if desired regenerated for other purposes by subsequent beneficial land users.

Making agreements on mutual land access provisions with Aboriginal people is discussed in the preceding section. The other main stakeholder group where mutual terms of access and accountability is paramount is pastoral property owners and occupiers. In their case, the property referred to is pasture, surface and ground waters (under regulated conditions), and the 'built capital' improvements that allow the managed, productive and efficient exploitation of the pasture and water. Pastoralists' exclusive right to use these resources (with some exceptions for water for shared practical use by others), and their ownership of built capital improvements and livestock are enshrined in Australian history and law. Various statutes, such as the Native Title Act, affirm other users' rights of access so long as they cause no damage to pastoral owners' property.

While some pastoral property owners have long, intergenerational connections to specific land, in many cases involving deep emotional attachment, their connection is legally and historically different to Aboriginal Traditional Owners. The difference is that pastoral property rights are alienable under law; even if they choose never to sell on their rights, technically they can. In contrast, Aboriginal Traditional Owners connections to land and waters are collective and inalienable, they can never be sold, they can only be acquired as a fact of birth into a 'chain of custody'. This principle of inalienable Aboriginal property rights is enshrined in the ALRA and the NTA. Outside of lands subject to these Acts, while the concept may not have the force of law, the ethnographic principle remains the same - there are rights and obligations on individuals in collective Traditional Owner descent groups as custodians of a long chain of extant, ancestral and descendant land connection. This is indivisible and cannot be traded away.

The inalienable 'chain of custody' is fundamental to the question of whether withholding consent for others access to land is potentially available. For Aboriginal Traditional Owners of land defined in the ALRA, the right to withhold consent is enshrined in law. For ethnographically determined Aboriginal Traditional Owners of other forms of land title, there is no legal right to withhold consent, however there is a moral right based on the 'chain of custody' argument, testable in a court of law. Recent history suggests extractive developers should not test the law because of the long development delays that could be induced by drawn-out legal processes. Treating fairly and equitably with Aboriginal Traditional Owners to reach a collaborative working arrangement is the best option.

Pastoral property owners cannot invoke the 'chain of custody' argument to support claims on a right of consent, hence they have a weaker moral case, and certainly no legal case. That said, for the same reasons that developers should reach formal agreement on the terms of mutual access and selective exclusion with Traditional Owners, resource developers should treat on fair and equitably terms with relevant pastoral property owners. The fundamental premise for such agreements cannot be about land access *per se*, but rather about permanent or temporary damage to or loss of the property rights in pasture, water, built infrastructure and livestock, with a well-drafted section on acceptable behaviours also strongly advised.

On the matter of compensation agreements with pastoral property owners, it is possible by reference to a schedule or precedent court cases to establish a compensation component in the agreements, including payments for loss, for instance of surface or ground water, in the case of mishap. The consideration of benefits (positive value exchange) is completely open to negotiation, including consideration of a project's ancillary improvements that can greatly improve pastoral operating conditions. This can include better roads, grid electrification, improved water availability, improved telecommunications, more skilled workers, training centres and general civic amenity.

As well as exclusive use and economic value, land can have significant cultural heritage and historical values. It can be the subject of pre-existing conflict with a range of competing land uses and have inherent environmental values which need to be protected. Various factors shape people's views about the value of land and how it should be used. Complex socio-political environments including inter-group tensions, exist independent of extractive developments and businesses. In this context, extractive operations can exacerbate existing tensions and the consequences can have a significant impact on host communities and business operations alike. Many extractive businesses and other parties did not fully appreciate these land-associated issues until the 21th century, even though the concept of multi-user land access has been enshrined in Australian law since the days of early European settlement and in Aboriginal customary law long before that. Enlightened businesses now do understand and seek to manage their operations within a multi-party land access regime, often seeking to actively work as mediators and reconcilers of pre-existing land access tensions.

While this role cannot be thrust upon them, and they should not simply presume to take it on, long-run business sustainability is dependent on societal and political stability. On this basis resource developers have a strong incentive to seek a consensual multi-user land access regime around their operations.

11.2 Origin's NT land access experience

We understand that the proposition of oil and/or gas exploration and development can be daunting for landholders and communities, particularly where the activity is new or at least not familiar. We also understand the importance of strong relationships with landholders and communities in onshore developments where every activity will take place in areas that may be visible, accessible and have the potential to impact amenity for other stakeholders.

In 2014, our first action after the announcement that Origin would become operator of the Permits was to notify impacted stakeholders and offer to meet in person at their convenience. We subsequently met the Northern Land Council (NLC) in Darwin and then landholders over the Permits as soon as practicable (i.e. within one month of the announcement). This commitment to communicate as openly and transparently as possible is core to Origin.

Much of our deep engagement with pastoralists has been in the process of negotiating compensation and land access agreements. Negotiations with pastoralists have been undertaken openly and transparently with a strong focus on achieving mutually agreed outcomes and minimising impacts on pastoralists. Well locations have largely been selected to minimise impact on pastoralists and in each instance pastoralists have been consulted about the proposed well locations prior to finalisation.

We have concluded Compensation and Land Access Agreements (CLAA) with five Pastoral Stations over the 2015-16 campaigns; some have included drilling and HFS, some have included drilling only, and others have included only access rights or rights to undertake civil works or purchase access to water. Although the details of these agreements vary, and are confidential under the terms of the agreements, there are a number of constants across these agreements:

- Origin has paid all legal and other reasonable fees (including pastoralist's time) for pastoralists, regardless of whether a successful CLAA has been concluded.
- The acceptance that a CLAA is required to undertake exploration activities and that such a CLAA will contain numerous legally binding requirements that are a condition of access to undertake activity.
- Flexibility regarding CLAA framework; that is Origin has not required any specific agreement framework and initially used a draft agreement negotiated by APPEA and the Northern Territory Cattleman's Association (NTCA). Both pastoralist recommended and Origin template agreements have been used as the basis for negotiations, but in each instance we have negotiated specific clauses to accommodate the interests of the Pastoral Station and the needs of our regulator mandated exploration program.
- Insurance: all CLAA for exploration activity have included provisions for insurance against unforeseen impacts on the physical or business assets of the Pastoral Station.
- Negotiations have been driven by the need for mutually agreed outcomes rather than by schedule. In 2015 we changed the drilling program and schedule to accommodate detailed negotiations that extended beyond the final date required to meet the original program requirements. The value of the long term relationship is far greater to Origin than a near term schedule goal.

- Open and transparent disclosure: we have entertained and answered as thoroughly as possible all questions put to us, this has included providing overviews of what future development could look like if the exploration and appraisal phases of the project are successful.
- Proactive communication: Through information sessions in Daly Waters, trips to visit our Queensland operations, visits to our operating rigs and HFS spreads we have attempted wherever possible to demystify exploration activities and allow the processes to be observed and questioned. We have not just advocated, we have listened; our confirmation of a shallow perched aquifer in the Amungee NW-1 area was based on shallow bores installed at the request of the landholder who had observed shallow water while drilling water wells to the regional Cambrian Limestone Aquifer (CLA).
- Attempts to accommodate pastoralist specific requests:
  - Local content: our tender assessment criteria for civil and construction works was weighted most strongly to the involvement of local contractors and businesses, which was a priority for some landholders (and we recognise as fundamental to our social license also). We may not have met the goals of the landholders, however, the health and safety management plans of our contractors is also of fundamental importance to us and we will need to work with local businesses to ensure they have a fair chance to meet the exacting standards expected of ASX listed entities with mature health and safety systems.
  - Increased water monitoring: to ensure that we can demonstrate whether and what impact our activity has had on water quality and level at each of our well sites we have installed monitoring bores and permanent data loggers in existing bores, in addition to taking regular water samples for analysis. This is far in excess of any regulatory requirement.
  - Infrastructure upgrading: in one instance a substantial (~35 km) section of road has been upgraded beyond the needs of the project as there will be lasting benefit to the pastoralist's business of cattle export.

There have been isolated instances where relationships with a small minority of pastoralists have deteriorated. We share responsibility for this, and accept this is partly because we have not met the standards we set for ourselves. The triggers for these breakdowns do not share any particular root cause, but rather reflect the complex external environment in which we are negotiating and operating under and the inherent uncertainty and challenges of person to company relationships. Despite these challenges, our experience has been overwhelmingly positive and demonstrates the potential for co-existence.

11.3 Consultation

There may be a risk that gas companies do not consult adequately with land owners, occupiers, or traditional owners, in gaining access to the land for exploration and extraction purposes

Response and controls

Exploration permitting conditions and agreement making with various land connected groups can ensure that adequate consultation and engagement takes place.

11.4 Consent

There may be a risk that gas companies enter the land without, where required, obtaining the consent of the landowner, occupier, or traditional owners, causing conflict

Response and controls

Exploration permitting conditions and agreement making with various land connected groups can ensure that an appropriate form of consent is legally recognised. No activity has been undertaken by Origin without prior and informed consent of Traditional Owners and landholders in legally binding agreements.

11.5 Conditions

There may be a risk that gas companies and landowners, occupiers, and traditional owners, do not negotiate mutually beneficial conditions associated with any agreement permitting access

Response and controls

Exploration permitting conditions and agreement making with various land connected groups negotiate mutually beneficial conditions.

11.6 Compensation

There may be a risk that compensation paid for access and/or disturbance to land will not be adequate. There may be a risk that if there is an incident in the exploration, extraction or production of any gas, the land may not be properly remediated or the land owners, occupiers, or traditional owners may not be adequately compensated

Response and controls

A properly constituted social impact assessment process and government over sighted compensation process for land access and potential mishap is in place as a condition of permitting.

11.7 Cumulative Risks

There may be cumulative risks associated with some or all of the risks identified above

Response and controls

Social impact assessments are run through iterative and cumulative scenarios to ensure to ensure all risks are comprehensively considered.

12 RISK THEME 9: REGULATORY FRAMEWORK

This theme addresses the key role that the regulatory framework plays in managing risk and compliance and articulates a broad range of sub-themes.

Appropriate legislation and regulation is in the best interest of all stakeholders: The current regulations are well suited to the exploration level activity currently underway in the NT, continuing these activities is critical to gathering data to inform what 'best in class' legislation should include in the NT context. A robust and transparent legislative and regulatory framework, supported by effective and credible monitoring requirements, that should include prescriptive minimum requirements in an objective based regulatory framework, are key to an onshore gas industry succeeding in the NT.

12.1 Background and context

A robust and transparent legislative and regulatory framework, supported by effective and credible monitoring requirements, are key to an onshore gas industry succeeding in the NT. Appropriate regulation is paramount to all stakeholders, including industry proponents, as without such regulation the actual or perceived risks of development may be considered to outweigh the benefits, and in such an environment moratoriums on activity can become total bans, as seen in Victoria recently.

There exist strict regulatory requirements in the NT that govern oil and gas exploration and development as there are in most jurisdictions in Australia and similar jurisdictions in other developed countries; such as New Zealand, Canada and the United Kingdom. Although the primary legislation in the NT covering exploration and development activities is the Petroleum Act (2016), there are many other acts, agreements and guidelines that are relevant to such activities as summarised in Table 25.

NT LEGISLATION
Petroleum Act 2016 and associated Regulations and Schedule of Requirements • Regulates the exploration for, and production of petroleum, including environmental protection measures which should be employed during exploration and production activities, including protection of parks and reserves and rehabilitation
Northern Territory Aboriginal Sacred Sites Act 2012 and associated Regulations • Provides for the protection of sacred sites, through establishing procedures for entering such sites and procedures for avoidance of such sites when developing and using land • Generally refers to land other than Aboriginal land
Heritage Act 2011 and associated Regulations 2012 • Serves to protect archaeological sites
Soil Conservation and Land Utilisation Act 2009 • Provides for the prevention of soil erosion and for the conservation and reclamation of soil
Environmental Assessment Act 1994 and associated Regulations • Provides for the assessment of the environmental effects of development proposals and for the protection of the environment • Defines environment as being "all aspects of the surroundings of man including the physical, biological, economic, cultural and social aspects"
Public and Environment Health Act 2011 • This Act provides a framework for regulations to be prescribed for all public health matters
Bushfires Act 2009 • This Act outlines regulations and established penalties for certain acts relating to lighting fires
Territory Parks and Wildlife Conservation Act 2011 and associated Regulations • Provides for the protection, conservation and sustainable utilisation of wildlife
Waste Management and Pollution Control Act 2011 • This Act protects and where practicable restores and enhances the quality of the NT environment. It encourages ecologically sustainable development and facilitates the implementation of National Environment Protection Measures established by the National Environment Protection Council
Work Health and Safety (National Uniform Legislation) Act 2011 • Provides for a balanced and nationally consistent framework to secure the health and safety of workers and workplaces
Water Act 2011, as amended 2013 • Provides for the investigation, allocation, use, control, protection, management and administration of water resources, including extraction of groundwater, waste management and water pollution
Weeds Management Act 2001, as amended 2013 • Identifies declared weeds (those which must be controlled) and provides a framework for weed management
Dangerous Goods Act 2012 • Provides for the safe storage, handling and transport of certain dangerous goods
COMMONWEALTH LEGISLATION
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 • Provides for the preservation and protection of places, areas and objects of particular significance to Aboriginal people
Environment Protection and Biodiversity Conservation Act 1999 • Provides for the protection of the environment and conservation of biodiversity, particularly species and places of national significance • Invoked only if a development is likely to have environmental impacts of national significance
Aboriginal Land Rights (Northern Territory) Act 1976 • Provides for the granting of Traditional Aboriginal Land in the Northern Territory for the benefit of Aboriginals, and for other purposes
Native Title Act 1993 • Provides for the recognition and protection of native title for Indigenous peoples

AGREEMENTS
Native Title Agreement between NLC and Origin • Details the environmental and cultural protection measures to be included in the EP
Exploration Permits • Details the environmental protection measures to be included in the EP
GUIDELINES
AS 1940: The storage and handling of flammable and combustible liquids, 2004 • Provides guidance for the operation and handling of flammable and combustible liquids
Codes of Practice of the Australian Petroleum Producing Exploration Association • Provides guidance for environmental management during petroleum exploration and production activities
Environmental Health Program Directorate Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent, 2014 • Provides guidance of the management of effluent in this context • It is noted that Territory Health Services will issue any amendments to the above Code on an annual basis
ISO 19011: Guidelines for quality and/or environmental management systems auditing, 2002 • Provides guidance on environmental auditing to a certifiable standard
The Northern Territory Dangerous Goods Regulations and Australian Standard 1985 (as amended 2014) • Provides regulation and guidance on appropriate storage requirements for on-site fuel tanks
Northern Territory Pastoral Land Clearing Guidelines (NT Pastoral Land Board, 2010) • Although clearing for roads or tracks is a significant cause of erosion on pastoral leases, there is no requirement to obtain formal approval from the Pastoral Land Board. Instead, clearing must be carried out in accordance with Land Clearing Guidelines (NRETAS, 2010)
Land Clearing Guidelines (NRETAS, 2010) • Provides technical advice for planning and undertaking land clearing in a manner that will avoid/minimise adverse environmental impact • Provides guidance for clearing along linear developments, such as roads, tracks, fence lines, pipelines and exploration lines • Outlines the circumstances under which approval for clearing must be sought
Integrated Natural Resource Management Plan for NT (NT Government, 2011) • Describes the current condition, use and threats, and provides possible management solutions for the Territory's natural resources and environments • Includes guidance for improved management of pastoral land, through control of weeds, responsible clearing, prevention of overstocking and reduction in wildfire occurrence.
Best Practice Erosion and Sediment Control (International Erosion Control Association, 2008) • Facilitates the identification of those issues that should be considered when formulating and evaluating strategies for best practice erosion and sediment control • Facilitates best practice stormwater management • Facilitates active avoidance or minimisation of soil erosion resulting construction activities • Facilitate best practice soil and sediment control management on sites.

Table 25. Legislation, guidelines and agreements relevant to oil and gas exploration and development activity in the NT.

Under the current regulatory regime the DPIR issues operators with an "authority" to undertake prescribed activities, in all instances that such an authority is provided, however, there is further scrutiny from other government departments (such as the Department of Transport) and also from independent parties such as the Environmental Protection Authority (EPA). The existing legislation and regulations provide the tools necessary for exploration to proceed in the NT, as recommended by Hawke (2015). Future regulation should add to existing onshore gas regulations rather than attempting to develop new regulations specifically for shale gas (Cook et al., 2013).

12.2 Failure to protect the environment

There may be a risk the regulatory framework does not adequately protect the environment (water, land, and air) from risks associated with hydraulic fracturing and associated activities.

Response and controls

The current regulatory framework provides substantial protection for the environment and includes stringent checks and regulatory oversight. There are regulatory frameworks operating within Australia and other parts of the world that have proven effective in controlling the specific risks associated with development scale activities of unconventional resources, which can be adapted for use in the NT.

Regulations:

The current regulatory framework provides substantial protection for the environment. Recommendations from Hawke (2015), adopted in 2016 by the then DME, have further strengthened these protections. We support the proposal to expand the Water Act to cover all industrial or agricultural activity and ensure holistic management of water as a resource. Moreover, the 'water trigger' under the Environmental Protection and Biodiversity Conservation (EPBC) Act 1999, is likely to apply to proposals to develop shale gas as it does to coal seam gas, where such proposals that are likely to impact significant water resources are referred to the Commonwealth.

Recent regulatory updates to the NT legislation require detailed environmental management plans (EMP) and risk assessments to be submitted prior to any exploration or development activity, these documents are reviewed by the Regulator in addition to the Environment Protection Authority (EPA). Before any activity can be undertaken the Regulator must ensure that environmental impacts and risks associated with the activity are reduced to a level that is as low as reasonably practical (ALARP) and acceptable.

In conjunction with petroleum legislation the NT EPA (under the Environmental Assessment Act 1994) can require an operator to prepare a public environmental report (PER) or environmental impact statement (EIS) if it believes the activity is capable of having a significant impact on the environment. Where a PER or EIS is required it must be prepared in accordance with the terms of reference developed by the EPA.

At a commonwealth level, any petroleum activity that has the potential to have a significant impact on a matter of national environmental significance is required to be referred to the Department of Environment and Energy (DoEE) for assessment. Where the DoEE believes that a significant impact is likely it must make a decision whether to approve with conditions or refuse the activity.

Monitoring:

To improve responsiveness and transparency of industry and the regulator, comprehensive monitoring provisions with ongoing automatic scrutiny of the resulting data and a well-trained and certified workforce should be legislated or required by regulations (O'Kane, 2014).

Baseline data and ongoing monitoring are key to illustrating that exploration and development activity is not adversely impacting the natural environment. The NT offers a relatively unique opportunity to undertake baseline studies where very little human development exists and there is effectively no existing oil and gas infrastructure. There would be an abundant new source of groundwater data for most parts of the NT if development of oil and/or gas does proceed, given the relative paucity of data for deeper aquifers – such data are important for fundamental scientific research and typically very difficult to obtain.

Infrastructure abandonment:

There may be a need to modify existing regulations or implement new ones regarding infrastructure rehabilitation to minimise (or prevent) a future public liability escalation, this is particularly relevant given the greater number of disturbance associated with unconventional developments.

Currently rehabilitation security bonds are a condition of approval for petroleum activities. They are designed to provide the NT Government with a mechanism to undertake rehabilitation where a holder has failed to fulfil their rehabilitation obligations. Rehabilitation security bonds are calculated in accordance with a template available from the NT government website.

For petroleum activities the template is blank with no defined units or costs of measure (as opposed to mining where the rates are defined) which has the potential to lead to inconsistent development of rates between industry and the government. Other jurisdictions within Australia have developed industry specific calculators for environmental rehabilitation with Queensland being one example.

Under Queensland requirements the need to provide financial assurance is contained within environmental legislation. The Queensland government has developed policies and guidelines around how financial assurance is to be calculated via industry specific unit rates with discount incentives when certain criteria can be met by the operator. The calculator has in built flexibility for operators to propose an alternate unit rate where it can be substantiated by 3rd party quotes. Discounts relate to financial stability and abilities to reduce waste and disturbance of sensitive areas.

As part of the process to have financial assurance returned to the operator (via the environmental authority surrender process), the Queensland government can then require a residual risk payment to be provided. The criteria for determining whether a residual risk payment is required is outlined in the Environmental Protection Act 1994.

We would support the development of a financial assurance and residual risk requirement for the NT petroleum industry that was modelled on the current Queensland approach. Unit rates within an industry specific calculator should be developed cooperatively between the NT government and the Australian Petroleum Production and Exploration Association.

12.3 Land access

There may be a risk the regulatory framework does not appropriately balance the rights of landowners, occupiers, and traditional owners with those of gas companies.

Response and controls

The current regulatory framework in the NT requires operators to negotiate access to pastoral leases to undertake exploration activity; this protects the rights of landholders. Likewise, there are legal protections for Traditional Owners that require negotiated exploration agreements and continuous consultation. The land access frameworks operating successfully in Queensland and South Australia also demonstrate that current approaches are effective in balancing the rights of all stakeholders during the development of unconventional gas.

A functional regulatory framework for land access is critical to both landholders and permit holders alike. The current regulations require that access is negotiated or an authority for activity will not be provided by the DPIR; although this is not currently legislated it is nonetheless enforced and enforceable at the regulatory level.

The perceived lack of support for rights of landholders in terms of access to their land should be addressed in legislation or regulation. Lack of consultation, inadequate compensation, property value decreases, and potential legacy issues are cited as major issues by landholders (O'Kane, 2014) as are the negative impacts on amenity and a lack of adequate benefits for their neighbours and their communities; regulatory guidance on such issues, particularly if objective based rather than prescriptive, would be received well by all stakeholders.

Origin does not support the creation of an onshore gas development landholder veto. Government, not an individual landholder, should have the ultimate right to decide whether the nation's energy resources are developed for the public good. State and Territory governments currently hold the rights to accessing energy resources in order to ensure they are developed responsibly to meet the energy security and supply requirements of Australia and the global market. The creation of a landholder veto effectively transfers the right into the hands of individual landholders to block access to that public asset.

The provision of a veto right also brings potential for significant pressure to be brought by third parties onto a landholder that can be unfair and distressing. Origin supports a resource rights model where Government determines which resources can be accessed through an open and transparent process of gazetting land for exploration, and then allows landholders to negotiate fair compensation for enabling access.

Although relatively few agreements have been entered into between industry and landholders in the NT, in South Australia and Queensland hundreds of agreements have been successfully negotiated. There is no reason to believe that such outcomes can't be replicated in the NT under the current principle that permit holders have rights of access, with appropriate caveats requiring consultation and appropriate compensation, alongside other landholders such as pastoralists.

12.4 Public health

There may be a risk the regulatory framework does not adequately mitigate public health risks associated with the unconventional shale gas industry.

Response and controls

There are regulatory frameworks operating within Australia and other parts of the world that have proven effective in controlling environmental health risks from unconventional gas development that can be adapted for use in the Northern Territory. Origin also supports further work to understand the potential for mental health impacts.

Preventing pathways from sources to receptors, of potentially hazardous materials is key to ensuring any risk to public health is minimised to ALARP. Regulations and monitoring that protect the environment are equally relevant to preventing events that contribute to this hazard and minimising the severity of any incident, overall leading to risk minimisation.

The potential for increased infrastructure associated with a development would also provide improvements in the provision of medical services, hence there is the potential to improve access to health care for communities in the Beetaloo if a development does proceed. A lack of health services is one of the key challenges for Aboriginal and other remote communities in the NT.

12.5 Aboriginal culture and communities

There may be a risk the regulatory framework does not adequately protect Aboriginal culture, values, traditions and communities from risks associated with the unconventional shale gas industry.

Response and controls

There are regulatory frameworks within Australia that seek to protect Aboriginal culture, values, tradition and communities from land use changes such as unconventional gas development. Origin is committed its relationships with Traditional Owners and to respectful engagement and collaboration on how to protect such important heritage, values and communities.

The recognition of Aboriginal legal rights at a general level, and in the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) (ALRA) and the *Native Title Act 1993* (Cth) (NTA) and at common law provide strong protection for Aboriginal communities in the NT. The current regulatory framework requires that exploration and/or production agreements, negotiated with guidance of the relevant land council, prior to the commencement of any exploration and development activity.

An agreement with Aboriginal custodians secured under common law contract, recognised under appropriate legislative provisions, provides for the strongest possible recognition and protection of Aboriginal custodial interests. The governance architecture of agreement implementation is essential for success and should be given prime consideration in agreement making, and this is relevant far more broadly than just the onshore gas industry. The competence of respective extractive businesses and Aboriginal groups and their advisors in making agreements is a major factor in ensuring good governance is understood and implemented.

12.6 Social impacts

There may be a risk the regulatory framework does not adequately mitigate the social risks associated with the unconventional shale gas industry.

Response and controls

Managing the social impact risks from any major development can pose numerous challenges given the complexity of community dynamics. There are examples of mature social impact regulatory frameworks that need to be assessed and adapted to guide the assessment and management of social risk in the NT.

The co-existence achieved by the gas industry and landholders in the majority of the Surat Basin, Queensland, and in the Cooper Basin, South Australia, is evidence of the ability to minimise adverse impacts on communities while also providing opportunities for economic advancement. Section 9 provides some insights into how adverse outcomes can be avoided. The primary protection to ensure that on balance benefits accrue is the requirement to complete a Social Impact Assessment and implement required actions or obligations as part of the approval process for a major project.

12.7 Economic impacts

There may be a risk the regulatory framework does not ensure that any economic benefits are appropriately distributed between the gas companies, the government and the community.

Response and controls

Equitable distribution of economic benefits is an important principle that Origin supports. Origin welcomes dialogue with the Government and other stakeholders on how economic benefits are distributed as the industry matures. It is important that there is transparency on the regulatory frameworks surrounding distribution of benefits well in advance of project investment decisions.

For directly impacted stakeholders such as landholders and Aboriginal communities, with effective consultation addressing stakeholder concerns and appropriate levels of compensation, gas development can provide new revenue streams.

Local councils must ensure their communities can cope with any industry influx, but if handled effectively industry activity can bring benefits to communities, especially to rural communities, in terms of increased employment, rents and servicing opportunities.

The current royalty regime would, based on development scenario modelling, provide substantial economic benefit to the NT Government (Deloittes, 2015). Broader policy of the NT Government of the day, if and when a development proceeds and royalty payments accrue, will dictate how benefits are distributed and regulating this would seem beyond the remit of a regulatory framework for the exploration and development of oil and gas.

At a national level, the potential for an increased supply of domestically produced gas could help deal with concerns about rising gas prices, possible future shortages, and electricity supply security. The economic impacts of rising gas prices and blackouts in South Australia in late 2016 and early 2017 have been reported widely.

12.8 Compliance and enforcement

There may be a risk of inadequate monitoring or enforcement of compliance with the regulatory framework. This may arise from, for example, inadequate resourcing of the regulatory agency or inadequate training of relevant officers.

There may be a risk that sanctions provided for in the regulatory framework are inadequate or are not utilised by the regulator.

There may be a risk that the cost of complying with the regulatory framework is too high for industry and the industry becomes uneconomic.

Response and controls

There are numerous examples of Government agencies who conduct industry monitoring, compliance oversight and enforcement that can be assessed and adapted for use in the NT. A compliance and enforcement function is an extremely important part of assuring compliance, which in turn underpins trust in the industry and supports social licence to operate.

Key elements of a regulatory framework that mitigates a risk of non-compliance will include some prescriptive minimum standards and objective based guidance:

1. Monitoring of the natural environment: type, frequency, review and reporting requirements
2. Monitoring of production rates and pressures: type, frequency, review and reporting requirements
3. Training: minimum requirements for industry professionals responsible for sign-off of reviewing and reporting
4. Training: minimum requirements for regulatory staff responsible for assessing compliance

To enable the implementation of such a framework effectively will require that processes across different government agencies and regulators are streamlined and coordinated. Agencies must be appropriately resourced, such that sufficient staff with appropriate knowledge and training are available to review data and reports, and assess non-compliances.

12.9 Complexity

There may be a risk that the regulatory framework is needlessly complex.

Response and controls

Many jurisdictions where unconventional gas development is established have evolved their regulatory frameworks over time to incorporate lessons learnt, improve efficiency, reduce unnecessary regulatory cost burden and delays. It is important that the lessons learnt in other jurisdictions are adopted in the NT to streamline the efficient development of the industry.

One of the strengths of the current NT Petroleum Act (2016) is its simplicity, which allows all stakeholders to review and understand the legislation. As legislation increases in complexity and increases in volume it becomes inaccessible to all except specialists, which is a poor outcome for all stakeholders. Objective based legislation and regulation can remain relatively simple as it is not necessary to explicitly consider every variation or outcome, but rather state objectives, minimum monitoring and reporting requirements and penalties for non-compliance.

Where possible, regulations regarding matters such as set-back distances, water usage, shared infrastructure costs, rates, etc. should be consistent across industries. This reduces complexity and recognises a principle that rules and regulations should be able to be consistently applied if they are sound and not arbitrary.

12.10 Regulatory capture

There may be a risk of 'regulatory capture' whereby the regulatory body becomes inappropriately aligned with industry and reluctant to regulate.

Response and controls

The risk of regulatory capture can be mitigated through the appropriate governance and transparency within regulatory agencies.

This is potentially a common risks for all government agencies, and is not isolated to industry proponents (i.e. the risk of capture by anti-industry organisations is equally as plausible). A whole of government approach to arm's length regulation is an expectation of the public.

12.11 Cumulative risk

There may be cumulative risks associated with some or all of the risks identified above.

Response and controls

Origin acknowledges that cumulative risks could arise from an absence or immaturity of regulatory mechanisms. This highlights the importance of work to map out and establish the suite of regulations and governance structures required to support the development of the unconventional gas industry.

The cumulative risk associated with the regulatory framework will be assessed thoroughly in due course through the EIS and SIA process if a development in the Beetaloo region is proposed.

13 WELL INTEGRITY

This chapter describes the key steps undertaken before and during well construction to ensure a well will meet its technical objectives and preventing unforeseen events that could adversely impact the environment. Operational safety and well integrity are the most critical considerations that are the responsibility of the Origin Drilling and Completions business unit.

Operational safety is a broad term that refers to the safety and wellbeing of Origin employees, contractors and sub-contractors, but also includes protection of the environment where work is undertaken. A key step in achieving good operational safety is working with contractors that have robust safety systems and cultures and ensuring the implementation of those systems on Origin sites and public roads to protect the workers on site, the community and the environment.

Well integrity refers to the appropriate design, execution and verification of the well as a whole system. In practical terms, the aim of well integrity is to minimise risk to people and the environment as a result of the long term operation of a hydrocarbon well. Typical risks to be considered are the pressures of the reservoir being targeted, the contamination of aquifers (particularly potable aquifers) and the prevention of cross flow between differently pressured subsurface permeable zones. Ultimately the goal is to have hydrocarbons flow from the reservoir to surface through the designated flow path with no leaks.

13.1 Standards and regulations

Well design at Origin is undertaken in line with in-house standards and government regulation. Origin's Drilling and Completions department have a range of standards for ensuring the products delivered are of a high quality, but the following have the most impact on well integrity during the design and construction of the well:

- Well Integrity Standard.
- Barriers Standard.
- Well Control Standard.
- Casing and Tubing Standard.
- Cementing Standard.
- Corrosion and Materials Selection Standard.

These standards are influenced by good industry practice, existing industry standards and practices (mostly American Petroleum Institute; API) and the experience and knowledge of Origin Drilling and Completions engineers. When writing and reviewing standards, Origin also considers the standards and practices of other major oil and gas operators.

Origin also conducts reviews of the requirements of the regulatory regimes in which they work. Often the requirements of the regulator will overlap with Origin's established standards but where they do not, Origin will implement the higher standard (i.e. opt for the conservative approach).

If Origin is unable to meet a standard or regulation or believes that the implementation of a standard or regulation results in added risk, permission to dispense with the requirement for that activity may be sought (either from the regulator or Origin's Technical Advisory function). Typically this is achieved through a management of change process that assesses the specific risk and controls to be implemented a result of not meeting the requirement.

Origin recognises that well risk differs depending on circumstances. To deal with this three well tiers are defined in the standards, with differing levels of technical scrutiny required.

Tier 1 wells are well types that are well known to Origin and drilled in fields where Origin has extensive experience. These wells are likely to be development wells that follow appraisal and piloting in a given area. The risks are well known and routinely managed. These wells can be approved by Principal Engineers.

Tier 2 wells are derivative designs of Tier 1 wells that have unique aspects that change the risk profile. They will still be constructed in fields that Origin has experience in or immediately adjacent to. These wells can be approved by the Drilling and/or Completions Manager (supervisor to a Principal Engineer).

Tier 3 wells are unique wells that may either be a totally new design, an exploration well or have a high risk aspect (such as being high pressure or offshore). These wells require additional technical scrutiny and are likely to have third party independent verification of design aspects. These wells must be approved the General Manager of Drilling and Completions (supervisor to a Drilling and Completions Manager).

13.2 Zonal isolation

Origin's Barriers Standard provides instructions on how wells should be constructed to prevent flow to surface and also between discrete permeable zones. A discrete permeable zone is a geological unit (typically defined by the relevant governmental geological authority) known to be permeable. The unit could contain water (an aquifer which may or may not be potable), hydrocarbons (a gas or oil reservoir) or neither in the case of a "thief zone" or zone above the water table.

Origin's standards require wells to be constructed with a minimum of two barriers in place between a hydrocarbon bearing zone and surface, although in line valve barriers may be open while the well is being produced. Essentially, reservoir fluids to be produced must flow into the well conduit and to the surface gathering system with no leak outside of that path.

Origin's standards also require that a minimum of one barrier is installed between a discrete permeable zone and surface and any other discrete permeable zone. Some examples of this would be:

- Any aquifer must be isolated from surface and other permeable zones.
- Any two aquifers must be isolated from each other to prevent them mixing and altering water quality over time.
- Any zones of differing pressure (hydrocarbon, water or otherwise) must be isolated to prevent cross-flow. This prevents future problems like aquifer deterioration and the pressure charging of previously normally or under pressured formations.

The Standard requires a decision on the number of barriers required, subject to a risk assessment. The assessment must determine whether or not any given barrier adequately manages the risk of cross flow. It may be necessary to install more than one barrier, such as:

- Isolating a particularly sensitive zone like a fresh water aquifer.
- Isolating a corrosive fluid like Hydrogen Sulphide.
- Providing redundancy across an area that may have a barrier installed that there is reason to believe may be or may become compromised.

The verification and testing of a barrier is covered in Chapter 4.2.2.

13.3 Drilling and well construction

During the design phase Origin standards provide the basis for minimum design requirements. The Drilling and Completions engineers will receive objectives and data from the Origin subsurface team (geologists and petroleum engineers) to begin planning. The Drilling and Completion's engineers will then develop well concepts that efficiently meet the required objectives and standards. These concepts will be peer reviewed and the best one chosen to move forward to detailed design.

During detailed design it is incumbent on the engineer performing the design to demonstrate how they have met the standards. Senior engineers are required to review and approve the design, and must audit the design. If a minimum requirement is considered not to have been met a list of actions to be met must be agreed before the project can move forward.

13.4 Integrity verification and testing

Any element that forms part of a well barrier envelope must be tested to verify its integrity. Specific requirements are set and must be met or remediated before well operations can continue (see Chapter 4.2).

The Origin standards contain very specific requirements of how many barriers are required in any given situation, what constitutes a permanent or temporary barrier and how that barrier must be tested. This is mostly governed by the Barrier Standard.

13.5 Production and well integrity monitoring

Following construction a well enters its operational phase (see Chapter 4.2) and typically an operations team would take accountability of the well at this point. The operations team have a separate, complementary standard to manage integrity, the Integrity Management Plan (IMP). The IMP defines monitoring, maintenance and integrity testing requirements and frequencies, as well as well integrity assurance activities. Well barriers are tested and pressures monitored regularly to ensure their performance over the lifecycle of the well.

13.6 Well Abandonment

When a well is no longer required it will be abandoned permanently. The only material Origin uses to permanently abandon wells is cement. Cement plugs are placed in wells to prevent cross flow between differently pressured formations and flow to surface. These plugs will undergo pressure testing to ensure that they have the integrity required of a long term barrier. As discussed in Chapter 4.2, cements used in these applications are specially designed for the conditions and long term isolation. Abandonment will be in line with the Cementing and Barrier standards as well as the local regulations. When Origin is satisfied that the abandonment plugs are in place and adequate, the regulator will be notified to provide approval of the abandonment. The wellhead is cut off and environmental cement plug installed at surface, along with a plaque engraved with the well details.

13.7 Well failure and loss of integrity

Well integrity is a key part of well design and a large amount of Origin's resources are dedicated to ensuring well integrity risks are adequately addressed and monitored. When discussing the failure of a well, it is important to distinguish between a barrier failure and a loss of well integrity. Most wells are a nested series of barriers that protect the environment from contamination (from hydrocarbons, HFS fluids, or any other fluids). Failure of a single barrier is unlikely to result in a leak path that could result in contamination. More likely this would trigger an assessment of the impact of the barrier failure and a remedial action plan. A loss of well integrity is a situation in which enough barriers have failed to allow a leak path that could result in contamination. Whether or not contamination occurs will depend on the net direction of pressure along the leak path.

Another important distinction is the type of barrier that fails. Well barriers can be classified broadly in three categories:

1. Drilling Barriers: such as drilling fluid or a blow-out preventer. These barriers are used to temporarily control the well while drilling it and do not form part of the long term well integrity plan. Taking a kick due to the fluid column being under balanced could be described as a barrier failure. However, this is a hazard which is well understood and monitored during drilling operations.
2. Replaceable Production Barriers: such as tubing or wellhead components. This type of equipment can be removed and replaced if worn/eroded or found to be faulty. Typically a well will be designed such that any temporary equipment can be isolated by a secondary redundant barrier or it will not be used as a primary part of the production system. For example a choke valve may wear over time but an isolation valve that will not be used to choke the well can be installed upstream of it to allow it to be changed out.
3. Permanent Barriers: such as casing and cement. These barrier types are robust and subject to modelling that investigates their integrity over the life of the well. It is important these types of barriers are installed and tested correctly as they are expensive to remediate and a failure may mean the well needs to be abandoned.

The philosophy of multiple barriers has been effective in preventing unforeseen events and impacts on the environment. Approximately 18,000 wells have been drilled onshore in Australia, with no systemic water quality issues reported in areas where exploration and development have occurred.

In Western Australia a survey by the Department of Mines and Petroleum of 1035 wells (offshore and onshore) found any adverse environmental impacts were very rare (Standing Committee on Environmental and Public Affairs, Legislative Council Western Australia, 2015). Of 1035 wells reviewed, 122 were found to have issues with barriers (mainly tubing, a replaceable production conduit), however, none were found to be leaking to the environment.

In Queensland from 2010 to March 2015, a total of 6,734 coal seam gas wells were drilled, with no subsurface leaks to the environment reported to the Petroleum and Gas Inspectorate (Gasfields Commission Queensland, 2015). The likelihood of a leak to the environment due to the subsurface well integrity failure can, therefore, be considered remote (or very near zero).

In North America there have been hundreds of thousands of wells drilled and tens of thousands of horizontal shale gas wells drilled and fracture stimulated. This provides a rich data source to examine barrier and well failure events. King and King (2013) considered 253,090 historical wells in Texas and divided the population into those constructed using modern standards (starting in ~1960's) and older wells.. Well integrity failure was ~0.02% for older wells and ~0.004% for newer wells. Another study of the Wattenburg Field in Colorado by Stone et al. (2016) found similar rates of failure. Of 17,948 wells drilled in the Wattenburg Field, 10 (0.06%) cases of methane migration to an aquifer were found. Only one of those 10 wells, however, was constructed with modern era construction standards.

Absolute statistics on well failure rates are not available on a global scale. Well failures are highly dependent on the geological conditions, well type and regulatory regime. In particular high pressures and temperatures and corrosive fluids increase the risk of a well failure. However these risks can be managed to prevent a loss of well integrity. It is important not to conflate a loss of a barrier with a loss of integrity as the reason for redundant barriers is to manage the risks present to an acceptable level.

Ingraffea (2013, 2014) claims that well failure rates in the Marcellus are between 6.9% and 8.9% (Figure 43). These well failure numbers have been commonly cited by opponents to HFS. Analysis of source data, however, suggests that failure rates reported by Ingraffea (2013, 2014) are overstated.. Ingraffea's analysis of Marcellus well failure rates relies on notice of violations (NOVs) issued by the Pennsylvania Department of Environmental Protection (PADEP. Ingraffea (2013,2014) mined the PADEP database for NOVs that they associated with the loss of well integrity, defined as wells leaking outside of production casing. The NOV categories that were included in Ingraffea's (2013,2014) well failure count are summarised in Figure 43. In addition to the wells that satisfied the NOV data mining criteria, Ingraffea's (2013, 2014) reported well failure count also included wells that were not issued NOVs, these wells were included on the basis of qualitative comments from the regulator included in the PADEP database.

VIOLATION CODES	DESCRIPTION/BIN	COUNT
78.73A; 78.73(b); 78.81(a)(2); 607.207; 210INADPLUG	Failure to prevent migrations to fresh groundwater	24
207B	Failure to case and cement to prevent migrations into fresh groundwater	11
78.85; 78.86	Defective, insufficient, or improperly installed cement	120
78.82; 78.83; 78.83GRNDWTR; 78.84; 209CASING	Defective, insufficient, or improperly installed casing	80
78.81D2; 78.83; 78.83COALCSG; 79.12	Defective, insufficient, or improperly installed casing or cement	49
78.73B; 78.81D1	Pressure control	82
210NCPLUG	Inadequate plugging	1

Table 26. Notice of violation codes and counts by Ingraffea (2013, 2014).

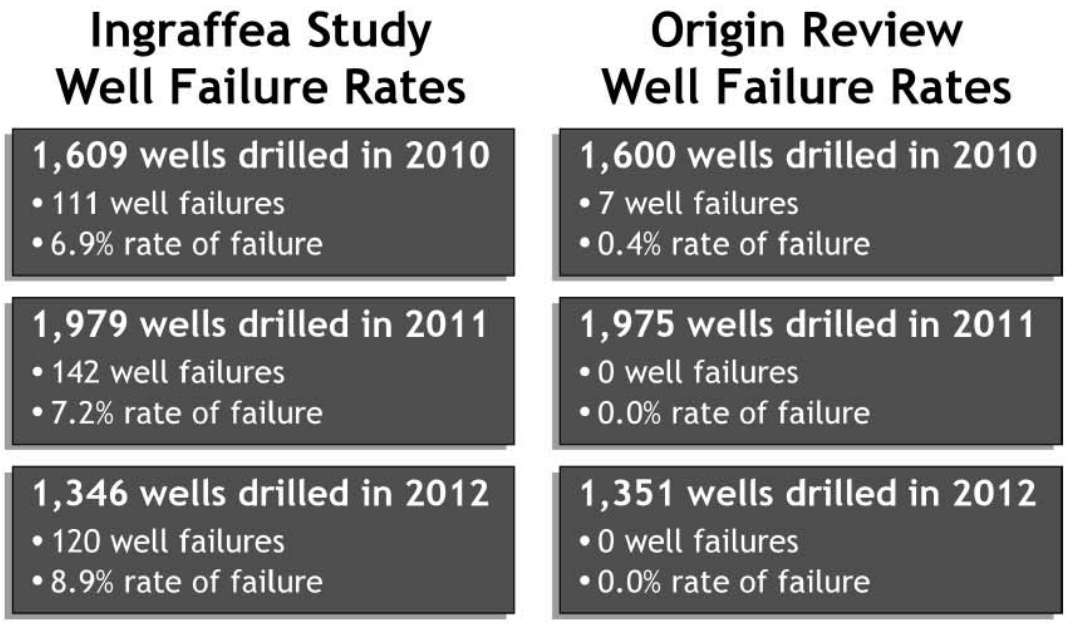


Figure 43. Comparison of statistical analysis of well failure reported by Ingraffea (2013, 2014) and Origin's analysis in this submission.

To assess the claims made by Ingraffea (2013, 2014) Origin compiled all NOVs issued against unconventional wells by the PADEP between 1 January, 2000, and 31 December, 2016 (Appendix 8). Firstly, when discussing the failure of a well, it is important to distinguish between a barrier failure and a loss of well integrity.

1. A loss of well integrity occurs when enough barriers have failed to allow a leak path that could result in contamination. Many of the NOV categories included by Ingraffea (2013, 2014) imply a potential barrier failure but not a loss of well integrity. Our interpretation is that only the following PADEP NOV categories indicate the potential for a loss of well integrity:
    i) **78.73(a) -** GENERAL PROVISION FOR WELL CONSTRUCTION AND OPERATION - Operator failed to construct and operate the well in accordance with 25 Pa. Code Chapter 78 and ensure that the integrity of the well is maintained and health, safety, environment and property are protected.
    ii) **78.73A -** Operator shall prevent gas and other fluids from lower formations from entering fresh groundwater.
    iii) **78.73(b) -** GENERAL PROVISION FOR WELL CONSTRUCTION AND OPERATION - Operator failed to prevent gas, oil, brine, completion and servicing fluids, and any other fluids or materials from below the casing seat from entering fresh groundwater, and prevent pollution or diminution of fresh groundwater.
    iv) **78.81(a)2 -** CASING AND CEMENTING - GENERAL PROVISIONS - Operator conducted casing and cementing activities that failed to prevent migration of gas or other fluids into sources of fresh groundwater.
    v) **207B -** Failure to case and cement to prevent migrations into fresh groundwater.
2. The NOVs associated with potential well integrity failures (i.e. categories 78.73(a), 78.73A, 78.73(b), 78.81(a)2 and 207B) were often issued pre-emptively during design or well construction phases (i.e. before any well integrity failure could occur).
3. The PADEP has been commended for their effective and robust regulatory framework, in particular with respect to HFS, by the State Review of Oil and Natural Gas Environmental Regulations (STRONGER, 2013). It is a sign of a well-functioning regulator that PADEP issued pre-emptive NOVs when minimum well construction requirements were not met.
4. 97 of the 473 wells that Ingraffea (2013, 2014) claimed failed did not receive a NOV, but were highlighted in commentary from a PADEP inspector. In these cases there is sufficient data to conclude there was a well integrity failure, and the absence of an NOV suggests that there was not.
5. PADEP require the operator to rectify NOVs through remedial work. The majority of the NOVs issued by the PADEP have been corrected by the operator in order to comply with the PADEP regulatory requirements and this is not accounted for by Ingraffea (2013, 2014).
6. Ingraffea's (2013, 2014) data only extends to 2012. Based on the PADEP NOV data compiled by Origin the number of NOVs has on average declined year on year. This is likely a function of a good regulatory framework managed by the PADEP resulting in operators that are aware of regulatory expectations.

Considering these points, Origin's review of the NOVs associated with well failure (Table 27) suggests a significantly lower failure rate than presented by Ingraffea (2013, 2014). Origin estimates the well failure rate based on the PADEP NOV data is between 0.05% and 0.11%, which align with recent studies by King and King (2013) and by Stone et al. (2016).

YEAR	UNCONVENTIONAL WELLS DRILLED	NOVs ASSOCIATED WITH POTENTIAL WELL FAILURE*		NOVs ASSOCIATED WITH POTENTIAL WELL FAILURE* WITH A CONFIRMED RELEASE TO THE ENVIRONMENT**		UN REMEDIATED*** NOVs ASSOCIATED WITH POTENTIAL WELL FAILURE* WITH A CONFIRMED RELEASE TO THE ENVIRONMENT**	
		TOTAL	AS A PERCENTAGE OF WELLS DRILLED	TOTAL	AS A PERCENTAGE OF WELLS DRILLED	TOTAL	AS A PERCENTAGE OF WELLS DRILLED
2002	1	0	0.00%	0	0.00%	0	0.00%
2003	4	0	0.00%	0	0.00%	0	0.00%
2004	2	0	0.00%	0	0.00%	0	0.00%
2005	9	0	0.00%	0	0.00%	0	0.00%
2006	37	1	2.70%	0	0.00%	0	0.00%
2007	114	2	1.75%	0	0.00%	0	0.00%
2008	332	1	0.30%	0	0.00%	0	0.00%
2009	818	4	0.49%	1	0.12%	1	0.12%
2010	1,600	13	0.81%	7	0.44%	2	0.13%
2011	1,957	5	0.26%	0	0.00%	0	0.00%
2012	1,351	2	0.15%	0	0.00%	0	0.00%
2013	1,214	3	0.25%	1	0.08%	0	0.00%
2014	1,371	1	0.07%	0	0.00%	0	0.00%
2015	784	5	0.64%	2	0.26%	2	0.26%
2016	504	0	0.00%	0	0.00%	0	0.00%
2017	185	0	0.00%	0	0.00%	0	0.00%
Total	**10,283**	**37**	**0.36%**	**11**	**0.11%**	**5**	**0.05%**

* NOV categories included: 78.73(a), 78.73A, 78.73(b), 78.81(a)2 and 207B

** PADEP NOVs where the comments indicated that no well integrity failure had occurred (i.e. pre-emptive NOVs, and NOVs associated to surface equipment such as separators) were removed

*** NOVs have not been confirmed as corrected, fixed, or remediated by the PADEP

Table 27. Origin review of well failure rates based on Pennsylvania Department of Environmental Protection (PADEP) notice of violation (NOV) data.

13.8 EPA well failure analysis and drinking water impacts

The EPA (2016) conducted an extensive, multi-year study on the impacts of the HFS water cycle on drinking water resources in the USA. EPA (2016) did not focus solely on well failures, and included a broad work scope that covered the entire HFS water cycle. In the following sections we briefly review the following material from EPA (2016):

1. Surface water and groundwater contamination resulting from surface spills associated with HFS operations
2. The potential for contamination resulting from HFS fluids entering groundwater resources via subsurface migration pathways caused by HFS operations – and the absence of evidence for such contamination for deep (>1500 m) shale gas HFS operations
3. Ground water contamination resulting from stray gas migration associated with HFS operations

13.8.1 Surface spills

The EPA (2016) reports surface spills associated with the chemical mixing and produced water handling stages of HFS operations that have impacted surface water or groundwater quality. Origin addresses the risks associated with surface handling of chemicals, HFS fluids, and flowback fluids in Section 4.3. The risks of handling chemicals are not unique to the oil and gas industry. Origin believes that these risks can be appropriately mitigated by applying the controls outline in Section 4.3.4, which describes the three tier barrier philosophy to prevent and mitigate surface spills. Origin's first barrier is to prevent spills through the appropriate design of the primary containment systems, and commissioning and operating procedures. Origin's second barrier is spill containment which is achieved through secondary containment. If the first two barriers fail Origin is prepared with a third barrier which is our spill remediation protocol. Together these barriers mitigate the risk of spills and in the event that a spill occurs the likelihood of it impacting the ground or surface water resources.

13.8.2 HFS fluid migration

None of the instances of ground water contamination reported by EPA (2016) were a result of HFS fluid migration associated with well injection (i.e. resulting from migration pathways related to fractures and the flow of fluids out of the production zone, fracture overgrowth out of the production zone, or fractures intersecting geological features). The EPA (2016) discuss factors that could lead to an increased risk of groundwater contamination as a result of HFS fluid migration, such as:

1. The vertical offset between the target formation and the groundwater resource, and
2. The presence of offset wells proximal to wells being fracture stimulated, particularly if such wells are old and were, therefore, not constructed to modern standards

The EPA (2016) conclude that the risk of contamination is highest in areas such as the Raton, San Juan, and Powder River basins which have small vertical offsets and lowest in areas such as the Marcellus and Barnett which have large vertical offsets. The Beetaloo is analogous to the latter as there is a very large vertical offset between the target intervals (Velkerri and Kyalla formations) and the groundwater resource (CLA). There are also multiple laterally continuous confining layers in the Beetaloo that separate HFS targets and the CLA. Origin's technical opinion is that in the Beetaloo there is effectively no risk of HFS fluid migrating into and contaminating groundwater resources due to the large vertical offset and the lack of legacy well bores – two key risk factors identified by the EPA (2016).

13.8.3 Stray gas migration

All the instances of potential ground water contamination associated with fluid migration referenced in the Well Injection chapter of EPA (2016) were linked to stray gas migration resulting in elevated methane concentration in groundwater. The EPA (2016) described stray gas migration as a "technically complex phenomenon to study because there are many sources and routes for migration". The source of the stray gas can be natural gas reservoirs (either conventional or unconventional), or coal mines, landfill, buried organic matter, or natural microbial processes. To complicate matters further it is difficult to determine whether stray gas derived from conventional or unconventional resources (i.e. thermogenic gas) found in ground water resources migrated naturally or as a result of leaking wells. This is particularly challenging in areas with inadequate baseline data (EPA, 2016). For this reason Origin is actively acquiring groundwater baseline data. Section 4.1.1 outlines Origin's ground water monitoring program.

The EPA (2016) assessment concludes that poorly designed and constructed wells can result in stray gas migration impacting ground water resources. The potential for stray gas migration is a risk that must be addressed in all wells and is not associated to a resource type (conventional or unconventional), a well orientation (vertical, deviated, or horizontal), or whether or not a well has been fracture stimulated. Leaking wells that have resulted in stray gas migration typically have common characteristics. The two most common outlined by the EPA (2016) are:

1. Inadequate surface casing depth (i.e. surface casing not landed deeper than the aquifer)
2. Inadequate top of cement (i.e. cement top not above the shallowest hydrocarbon bearing formation)

When wells are properly designed the occurrence of stray gas migration is extremely low. As such, Origin believes that this risk can be effectively mitigated through proper well design and construction (see Section 4.2.2). In the Beetaloo, Origin has managed the risk of stray gas migration by setting the surface casing below the groundwater resource (CLA) and by cementing to above the shallowest hydrocarbon bearing formation (typically the Chamber's River Sandstone).

13.8.4 Case study: Pavillion, Wyoming

The Pavillion Gas Field, in Wyoming, is included in the EPA (2016) study and is often referenced by gas industry opponents (e.g. Lock the Gate) as an example of the risks associated with unconventional development and HFS. There are several misconceptions about the Pavillion Gas Field that are worth clarifying. It is clear from a review of the EPA (2016) reporting on issues at Pavillion that although drinking water is impacted by stray gas at Pavillion, the impacts are not linked to HFS but are associated with a combination of:

- natural migration.
- poor wellbore design, and
- the historical practice of using unlined pits containing invert drilling mud.

Important context and clarifying points related to the Pavillion Gas Field:

- The Pavillion Gas Field is conventional gas field: "The Pavillion Gas Field is different than gas fields recently associated with hydraulic fracturing in other areas, in that the gas is sourced from permeable sand reservoirs using standard vertical wells, and not sourced from less permeable shale using horizontally-drilled wells" (AME, 2016).
- The HFS operations that have occurred in the Pavillion Gas Field are designed to bypass near wellbore damage and as such the typical HFS size is very small. Treatment fluid volume typically range between 75 and 100 barrels (12 to 16m^3).
- The AME (2016) findings state that the "evidence does not indicate that hydraulic fracturing fluids have risen to shallow depths utilized by water-supply wells. Also, based on an evaluation of hydraulic fracturing history, and methods used in the Pavillion Gas Field, it is unlikely that hydraulic fracturing has caused any impacts to the water-supply wells" (AME 2016).
- AME (2016) findings state that some wells are experiencing slow gas seepage (AME, 2016). A report on the Pavillion field by AME (2016) identified a similar set of risk factors for stray gas fluid migration that Origin have previously discussed in Sections 4.2.2 and (13.8.3 above) including: uncemented production casing, shallow surface casing, and the presence of both an intermediate pressurized gas zone and a permeable groundwater zone encountered in the same production wellbore.

Many issues are falsely attributed to HFS activities. Stray gas migration is frequently wrongly attributed to HFS operations when it is a function of poor wellbore design and construction. Origin's standards and the strong NT regulatory requirements (Chapter 4.2 and Chapter 13.1-13.6) provide multiple layers of protection to prevent stray gas migration from impacting groundwater resources.

14 GEOLOGY

14.1 Overview

This Section is intended to provide geological information relevant to unconventional prospectivity and HFS in the region of the NT where the Roper Group and equivalents (Munson and Ahmad, 2013; Munson, 2016) are mapped across the greater McArthur Basin (Betts et al., 2015) (Figure 44). More detailed descriptions of the geology of the Beetaloo area are provided as this is the area of Origin's exploration focus in the region.

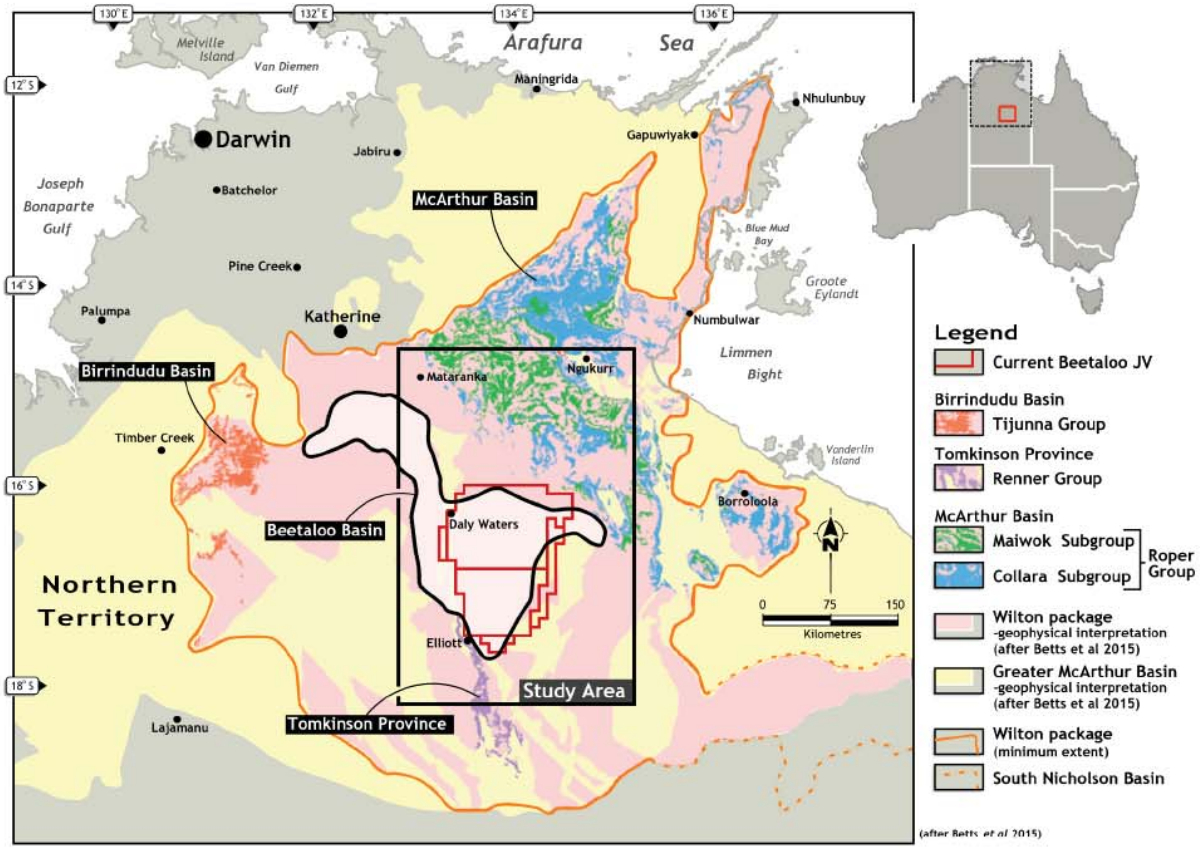


Figure 44.. The extent of the Roper Group and equivalents within the greater McArthur Basin after Munson (2016).

The Roper Group is a Mesoproterozoic succession of silicilastic rocks that is unconformably bound by the Nathan Group (below) and the Barkly Group (above) (Figure 45). The configuration of the formations and units that collectively comprise the Roper Group in the Beetaloo is illustrated schematically in Figure 46. The Roper Group is largely flat lying and unstructured through the core of the Beetaloo.

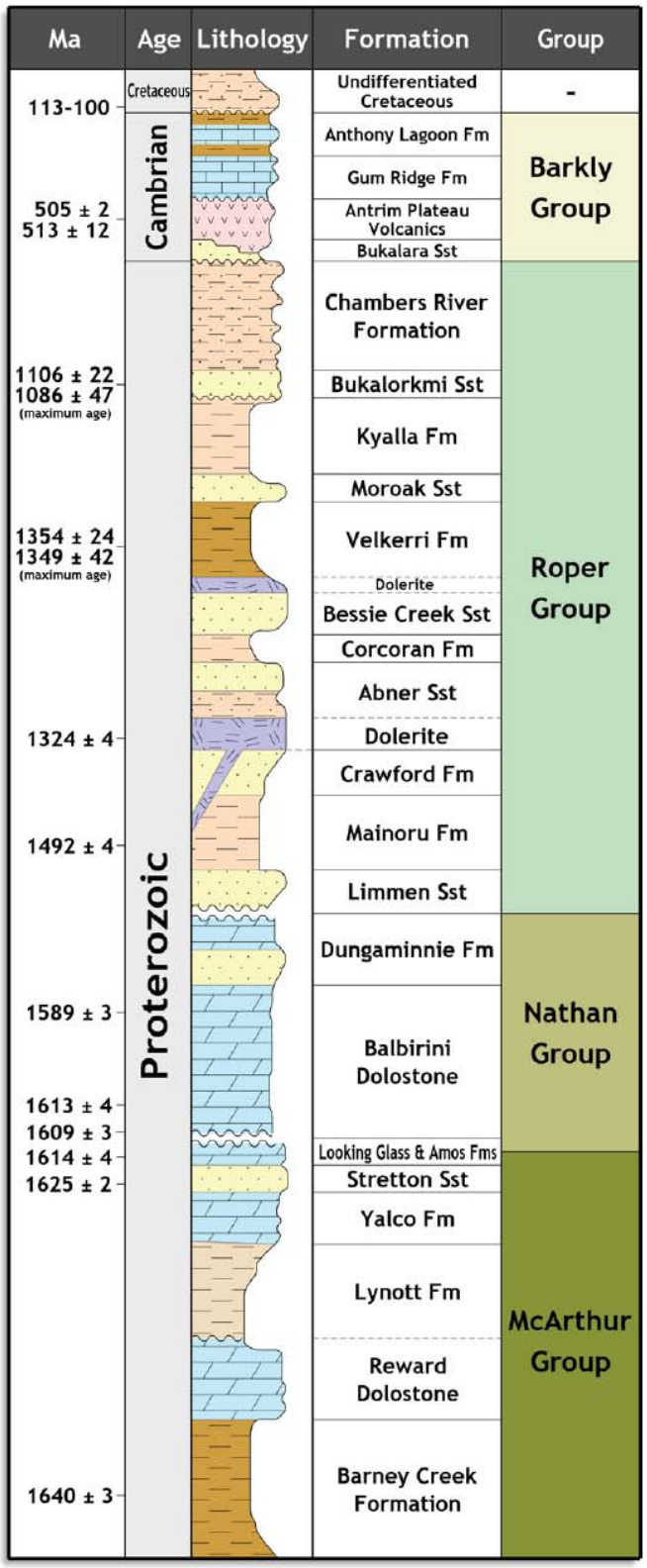


Figure 45.. Stratigraphic Chart representative of the Greater McArthur Basin, which includes the Proterozoic successions of the McArthur Group, Nathan Group, Roper Group and Barkly Group.

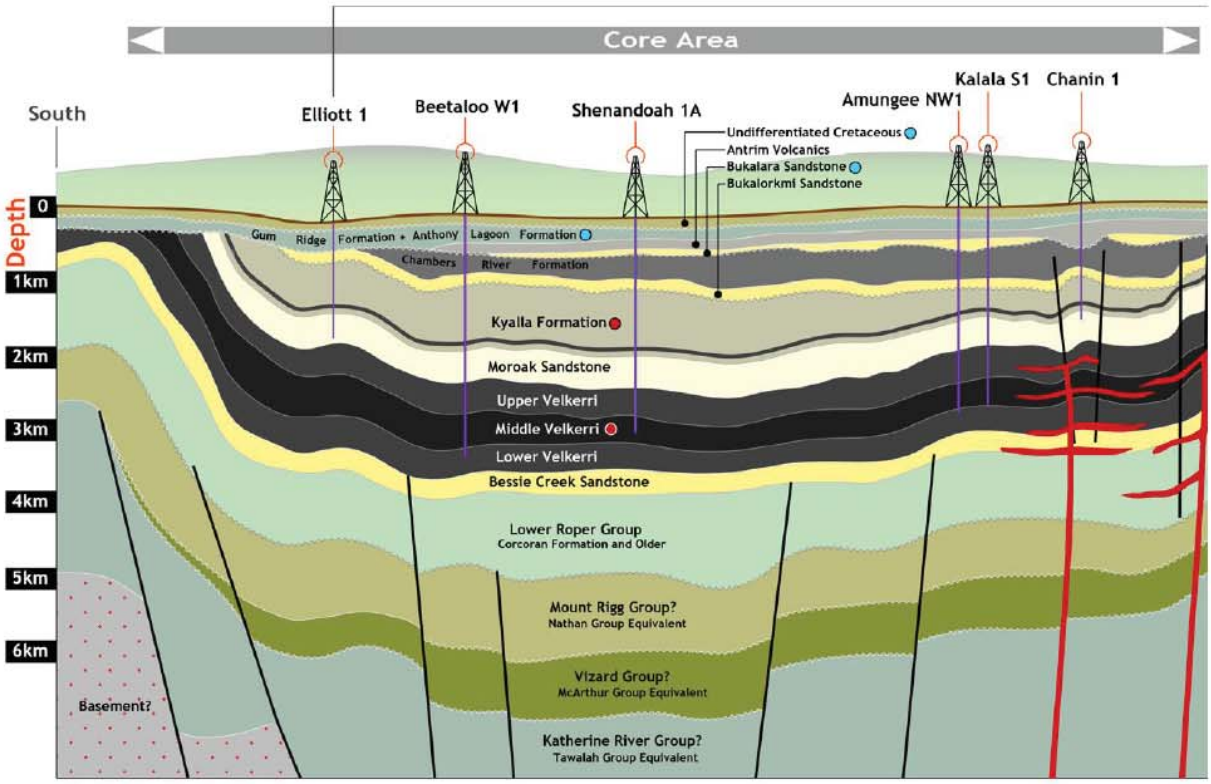
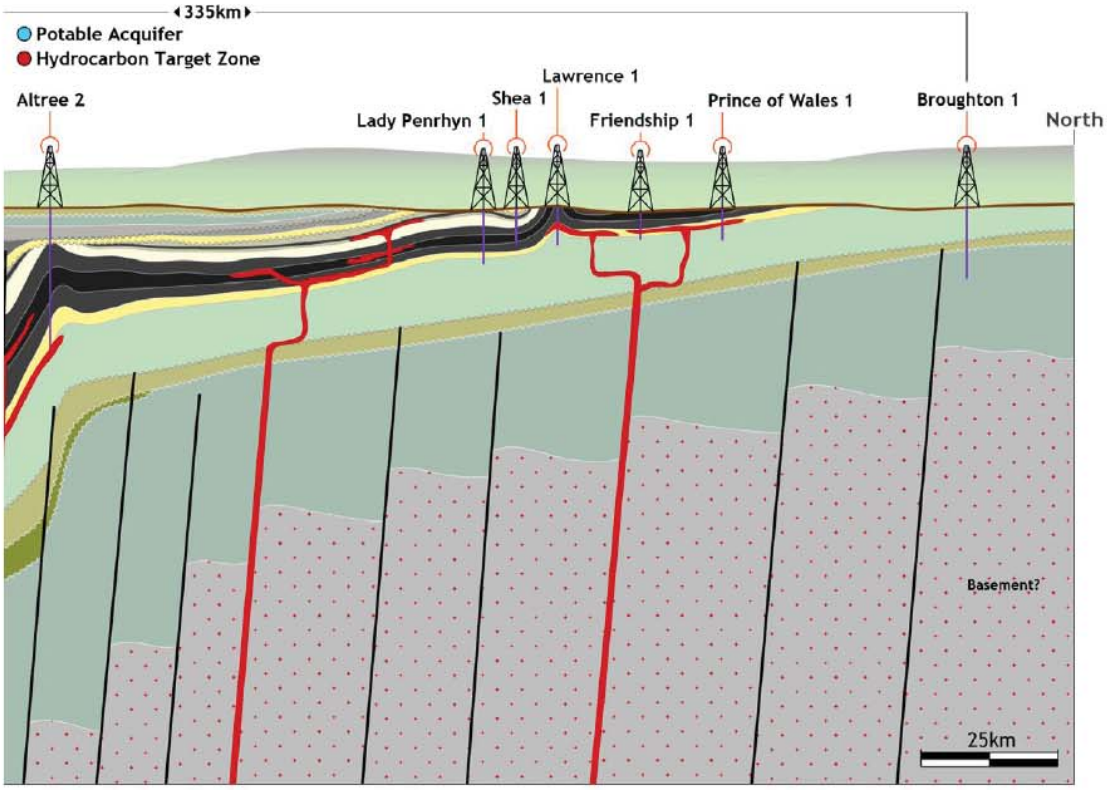


Figure 46. Schematic N-S cross section across the Beetaloo, which was a major depocentre for over a billion years and includes basin successions (or equivalents) from the McArthur Group, Nathan Group, Roper Group (all Proterozoic) and the Barkly Group (Cambrian).



The prospectivity of the primary unconventional targets in the Beetaloo, the source rock intervals within the Velkerri and Kyalla formations, is discussed at a high level in the following sections. The primary purpose of the subsequent sections, however, is to detail the in-situ geological barriers that separate the target formation intervals, (where HFS will be required to allow hydrocarbon production), from any potable aquifers. Geomechanical data and models illustrate there is no potential for a hydraulically induced fracture to grow out of zone and into a potable aquifers.

14.1.1 What is a source rock? What makes a 'good' source rock?

A source rock is a key element in any petroleum system (Figure 47), it is the rock that is capable of generating or that has generated movable quantities of hydrocarbons (AAPG, 2017). In conventional oil and gas resources, hydrocarbons migrate out of the source rock and travel along a migration pathway until they either reach a trap where reservoir and seal rocks allow their accumulation or until they reach the earth's surface where they naturally seep/release to atmosphere. In unconventional oil and gas resources, however, the source rock is also the reservoir and seal rock – that is, it is a self-sourcing and self-sealing system and no migration or trap is required.

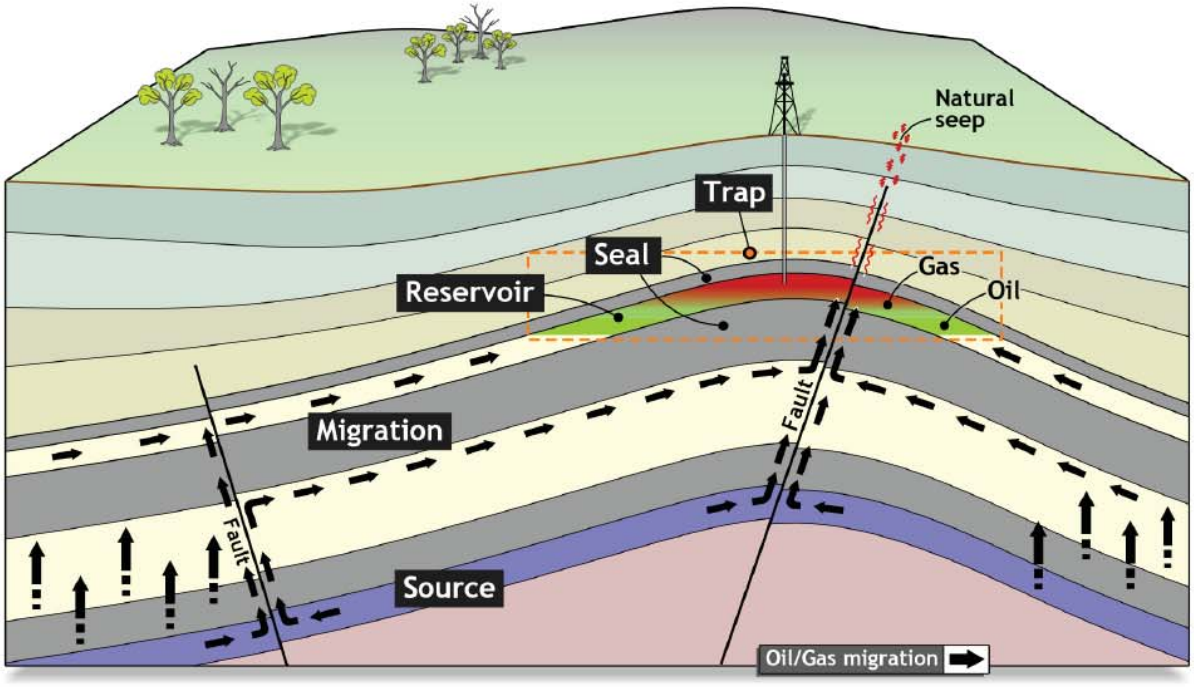


Figure 47. Schematic representation of the key elements of the petroleum system. Despite hydrocarbon generation and migration being critical, timing must also be considered when assessing whether a hydrocarbon accumulation is likely to be found.

Source rocks are, by definition, enriched in organic carbon; typically through the accumulation and preservation of plant and/or animal matter. Different types of organic materials result in different types (and classifications) of source rocks. Accumulation of plant based and woody type organic materials (e.g. peat swamps) will ultimately produce coal if buried to sufficient temperature and pressure; coals are often close to 50% organic matter. Whereas the accumulation of animal matter (typically in the form of micro-organisms, e.g. plankton, foraminifera, algae) produces "black shales" if buried to sufficient temperature and pressure; black shales will typically have much lower fractions of organic matter relative to coal (on the order of 2-20%).

As land plants are not present in geological history until the Ordovician (488 to 443 Ma[10]), there is no potential for coal source rocks in the Beetaloo below the thin veneer of Cretaceous and recent rocks that are not exploration targets. There are, however, black shales across large parts of the Beetaloo and broader McArthur basins in the Proterozoic strata. Some of these source rock intervals are of very high quality. There are a number of key parameters that define source rock quality:

- Total Organic Content (TOC).
- Quality of organic content (type and proportion of individual kerogens – which controls the prevalence of hydrogen and oxygen).
- Maturity of organic material (largely a function of peak temperature the rocks have been exposed to during burial).

There are numerous metrics and plots that geochemists use to classify source rock quality. One relatively simple approach is illustrated in Figure 48, which plots total organic carbon against the amount of gas generated when heated (S2); for relatively immature samples (such as those from the shallower Walton-2 well) very little organic carbon has been converted to natural gas. Conversely, samples from deeper within the Basin (e.g. Amungee NW-1) have little remaining potential to generate gas, but we can confidently infer that large quantities of natural gas have been cracked from the source horizons within the Velkerri Formation at these depths. Figure 48 shows that both the Velkerri Formation and Kyalla Formation have excellent source rock properties at varying levels of maturity across the Beetaloo Basin.

10 Ma: million years

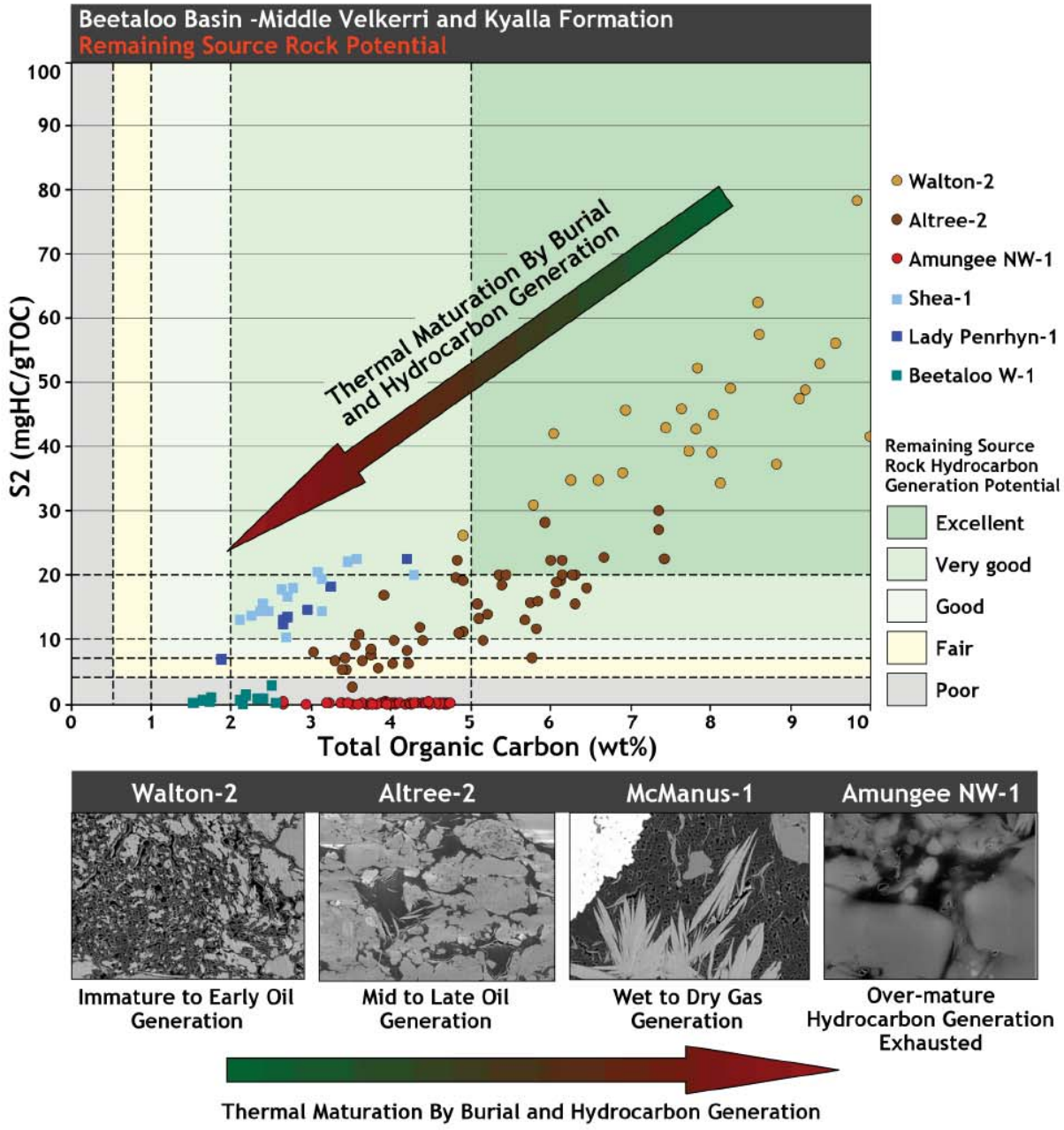


Figure 48. Total Organic carbon vs S2 (gas expelled during systematic heating as part of the Rock Eval™ process) plot shows the 'excellent' quality of the Velkerri Formation and Kyalla Formation source rock intervals.

14.2 Beetaloo Geology

14.2.1 Data Availability (Geology and Geophysics)

The distribution of wells that penetrate the Velkerri and/or Kyalla formations and 2D seismic data is shown in Figure 49. Relative to much of the NT, data coverage across the Beetaloo area is good with ~20 wells penetrating the Velkerri Formation, ~15 wells penetrating the Kyalla Formation, and ~9,500 km of 2D seismic data.

Most of the wells included in Figure 49 were drilled as petroleum exploration wells between 1988 and 1993 by Pacific Oil & Gas. There are conventional core and wireline log data available from most of these 'legacy' wells, which are helpful in constraining the extent, depths and intrinsic properties of the Velkerri and Kyalla formations (Figure 50 and 51). Very little exploration activity occurred in the late 1990s and early-to-mid 2000s, until Sweetpea Corporation drilled Shenandoah-1 in 2007, which was subsequently deepened to the Velkerri Formation by Falcon Oil & Gas in 2009. Shenandoah-1A is a key well as it was the first deep penetration of the Velkerri Formation in the Beetaloo and the first well to evaluate the Velkerri Formation as a primary exploration target.

Since the drilling of Shenandoah-1 there has been an increase in activity with ~10 wells drilled since 2014. These recent wells have modern wireline log data suites specifically optimised to evaluate the source rock targets of the Velkerri Formation and/or Kyalla Formation. These new data have provided substantially more information regarding the geology and prospectivity of the source rock plays within the Beetaloo.

Seismic data within the Beetaloo area are of variable quality, with clear imaging of the subsurface possible where the Antrim Plateau Volcanics (shallow basalts – Figure 45) are absent but generally poor imaging quality when present (Figure 52 and 53). The seismic data are excellent for understanding the morphology of the Beetaloo Basin, including the relatively steep western, southern and northern flanks and the more gently shoaling eastern flank. The seismic data also demonstrate the strata within the basin (i.e. away from the steep flanks) are relatively gently dipping and largely unstructured with a notable absence of large scale, regional faults or structures.

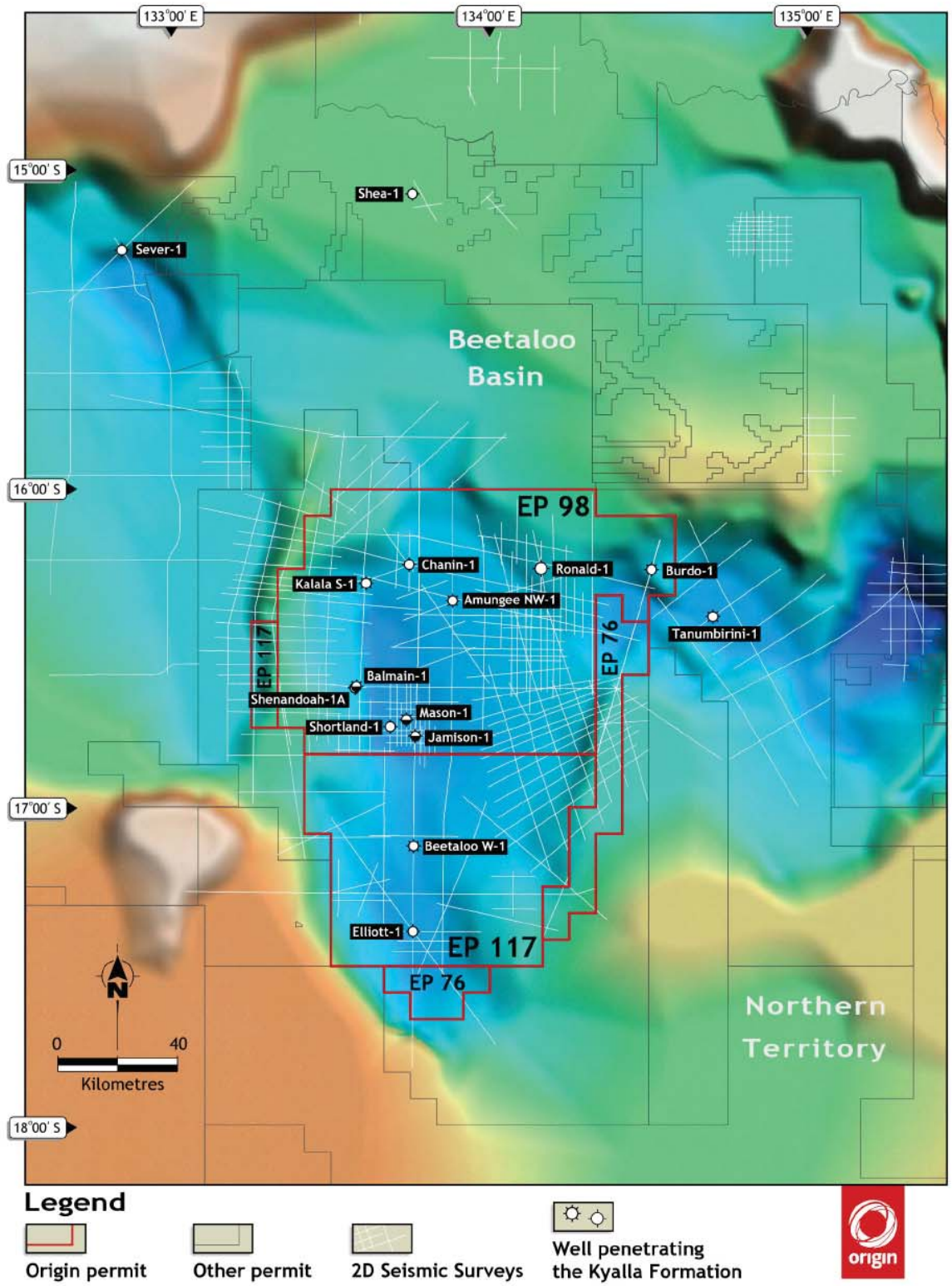
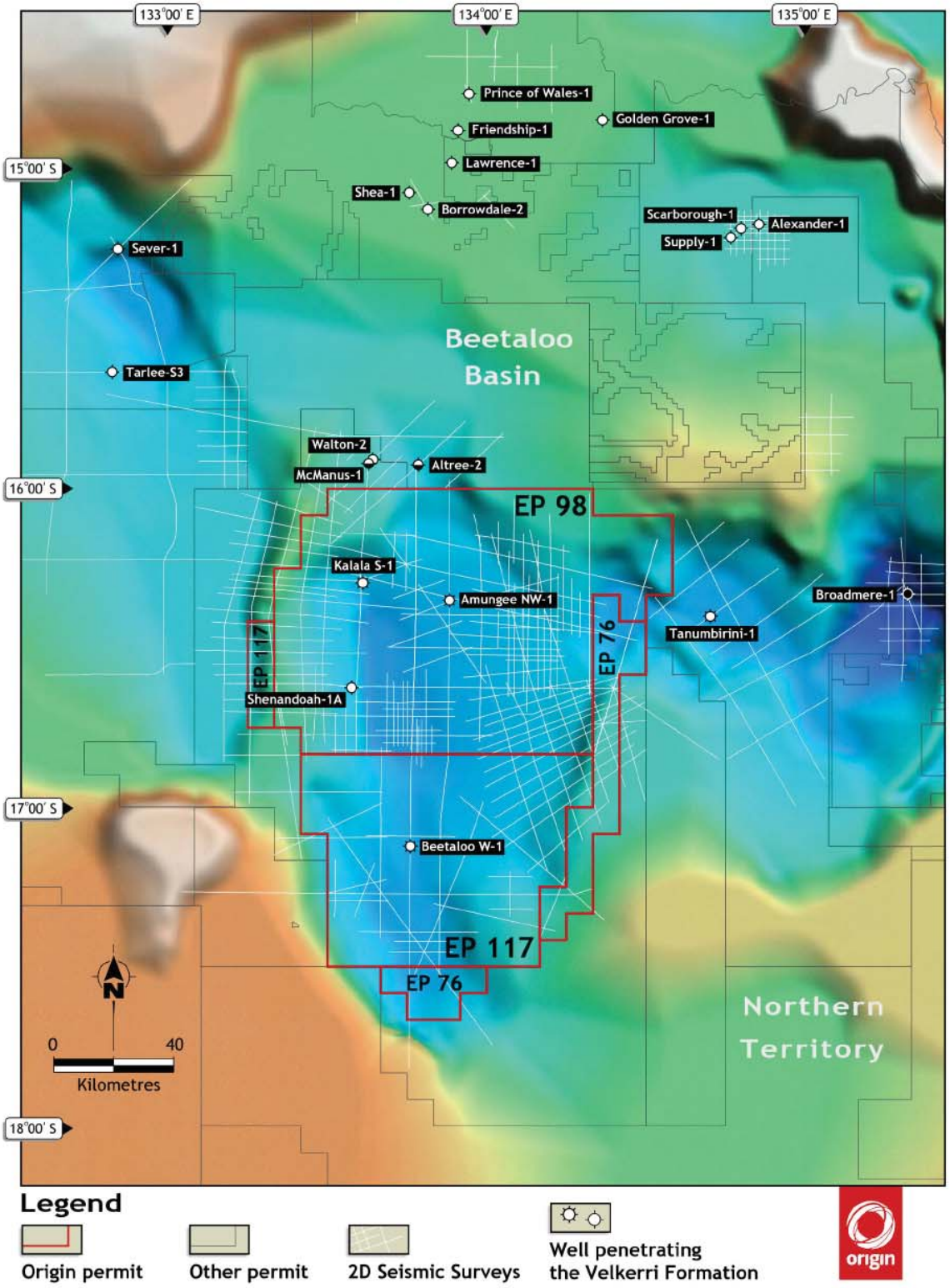


Figure 49. Wells and seismic data useful in constraining the presence and quality of source rocks in the Beetaloo region.


133°00' E
134°00' E
135°00' E
15°00' S
16°00' S
17°00' S
18°00' S
Prince of Wales-1
Golden Grove-1
Friendship-1
Lawrence-1
Shea-1
Borrowdale-2
Scarborough-1
Alexander-1
Supply-1
Sever-1
Beetaloo Basin
Tarlee-S3
Walton-2
McManus-1
Altree-2
EP 98
Kalala S-1
Amungee NW-1
Broadmere-1
Tanumbirini-1
EP 117
EP 76
Shenandoah-1A
Beetaloo W-1
EP 117
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Northern Territory
N
0
40
Kilometres
Legend
Origin permit
Other permit
2D Seismic Surveys
Well penetrating the Velkerri Formation

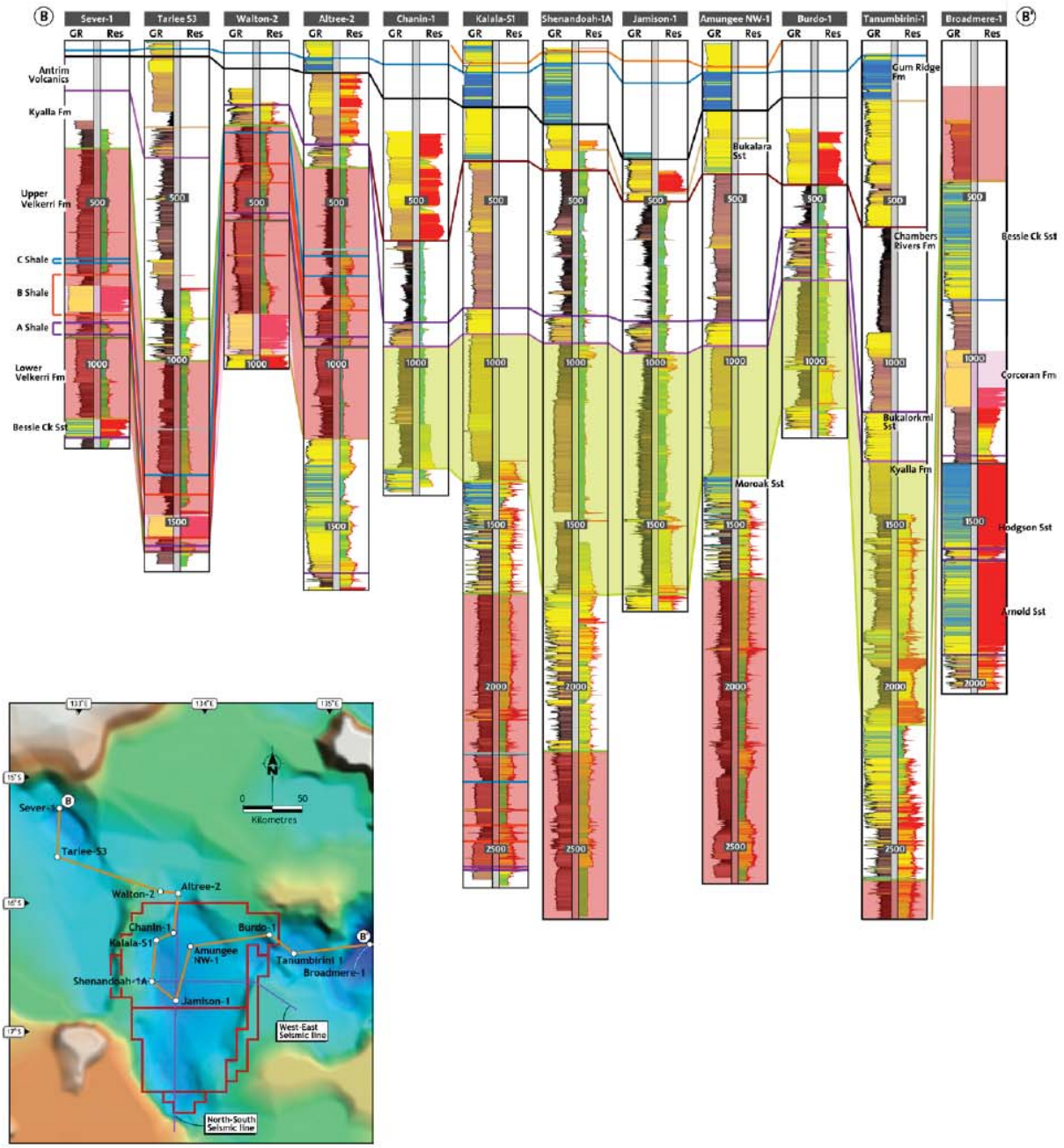

Figure 50. E-W cross section through the Beetaloo of wells drilled from 1998 to 2010 that penetrate the Velkerri and/or Kyalla formation.

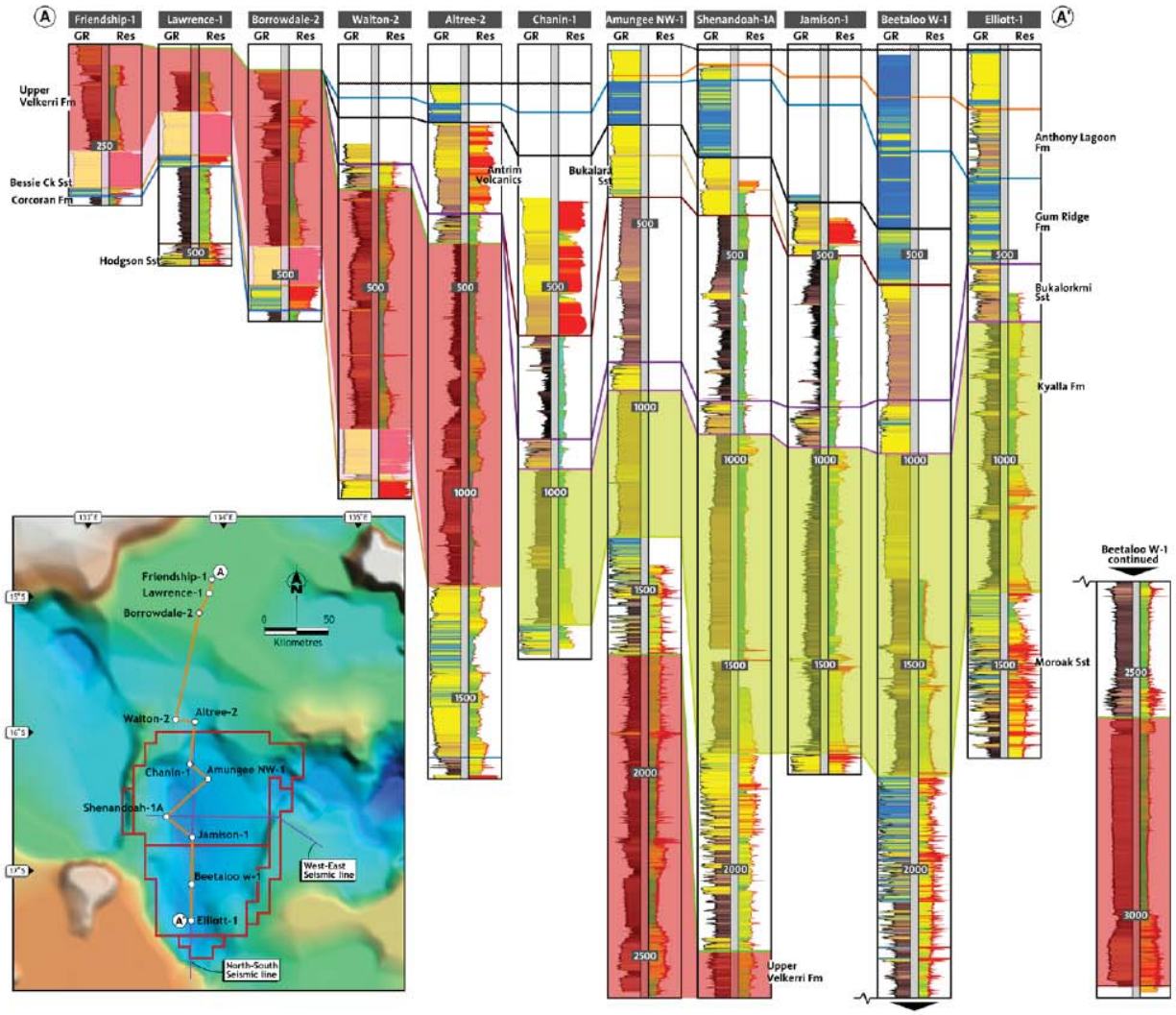

Figure 51. N-S cross section through the Beetaloo of wells drilled from 1998 to 2010 that penetrate the Velkerri and/or Kyalla formation.

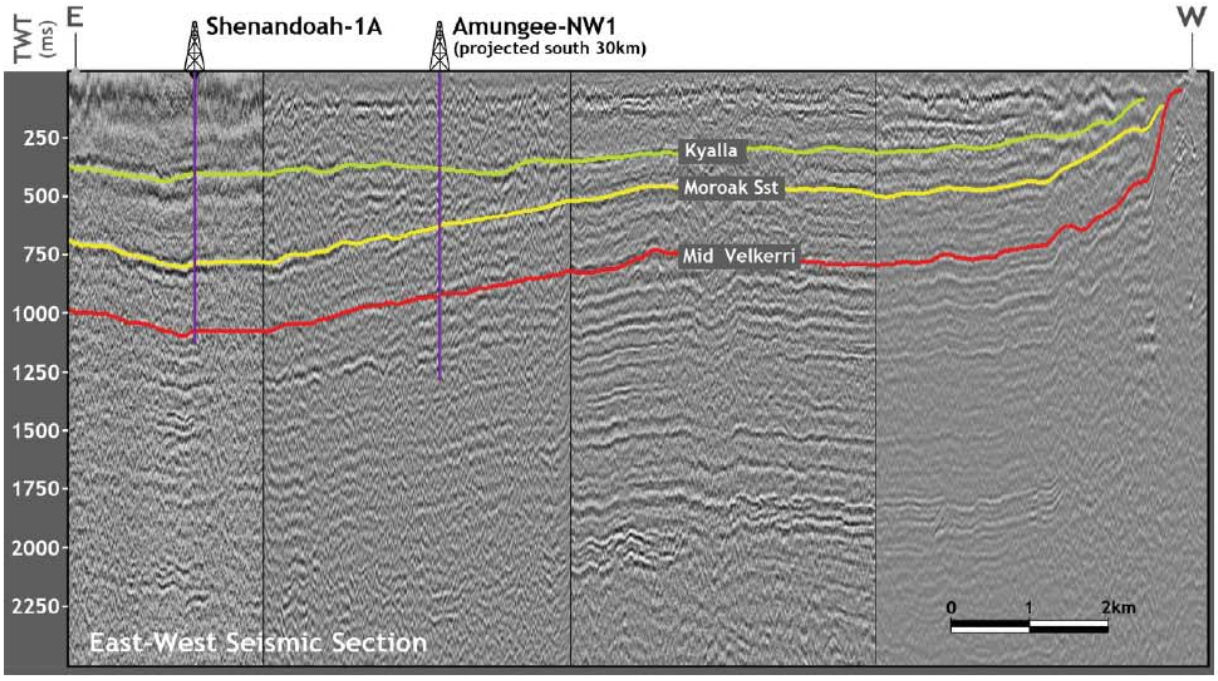

Figure 52. E-W composite seismic line across the central Beetaloo – see Figure 51 for location. The steep western flank is not imaged in this line, but the gradually shoaling of the strata to the east is evident.

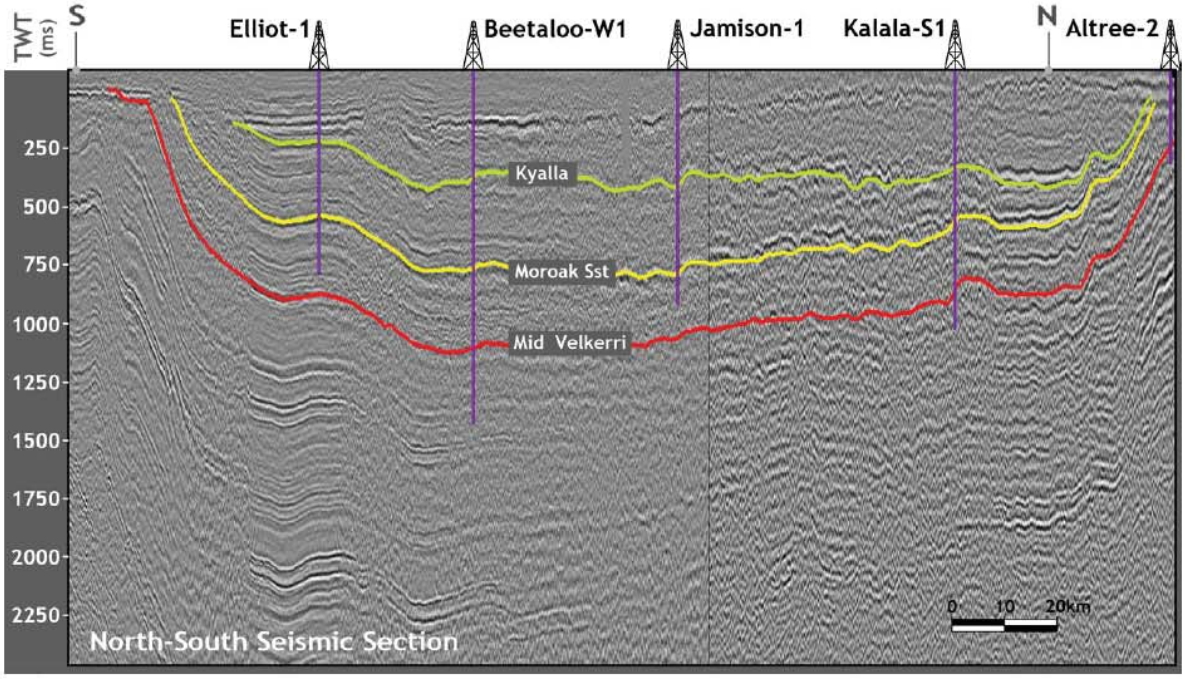

Figure 53. N-S composite seismic line across the Beetaloo that illustrates the relatively steep southern and northern flanks – see Figure 51 for location.

14.2.2 Regional Setting – McArthur, Roper and Beetaloo basins

The greater McArthur Basin is an informal term for a vast, predominantly sedimentary, terrane stretching across the northern part of the NT from north-eastern Western Australia to north-western Queensland (Figure 44). Despite covering a great portion of the NT, the total subsurface extent of the McArthur Basin remains poorly constrained. A remarkable aspect of the McArthur Basin is that it preserves some of the oldest, organic-rich source rock intervals in the world within the Barney Creek (Paleoproterozoic, >1640 Ma), Velkerri Formation and Kyalla Formation (Mesoproterozoic, 1600-1000 Ma). The environment of deposition throughout much of the Proterozoic is interpreted as a restricted marine environment with high organic productivity. This resulted in a prolific, long-lived, source-sink system where organic-rich sediments accumulated and were preserved over a vast area. Despite their age, these source rocks have not been exposed to extreme alteration, rather they have remained within the depth and temperature ranges for the thermogenic generation of gas.

The Beetaloo is one of the largest and deepest depositional centres within the greater McArthur Basin (Figure 44). It is structurally subdivided into three geographical areas by two north-south trending structural highs; the structurally complex Daly Waters Arch (west) and structurally benign Arnold Arch (east) that separate the Gorrie Sub-Basin, the core of the Beetaloo Sub-Basin and the OT Downs Sub-Basin from west to east respectively (Figure 54). North of the Beetaloo area seismic and well penetrations indicate that the strata shallow significantly (e.g. Figure 51). Typically the Kyalla Formation has been eroded outside of the Beetaloo area and the Velkerri Formation is often found at depths of <1000m or in some areas it has also been eroded. The Beetaloo area retains the thickest and most complete Roper Group section.

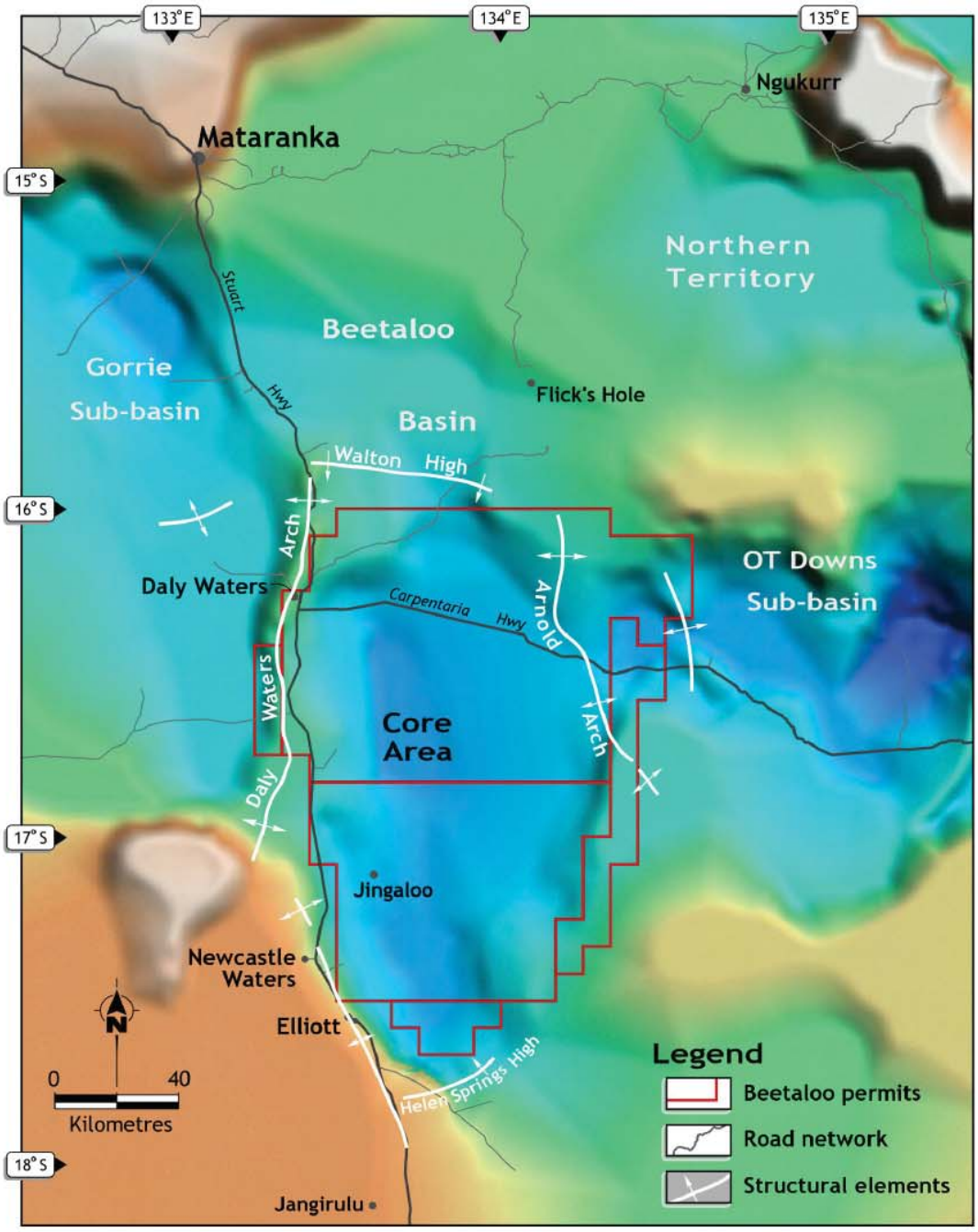

Figure 54.. Geographic sub-division of the Beetaloo Basin based on structural lineaments.

The Roper Group comprises six, stacked successions of predominantly marine mudstone and sandstone units which reach thicknesses in excess of 3,000 m (Abbott and Sweet 2000). Post deposition, the Roper Group has been intruded by dolerite dykes and sills (Derim Derim Dolerite) in the Gorrie Sub-Basin and north-western Core area. The succession has yet to be fully penetrated in the deepest portions of the Basin; however, the Group can be interpreted in seismic and well data across the Beetaloo area, where it is characterised by a consistent thickness and lateral continuity (Munson 2014). Based on the Abbott and Sweet (2000) type section for the northern Beetaloo and Tanumbirini-1 for the OT-Downs and Core area, mudstone comprises over 60% and 80% respectively of the total Roper Group thickness.

14.3 The Velkerri Formation

The Velkerri Formation comprises up to 900 m of mudstones with interbedded siltstones and organic-rich source rock intervals (Figure 55), which is based on log data from wells across the Beetaloo. Note the most common lithology is organically lean, clay-rich shale rather than source rock. The source rock intervals make up a relatively minor proportion of the total Velkerri thickness.

The Velkerri Formation is subdivided into three informal members – lower, middle and upper Velkerri Formation members. The source rock intervals found in the middle Velkerri, are sub-divided into the "A Shale", "B Shale" and "C Shale" from oldest to youngest (Figure 55).These organic-rich mudstones are separated by organic-lean siltstones – i.e. the Velkerri is not a homogenous target that has gas equally distributed throughout. This is a key point for understanding how the Velkerri can be both a target/reservoir and also provide barriers to fracture height growth.

Overlying the prospective targets in the middle Velkerri Formation are hundreds of metres of clay-rich shales that are not prospective for hydrocarbon exploration. The upper Velkerri is a regional aquitard (effectively impermeable) and a barrier to fracture growth due to its contrasting elastic properties and higher stress magnitude. Fractures initiated in the middle Velkerri, therefore, will not propagate into the upper Velkerri. Subsequent sections cover in detail the concepts of geological barriers to fracture growth.

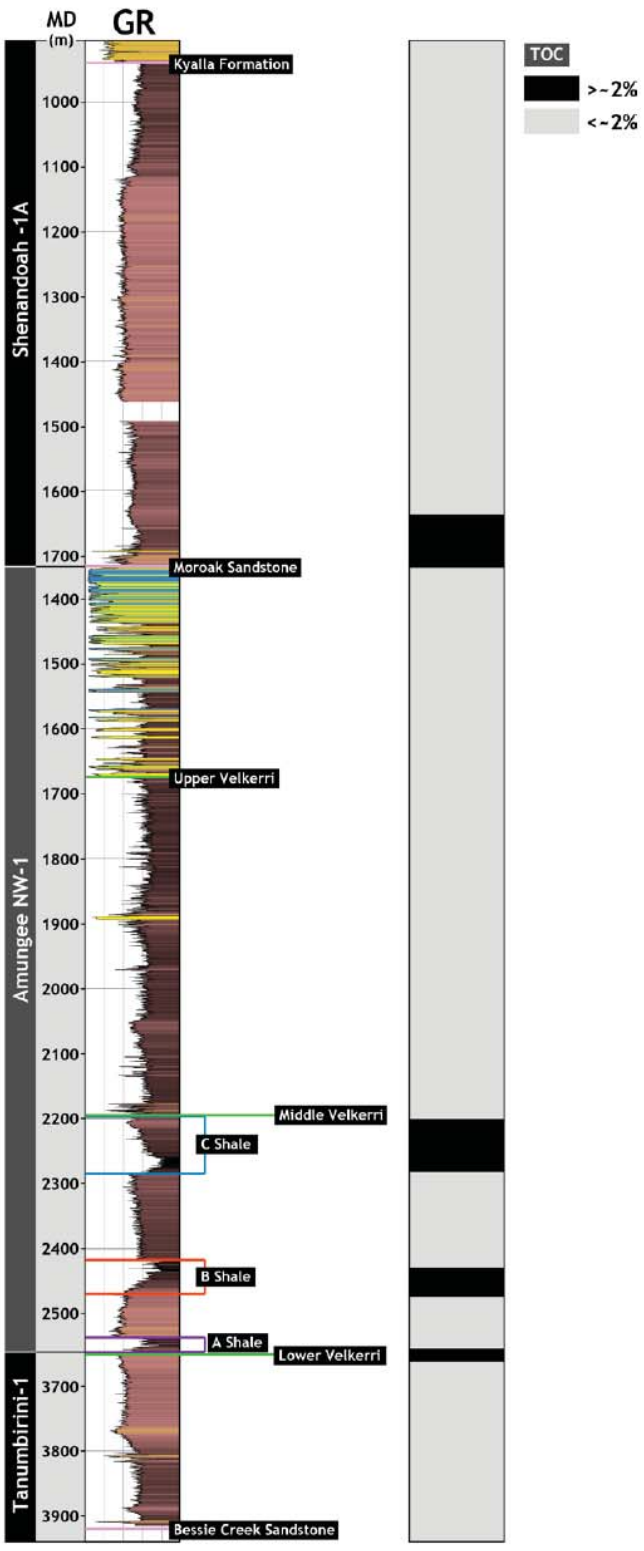

Figure 55.. Velkerri Formation type section based on log data from wells across the Beetaloo. Note the most common lithology is organic-poor, clay-rich shale rather than source rock (TOC>2%), which makes up a relatively minor proportion of the total thickness and is concentrated in the middle Velkerri Formation.

14.4 The Kyalla Formation

The Kyalla Formation, dominated by grey and black siltstones and shale, is separated from the Velkerri Formation by the Moroak Sandstone (Figure 45 and Figure 55). The Kyalla Formation is conformable with the underlying Moroak Sandstone, but has an erosional and disconformable contact with the overlying Cambrian succession (Figure 46). The thickness of the Kyalla Formation is therefore variable depending on location within the Beetaloo with the thickest succession in the central Beetaloo and thinnest section towards the flanks. A maximum thickness of ~785 m is observed at Beetaloo W-1, where upper, middle and lower Kyalla members can be defined.

Although the Kyalla and Velkerri formation source rock intervals share some similar characteristics, the Kyalla Formation is neither as thick nor as enriched in organic carbon. Organic richness within the Kyalla Formation is generally confined to the lower member. The middle and upper Kyalla members in a similar fashion to the Velkerri are regional aquitards and geological barriers to any fractures induced in the organic rich lower Kyalla due to the contrasting elastic properties and higher stress magnitudes. The effectiveness of geological barriers to fracture height growth can be assessed by building a geomechanical model conditioned with data from core analysis and wireline logs.

14.5 Geological Barriers to Fracture Height Growth

14.5.1 Geomechanics and elastic properties

Geomechanics refers to the specialist field of geology that deals with the mechanical characterisation of rocks and the deformation of rocks due to changes in stress, pressure and temperature. Solid materials have an ability to resist and recover from deformation, this property is termed elasticity. In its simplest form the theory of elasticity is founded on the assumption that when a change in applied force (stress) is relatively small the deformation (strain) is nearly always linear in an isotropic medium. This is known as Hooke's Law.

The elastic properties of materials are typically described by a standard set of moduli and/or ratios, which are almost universal to a broad range of engineering and science disciplines. The most commonly assessed and utilised elastic properties in geomechanical studies are summarised in Table 28. In combination, these parameters describe how a material will behave when stress is applied These parameters are also the key inputs to calculate formation stress which in turn is the key input into fracture propagation models, which can estimate how far and in which directions induced fractures will propagate.

PROPERTY	DESCRIPTION	BRITTLE (e.g. quartz)	DUCTILE (e.g. clay)
Young's Modulus	A material's resistance to compression under a uniaxial load	97.2 GPa	0.06-0.15GPa
Poisson's Ratio	A measure of a materials lateral expansion relative to longitudinal contraction or compression	~0.1	0.4
Shear Modulus	A material's resistance to shear deformation	44 GPa	6.85 GPa
Bulk Modulus	A material's resistance to confining pressure (e.g. hydrostatic pressure)	38 GPa	20.9 GPa

Table 28.. A simplified summary of elastic properties relevant to geomechanics.

The elastic properties of formations of interest (i.e. the target interval(s) and surrounding intervals or barriers) are typically measured in two ways:

- Wireline logging: continuous sonic shear and compressional velocities and density data can be acquired on wireline conveyed logging tools; from these data the parameters in Table 4.1. can be calculated. These are described as "dynamic measurements".
- Core analysis: core recovered from the well is analysed at conditions representative of those in-situ. Testing is performed in specialised laboratories where the elastic parameters can be directly measured by applying force (stress) to the samples and recording changes in the physical shape of the sample (strain). These are described as "static measurements".

Both dynamic and static data are used to understand the geomechanics of the target intervals and the surrounding rocks prior to HFS.

14.5.2 Brittle and ductile rocks, stress, and fracture propagation

Brittle as a qualitative term has a very similar "plain English" meaning to the quantitatively defined (in materials sciences) terms of strength, hardness and toughness. The brittleness of a material is relatively intuitive; we understand that very brittle materials (such as glass) will break or fracture, when subjected to stress, without significant plastic deformation (i.e. bending or flexing) and the cracks will continue to propagate with minimal or no continued application of stress. In contrast, ductile materials (such as molding clay) will deform (i.e. compress, bend or change shape) extensively before cracking or fracturing and cracks will not continue to propagate unless continuous forces is applied.

Brittle and ductile materials will have very different stress vs strain curves (Figure 56) are also characterised by very different elastic properties (Table 28).These properties may also be anisotropic such that there is a greater magnitude in one direction than another due to the fabric or layering of the rock. The primary control on ductility of a rock is its composition; particularly its ratio of clays to either quartz or carbonate, its degree of compaction and internal arrangement of particles.

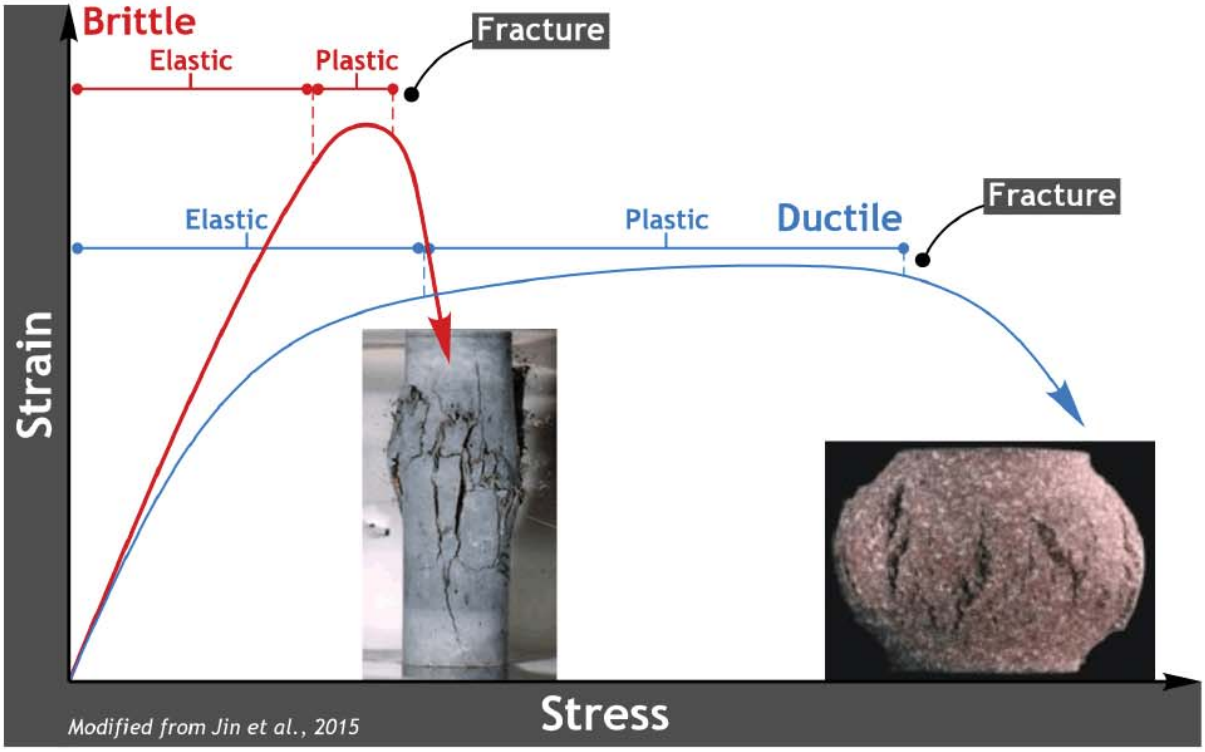

Figure 56. Stress vs strain curves for brittle and ductile materials.

For rocks to be amenable to fracture stimulation they must be relatively brittle. Empirically, if the clay content exceeds 40% of the rock volume then the rock will yield and deform rather than fracture and thus the required permeability for gas production to occur at commercial rates is unlikely to be achieved. An ideal scenario for fracture stimulation is to have organic rich and clay poor target intervals sandwiched between clay rich intervals such that a fracture will initiated in the organic rich target and preferentially grow within this target due to the high stresses associated with the upper and lower boundaries formed at the contact between the target interval and the clay rich strata surrounding it.

Although mineralogy and elastic properties are first order controls on the magnitude of stress produced in a rock for a given strain, it is the stress which a rock is under in an undisturbed or in-situ state that controls how fractures initiate and propagate. Simplifying assumptions allow the definition of three principal stresses (Figure 57), one in the vertical and two in the horizontal planes. The relative magnitude of these stresses governs the stress state of the subsurface.

Vertical stress is essentially a function of the 'weight' of the overlying rocks, and is calculated accurately from wireline derived density data. In many sedimentary basins the largest of the three principal stresses is the vertical stress and we refer to this as a 'normal stress' regime.

Horizontal stress is a largely a function of Poisson's Ratio (more strictly it is defined by Biot's theory on poro-elastic behaviour), and the tectonic stress associated with local or regional forces in the crust produced through plate tectonic processes. Figure 57 illustrates schematically the situation where the two horizontal stresses are not equal and there is a differential stress. The differential stress magnitude is an important control on fracture complexity.

The physical principles controlling material behaviour are well understood in engineering and geotechnical disciplines. The stress magnitude within a material given a set of intrinsic elastic properties and extrinsic stresses or strains is a mature science.

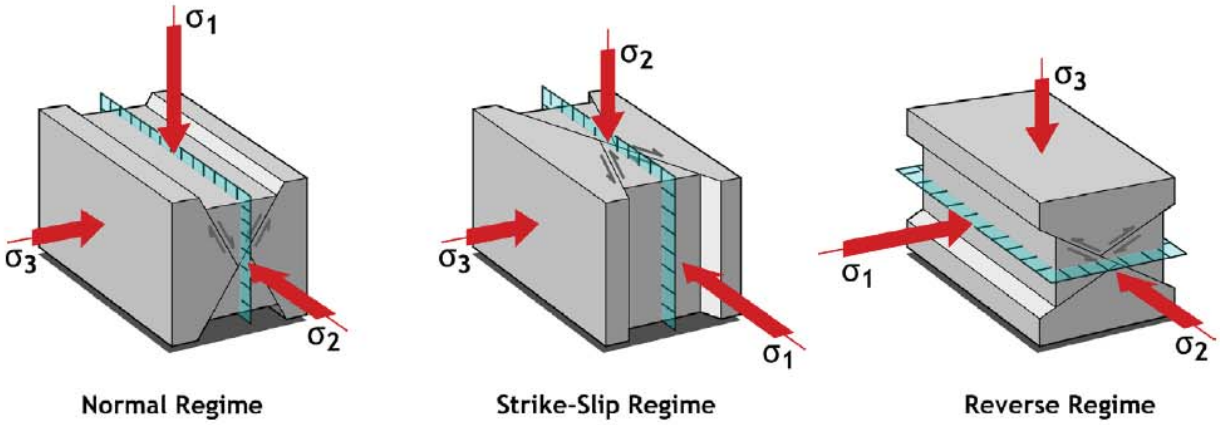

Figure 57. Schematic representation of the three principal stresses that are controlling factors on the type and orientation of fractures induced by hydraulic fracturing.

14.5.3 Mechanical earth models

Mechanical earth models (MEM) are used in various phases of exploration and development to help understand; drilling hazards, risks and optimisation strategies, fracture stimulation parameterisation, and fines (silt/sand) migration (Figure 58). The MEM integrates the static and dynamic data discussed above, but also incorporates data from drilling (such as mud weight). Key calibration data for an MEM include:

- mud weight: mud is used to maintain overbalanced hole conditions where the pressure in the well bore is greater than that in the formations being drilled, hence mud weight is a proxy for pore pressure.
- image log interpretations: image log data (Figure 59) provide images of fractures (induced by drilling or naturally occurring) and borehole breakouts and are important in assessing the accuracy of the MEM predictions.
- diagnostic fluid injectivity tests (DFIT): DFIT data provide a quantitative estimate of a number of key parameters such as breakdown pressure (the pressure at which a fracture is initiated), closure pressure (closure of a fracture approximates minimum horizontal stress) and the permeability and pore-pressure (if pressures are measured for a sufficiently long time period – which can be many months in low permeability shale rocks).

An MEM is used, in conjunction with knowledge of the well configuration (e.g. casing diameter, depth, tortuosity, etc.), to predict at what pressure a fracture will initiate and accordingly plan the appropriate pumping rates to optimise pressures. Once a fracture is initiated, it will dilate (or open) against the minimum horizontal stress and will propagate in the direction of the maximum horizontal stress (Figure 60), hence the orientation in which a fracture grows in the horizontal plane can be confidently predicted if horizontal stresses are known (it is reasonable to assume that formations, especially shales are infinite acting in the horizontal axis, whereas in the vertical axis the formations have a discrete height as this is the nature of 'layer cake' geology evident in sedimentary basins).

The vertical growth of fractures in sedimentary basins is limited because layered rock materials are not homogeneous or isotropic and the layering creates heterogeneous properties both within the layers and at the interfaces. This, in conjunction with the stress contrasts that are largely a result of these properties, creates an environment where vertical fracture growth is hindered and lateral fracture growth is the preferred path of least resistance.

Many studies demonstrate that in-situ stress contrasts stress contrasts have the most significant effect on fracture height growth (Perkins and Kern 1961, Simonson et al. 1978; Voegele et al. 1983; Palmer and Luiskutty 1985, Warpinski et al. 1982, Fischer et al. 2011). Warpinski et al. (1982) gathered observations from experimental testing at sites that were mined back to allow fractures to be studied and confirmed that height growth is indeed impeded by lithology contrasts where in-situ stresses differ. Fischer et al. (2011) summarize three mechanisms by which material property contrasts limit fracture height growth:

1. the effect of a fracture approaching an interface with modulus contrast,
2. the effect of modulus on the width of the fracture and the resulting impact on flow resistance caused by a width change, and
3. the difference in fracture toughness between layers.

Secondary controls on fracture height growth include inelastic forms of energy dissipation such as shear failure, bed slip, and plastic deformation.

Fischer (2011) also summarised microseismic data from several major US shale plays to demonstrate that induced fractures from HFS do not grow substantially above the well bore, in relation to the depth of the well, and that no uncontrolled fracture height growth into an aquifer has been observed (Figure 28). These data are evidence that aquifers are not at risk from uncontrolled fracture height growth during HFS operations.

The natural containment barriers in reservoirs are extremely effective not only in containing the energy of HFS operations during the high-pressure pumping stage but also at ensuring no migration occurs over longer time periods. This is proven by the fact that low-density oil and gas remain trapped in and below the shale rocks even after tens of millions of years of major earthquakes and other tectonic events (King and King, 2013). In some limited areas, the natural configuration of the geology and geography allows the slow movement of oil, gas or salt water to the surface where hydrocarbon seeps occur. Natural seeps have been active for millions of years and are typically known to local communities or indigenous peoples if they exist, they are used by oil and gas explorers as confirmation of the presence of a working petroleum system.

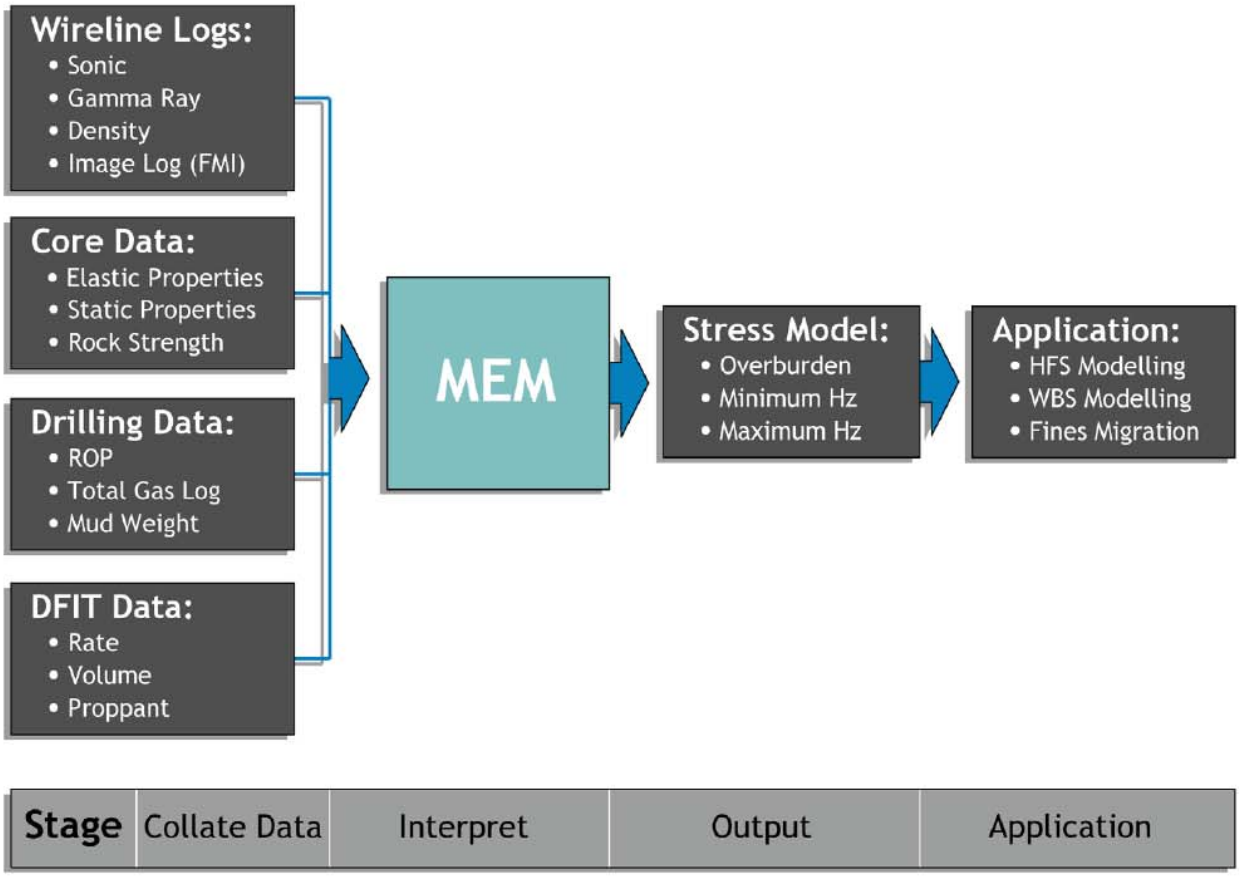

Figure 58. Flowchart showing key input data required to construct a Mechanical Earth Model (MEM) and the application of a MEM to ongoing activity.

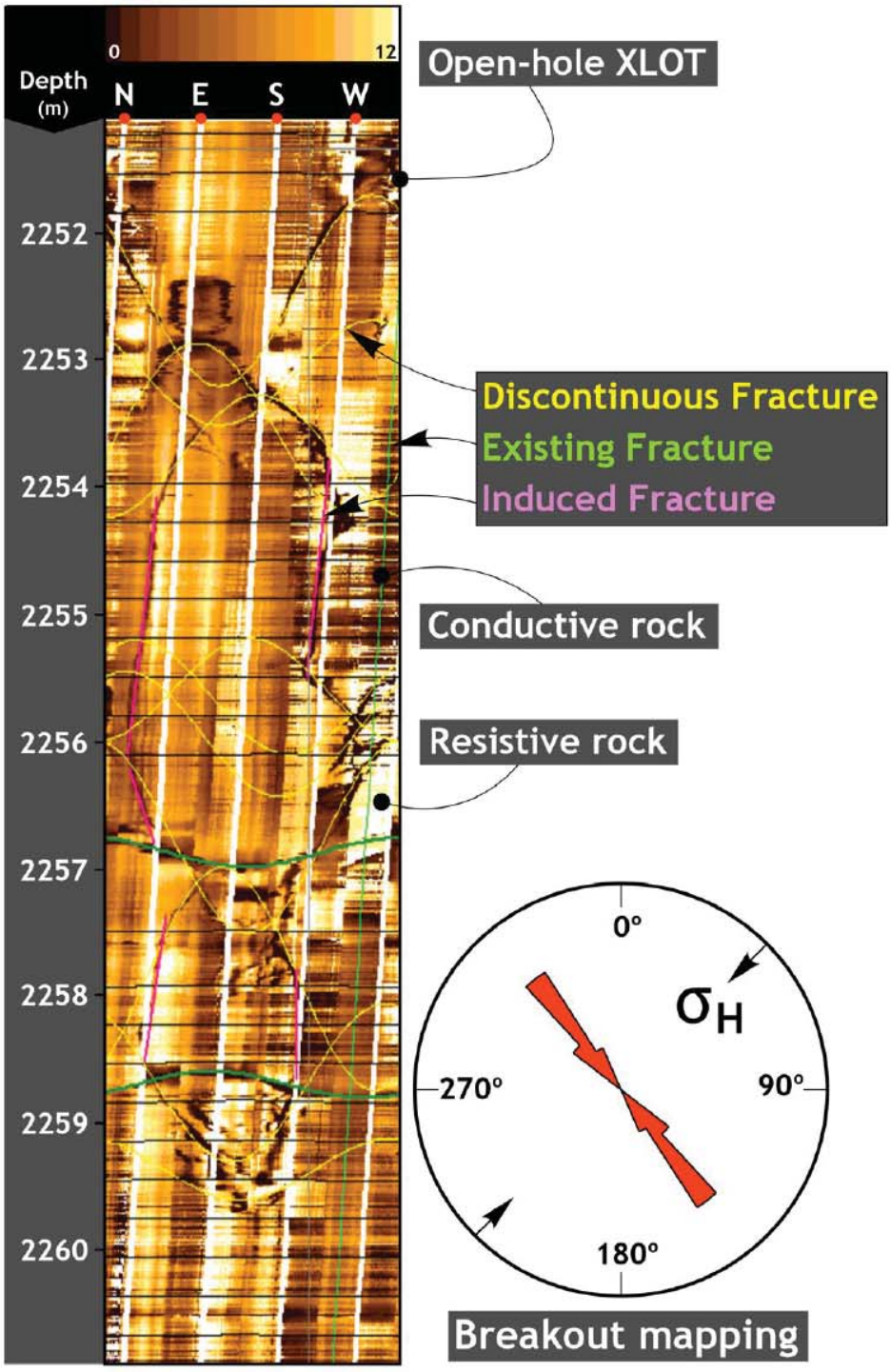

Figure 59. Image log data are acquired during wireline logging and provide an image of the formations based on their electrical properties; formation dips, fractures and faults can be interpreted on these images in addition to small fractures or well bore elongation that occurs during drilling. The interpretation of these features provides important information regarding the stress state in the subsurface.

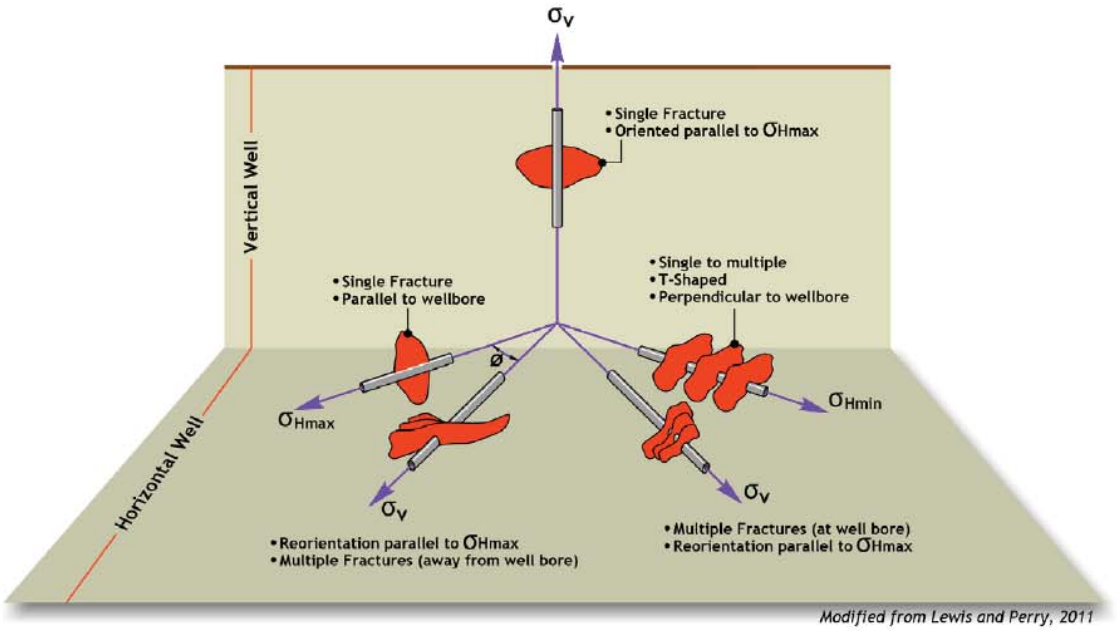

Figure 60. Schematic representation of fracture orientation.

14.6 Shallow gas occurrences

Naturally-occurring hydrocarbon seeps have been reported and confirmed in most hydrocarbon-producing basins (Hunt, 1995). Examples include the well-documented gas seeps in California (USGS, 2017a), and Queensland (Gasfields Commission, 2013). Naturally-occurring seeps are often associated with the outcrops of hydrocarbon-bearing rocks, or geologic features such as faults, and fractures which may, in certain circumstances, act as conduits for gas and oil migration from deeper formations to the land surface.

Some natural seeps can leak substantial volumes of hydrocarbons. Estimates of leaked volumes from natural seeps in the Gulf of Mexico are approximately one-quarter of the leaked volumes associated with the Macondo Blowout in 2010 (King and King, 2013). The Gulf of Mexico is distinct from the Beetaloo as substantial generation of hydrocarbons has occurred in the relatively recent geological history (as distinct from the Beetaloo where peak generation occurred over 350 Ma).

Known and suspected shallow gas occurrences have also been identified in the NT, independent of any oil and gas activity; however, they have been relatively rare, which illustrates that most geological structures are not active fluid conduits. Dunster (2009) published a summary of instances where evidence of hydrocarbons were observed at surface or in shallow bores across the Southern Georgina, McArthur, Beetaloo, Daly, Wiso, Amadeus, Ngalia, South Nicholson, and Carpentaria basins. This summary documents both confirmed and anecdotal reports, from a wide variety of sources, and is strong evidence that shallow gas in the NT is entirely natural and not a consequence of oil and gas exploration activity or HFS.

In the Beetaloo area there have been numerous anecdotal reports of shallow gas (Dunster, 2009), mostly associated with the drilling of water bores. Given the number of water bores drilled in the region, however, it is clear that such occurrences are rare. As recently as 2016 a water bore on Gilnockie Station encountered gas (ABC, 2016), interestingly this bore is relatively close to the sub-crop edge of the Velkerri Formation – proximity to such a sub-crop edge is a known risk factor in shallow gas occurrences.

If development activity proceeds in the Beetaloo area the statistical likelihood of encountering shallow gas will increase as the number of wells drilled increases, however, the pre-development evidence of the presence of shallow gas illustrates that this phenomenon is entirely natural.

14.7 Seismicity in the Northern Territory and Beetaloo Basin Region

14.7.1 Earthquake activity

Large earthquakes are relatively rare in Australia with an earthquake exceeding magnitude 7 occurring somewhere in Australia every 100 years or so; in contrast in active areas like Japan, Philippines or California earthquakes of magnitude 7 occur every few years (SRC, 2017). Earthquakes are comparatively rare in the NT, even in the Australian context, with the exception of a couple of limited areas around Tenant Creek and west of Alice Springs (Figure 61).

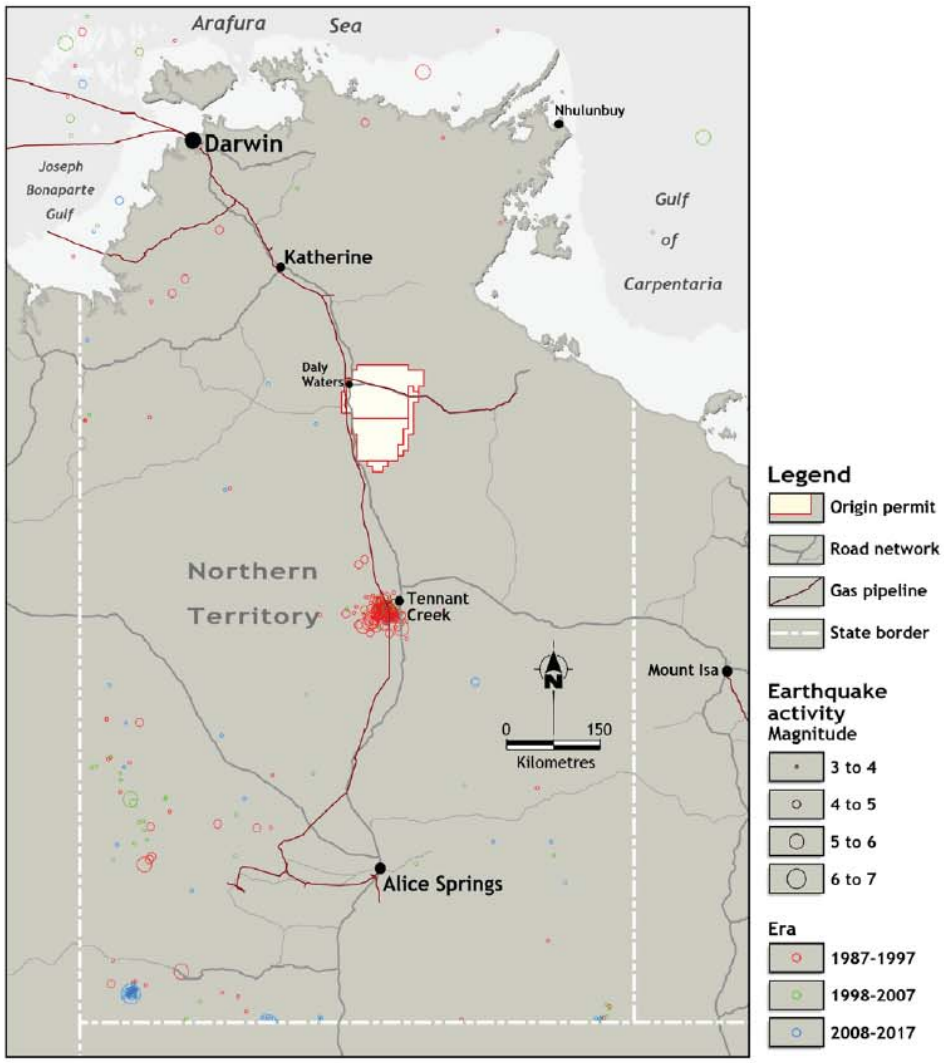

Figure 61.. Earthquakes greater than magnitude 3 from 1987 to 2017 across the NT showing an absence of activity in the Beetaloo area.

The largest known earthquakes in the NT occurred near Tennant Creek in 1988, where a sequence of three earthquakes with magnitudes around 6.2-6.4 occurred in a twelve-hour period. Thousands of aftershocks have since been recorded, and whilst the rate has decreased it has not yet returned to its pre-1987 level which was close to zero for the previous 20 years apart from a nearly year-long precursory sequence of earthquakes that initiated in January 1987 (McCue 2013).

In the Beetaloo area there have been no earthquakes over magnitude 3 measured since records began. The area is not prone to seismic activity, and there is no evidence in seismic data of recent earthquake activity as most faults and major structures are confined to Cambrian and older strata.

14.7.2 Induced seismicity

Earthquake activity or induced seismicity, of magnitudes sufficient to be measured or felt at the surface, associated with HFS operations is very rare. Highly publicised events associated with HFS operations have been recorded in northeastern British Columbia (Montney Play) and the United Kingdom (Bowland Shale). After hundreds of thousands of fracturing operations, the fact that there are so few examples of felt seismicity suggests that the likelihood of inducing felt seismicity by hydraulic fracturing is extremely small (Davies et al., 2013).

The issue of induced seismicity has gained increased exposure due to high magnitude events in Oklahoma that have caused damage to built infrastructure. However, the USGS has stated very clearly HFS is not causing most of the induced earthquakes and point out that wastewater disposal is the primary cause of the recent increase in earthquakes in the central United States (USGS, 2017b).

Wastewater disposal wells, which dispose of a range of waste products from conventional oil and gas operations and other industries, typically operate for longer durations and inject much more fluid than hydraulic fracturing, making them more likely to induce earthquakes. Wastewater injection can raise pressure levels sufficiently such that the likelihood of induced earthquakes increases – although most injection wells are not associated with felt earthquakes.

A combination of many factors is necessary for injection to induce felt earthquakes. These include: the injection rate and total volume injected; the presence of faults that are large enough to produce felt earthquakes; stresses that are large enough to produce earthquakes; and the presence of pathways for the fluid pressure to travel from the injection point to faults. Since the introduction of basic pressure monitoring at injection sites in Oklahoma, earthquake frequency has begun to reduce (Langenbruch and Zoback, 2016). The regulatory requirements to ensure injection is managed safely and responsibly are relatively straightforward (i.e. require monitoring and reporting of injection well pressure and limit injection pressures to a reasonable safety factor).

Davies et al. (2013) illustrate that induced seismicity directly attributed to HFS operations is of such a low occurrence rate that the documented cases are statistical anomalies rather than commonly reoccurring phenomena. Seismicity associated with HFS commonly has Richter magnitudes of approximately 1 (Davies et al, 2013). The Richter scale is a base 10 logarithmic scale of the amplitudes recorded by seismographs. This means for every integer increment (i.e. 3 to 4) the magnitude increase is 10 fold. In terms of energy released it equates to a 31.6 times increase meaning low Richter values correspond with low energy events.

For reference the 2004 Sumatran earthquake, which occurred on a tectonic plate boundary where faults penetrate deep into the crust, had a magnitude of 9.3. The Sumatran earthquake, which was approximately 200,000,000 times larger than the seismicity associated with HFS, produced ~2m of uplift at the seafloor and ~20m of movement on the fault at depth. This supports the interpretation that an event in the Beetaloo of a magnitude to influence surface water or groundwater processes is effectively zero.

Although a low risk in the NT, risk mitigation remains prudent given the high potential consequences in terms of public perception and industry reputation (i.e. it is likely that there would be no damage to built infrastructure or adverse environmental or human impacts, but there would be a perception that HFS is not safe if there was a felt seismic event induced). FrogTech (2015) provide a detailed summary of science and regulatory based tools to minimise the risks associated with induced seismicity. These tools include:

- Improved structural mapping in areas of potential activity.
- Establishment of a traffic light control system for responding to an instance of induced seismicity, which incorporates; monitoring of seismicity, establishing action protocols in advance, require the ability to alter fluid injection schedule in real time.
- Development of a checklist to determine if HFS might cause seismicity. Example checklist questions could include:
  - Are large earthquakes known in the region?
  - Are major faults mapped within 20 km of the HFS operations?
  - Are these faults active?
  - Do stress measurements in the region suggest rock is close to failure?

The risk of induced seismicity in the Beetaloo is considered low; however, minor regulatory updates would be prudent to ensure that the risk is appropriately managed.

15 ADDRESSING COMMUNITY CONCERNS

15.1 The 67,000 well development fallacy

FrogTech (2013) undertook a study, commissioned by the Australian Council of Learned Academies (ACOLA) into "Potential Geological Risks Associated with Shale Gas Production in Australia". This study attempted to quantify potential water usage associated with HFS in Australia based on assumed well counts in a number of basins considered potentially prospective. The 'estimate' for the NT alone, across four basins (the Amadeus, Georgina, McArthur, and Wiso basins; Table 29), was 67,343 development wells. This estimate was made as a means to model water requirements in isolation, so no limitations regarding prospectivity and exploration success/failure, gas market, pipeline capacity limitations, logistics, capital availability, or permitting were considered. The calculations also assume an 800 m well spacing, which is not representative and therefore over-predicts well counts by a factor of two.

NT BASIN	NUMBER OF SHALE GAS WELLS	WATER NEEDED FOR FRACKING (GL)	FRACKING WATER PER YEAR (GL)	GROUNDWATER SUSTAINABLE YIELD (GL/YR)	GROUNDWATER ABSTRACTION (GL/YR)	% ABSTRACTION OF SUSTAINABLE YIELD (PRESENT)	% ABSTRACTION INCLUDING FRACKING OF SUSTAINABLE YIELD
Amadeus	12,679	190	7.6	142	14	9.9%	15.2%
Georgina	28,331	425	17	241	64	26.6%	33.6%
McArthur	15,506	233	9.3	749	9	1.2%	2.4%
Wiso	10,827	162.4	6.5	106	4	3.8%	9.9%
Total	**67,343**						

Table 29. FrogTech (2013) estimates of water usage in NT basins considered prospective (at the time) for unconventional gas based on assumptions regarding number of wells.

Although the estimate of wells was made to allow water usage to be estimated it has been interpreted by many as an estimate of what development is likely to proceed. These two concepts are different and it is clear from FrogTech (2013) that they were not inferring that all of these wells would ever be drilled. The conclusion of the report, even assuming the vast numbers of wells all proceed, was that the sustainable yield of the aquifers in question would not be exceeded, and in the case of the McArthur the abstraction is less than 2.5% of the sustainable yield.

The Georgina Basin provides an excellent example of why the FrogTech (2013) well estimates should not be used as an estimate of potential future activity. Since 2014 there has been no exploration activity in the Georgina Basin, following more than 10 unsuccessful exploration and appraisal wells in the preceding years. The categorical lack of exploration success, and the mechanism of failure (i.e. an absence of moveable hydrocarbons), has effectively sterilised the unconventional prospectivity in the Basin. Therefore, it is unlikely that any of the 28,331 wells estimated by FrogTech will be drilled. Similarly, further evaluation of the Wiso Basin has indicated very limited unconventional prospectivity in that Basin and it is unlikely substantial exploration will be undertaken, let alone development of any of the 10,827 wells used to forecast water requirements by FrogTech (2013).

The high well number estimates of FrogTech (2013) have been exacerbated in the public domain by the current status of exploration permits, either granted or under application across the NT, with almost the entirety of the NT covered. Although permits exist across very broad areas, the reality is that there are very few areas that are prospective for unconventional gas. If gas development does proceed in the NT, it is likely that it would proceed relatively slowly in terms of well counts and that it would impact a small area relative to the total area of current permits.

15.2 Land utilisation and unconventional gas developments

As outlined in Chapter 3.2, the use of multi-well pads and horizontal wells substantially reduces the surface footprint of a shale gas development relative to fields that are developed with vertical wells from single-well pads. Often images of vertical well developments are used to communicate what the surface impacts of a shale gas development could look like in the NT, this is obviously not an accurate representation.

The USA has an extensive history of conventional (vertical well based) oil and gas development, and more recently unconventional oil and gas development (vertical and horizontal well based depending on area). Shale gas developments can cover large areas due to the geological continuity of the reservoirs in shale rocks, so the absolute numbers of wells developed is also large. The efficiency of these wells if often, however, overlooked; shale plays typically have 3-20 times less wells per square kilometre than onshore conventional developments (Table 30).

Areas where there is no history of conventional development, but more recent unconventional development of shale gas, provide the best analogue to the Beetaloo of the surface impacts of development. Eastern Ohio, where the Utica Shale Play is being successfully developed is an excellent example of such an area, particularly as the area being developed today for shale gas is adjacent to conventional developments (Figure 62).

The difference in well density is immediately apparent in Figure 62, and illustrates why using an area that has had conventional developments prior to unconventional development is not suitable as a way to portray what surface impacts of shale gas alone may look like. In areas where only horizontal wells from multi-well pads have been developed (Figures 63, 64 and 65) the surface expression of the gas development is minimal. Even where relatively short laterals (~1.5-2 km) have been drilled (Figure 63), early in the development cycle as the geography and geology specific optimisations were being learnt, and the area is fully developed the footprint at surface is minimal. Where longer laterals (~2 to >3 km) have been drilled (Figures 64 and 65) and development is underway there is a smaller expression at surface of the gas development.

In all these examples the surface footprint of the shale gas development is a relatively minor impact on the total area. These images, which are an accurate analogy for the Beetaloo, are very different to the types of imagery used by those opposed to gas developments in the NT. The coexistence of this type of surface development with low-density cattle grazing in the Beetaloo is something that Origin is confident can be achieved.

FIELD	PLAY TYPE	WELL TYPE	WELLS PER km²
Notional Beetaloo development (Figure 14)	Shale gas	Horizontal	0.83
Generation 1 Utica short well development (Figure 63)*	Shale gas	Horizontal	1.33
Generation 2 Utica medium well development (Figure 64)*	Shale gas	Horizontal	1.00
Generation 3 Utica long well development (Figure 65)*	Shale gas	Horizontal	0.63
Pavillion**	Conventional gas	Vertical	2.70
Big Lake***	Conventional gas	Vertical	2.86
Clinton Fm. Ohio (Figure 62)*	Conventional oil	Vertical	7.14
Merrimelia***	Conventional oil	Vertical	11.11

* Data from ODNR Ohio Oil & Gas Wells map viewer

** Data from AME 2016

*** Data from Gpinfo

Table 30. Comparison of well density (i.e. wells per km2) for different fields and play types. Horizontal wells from multi-well pads are an efficient way to develop large resources..

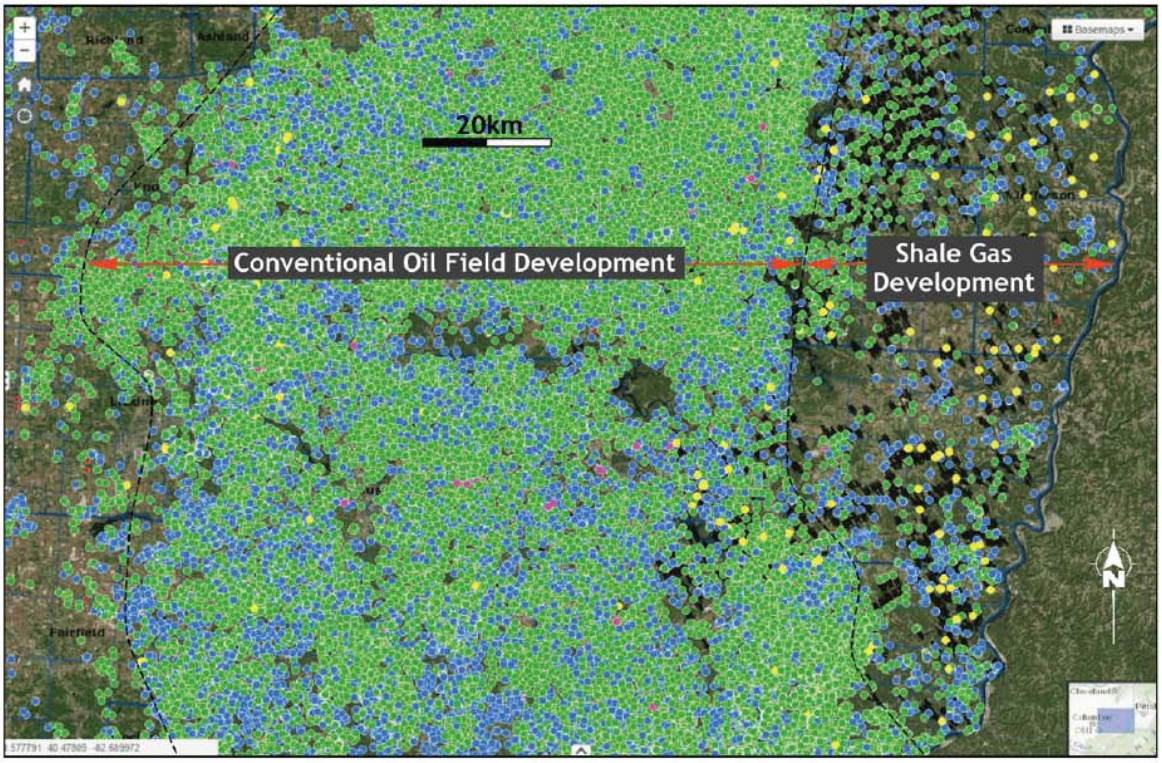

Figure 62. Aerial photography from eastern Ohio showing well locations over conventional and unconventional developments. The density of wells is far greater in the area where conventional fields have been developed.

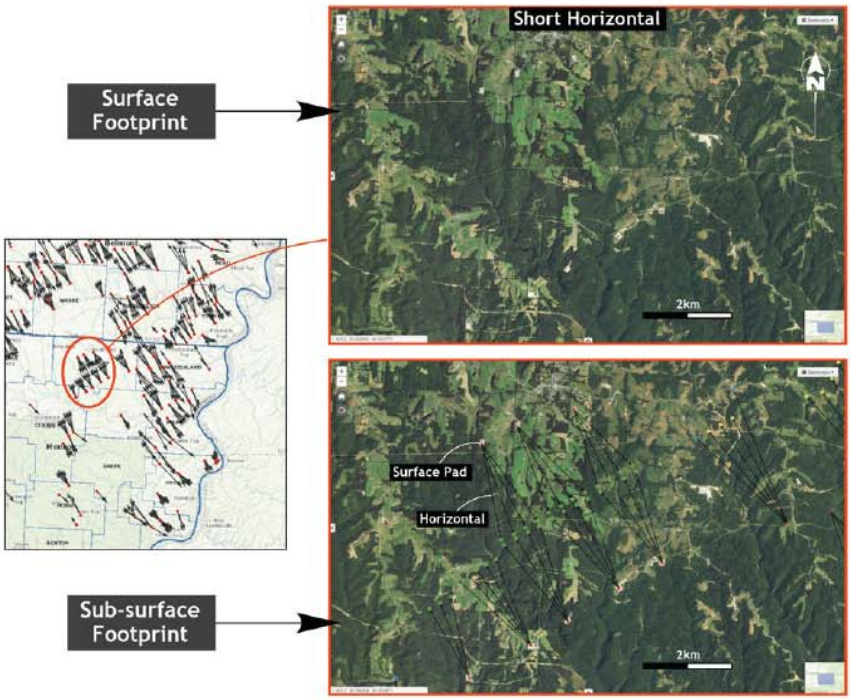

Figure 63.. A montage of maps and aerial photographs, with well locations and trajectories, from an area in Eastern Ohio where the Utica Shale has been developed with relatively short (1.5 km) lateral sections in horizontal wells.

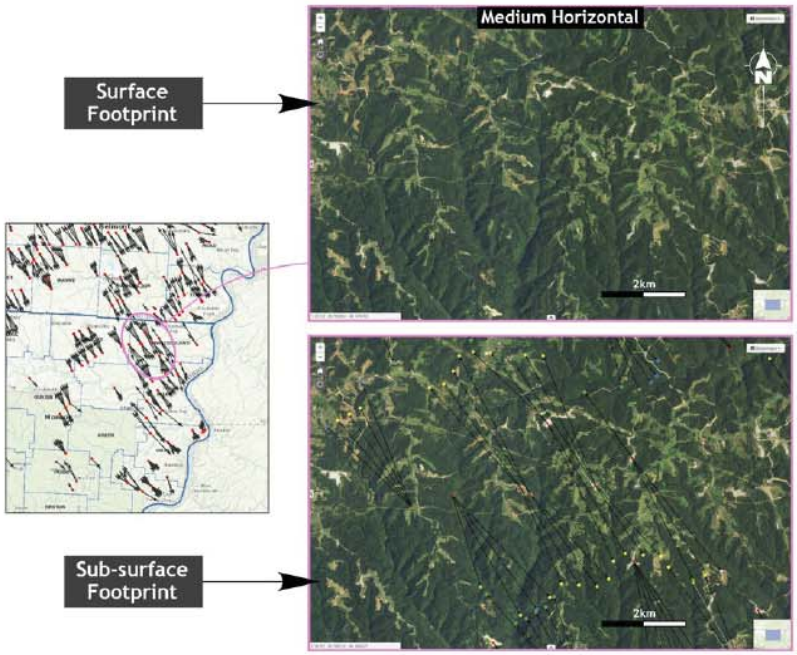

Figure 64. A montage of maps and aerial photographs, with well locations and trajectories, from an area in Eastern Ohio where the Utica Shale is under development using ~2 km long lateral sections in horizontal wells.

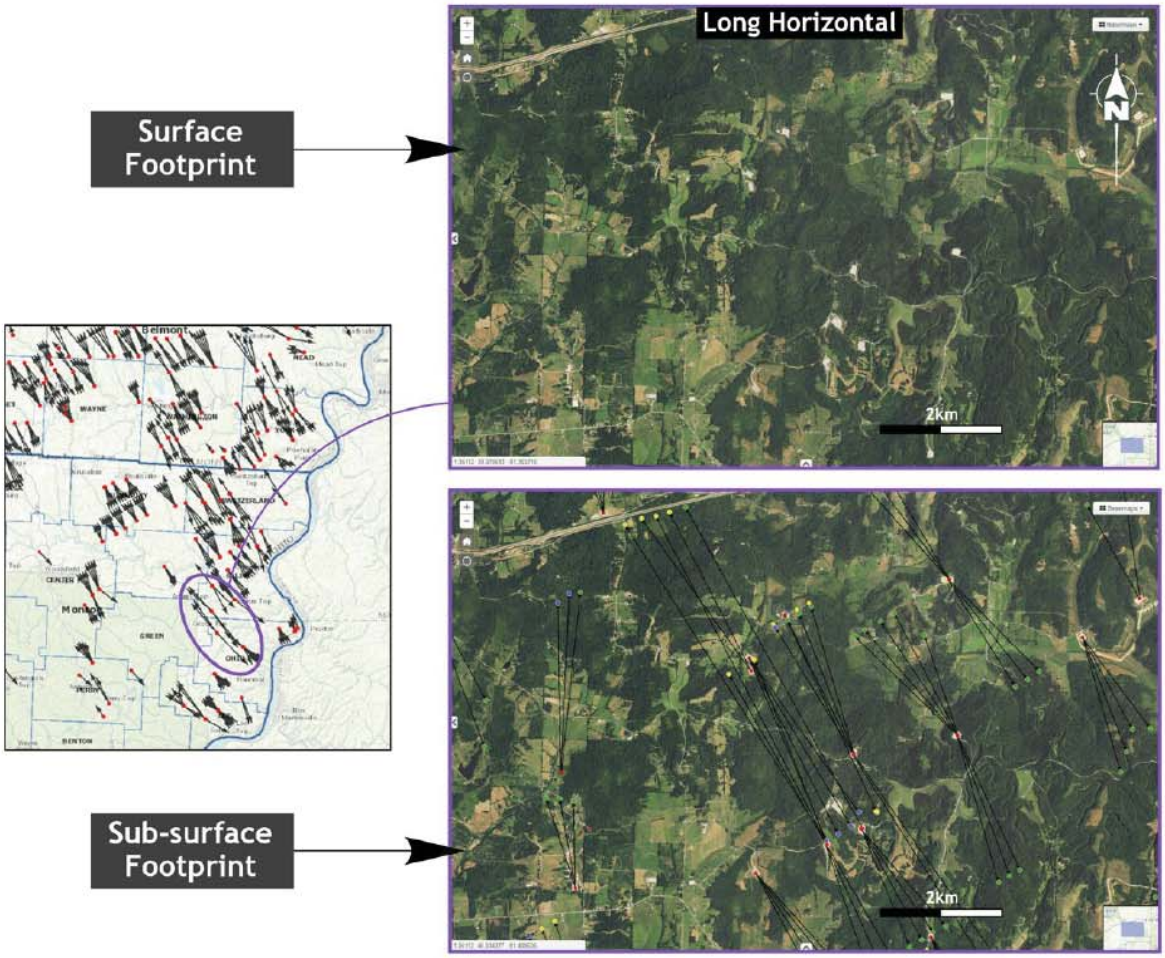

Figure 65. A montage of maps and aerial photographs, with well locations and trajectories, from an area in Eastern Ohio where the Utica Shale is under development using >3 km long lateral sections in horizontal wells.

16 CONCLUSIONS

Coexistence with pastoralists, Traditional Owners, and the local and regional communities that host our activities is fundamental to Origin's future in the NT. Demonstrating that there does not have to be a choice between caring for the environment and gas development, or between agriculture and gas development, or between recreational tourism and gas development is a responsibility Origin takes seriously. Protecting the water resources of the NT, which sustain the unique natural environment across the Territory and is critical to businesses and communities in all parts of the Territory, is not optional – contamination or over-exploitation are not acceptable.

The "Water" risk theme is called out by this Inquiry directly, and many of the other risk themes flow from the risk to groundwater of either contamination or over-exploitation. This is why so much of our submission is based around well integrity – how each well is designed, tested, confirmed and sustained for the life of the well, including abandonment. A clear regulatory structure, with a combination of prescriptive minimum standards in an objective and outcomes-based framework is necessary to ensure that water resources are protected.

The NT Petroleum Act (2016) (The Act) provides an excellent platform to ensure the onshore gas industry in the NT can continue to safely explore, appraise and develop gas resources for the benefit of the NT and Australia more broadly, while preventing unforeseen impacts on the natural environment. Legislative and regulatory reform will improve parts of The Act which do not consider the increased scale of activity that industry would require if a large-scale development was undertaken. Such reform can be enacted in parallel to exploration where activity levels are effectively identical to the conventional exploration activities that were envisaged when The Act was introduced.

The information and experiences shared in this submission identify a path forward for the unconventional gas industry that allows the risks from development to be carefully controlled. As a result, Origin recommends that the NT lift its current moratorium on hydraulic fracturing in order that exploration and appraisal activities can continue. This supports acquiring the key data and experiences relevant to the NT context to inform industry, the regulator, and other NT Government and independent agencies. As this activity continues key elements of a successful regulatory framework can be further developed, implemented and tested ahead of any larger scale development.

Gas development, and all development, comes with a level of inherent risk. The absence of development also introduces risk. In this submission we have provided detailed discussions of risk controls that already are, or could be, put in place to ensure that the risk of unforeseen impacts on the environment, or to communities and the economy are minimised to levels that are as low as reasonably practicable. While risks are minimised, the potential opportunity for the NT to support the introduction and expansion of a new major industry partner is great and could bring sustainable development, investment and employment to regional NT where there are few other prospects for change.

The potential for Australia is equally important, the Beetaloo may provide one of a small number of potential means to meet Australia's medium to long term domestic gas requirements and support the ongoing transition to a lower carbon intensity energy market.

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18 APPENDICES

18.1 Appendix 1 – Health Safety and Environment

HSE Management Plan Summary

Summary of all HSE incidents during the 2015-2016 Origin Energy Beetaloo Drilling Campaigns

18.2 Appendix 2 – CSG community guide

Origin guide to CSG activity for communities

18.3 Appendix 3 – Groundwater

Origin Energy Groundwater Monitoring Program (GMP)

18.4 Appendix 4 – Well acceptance criteria

Origin Energy Well Acceptance Criteria (WAC) Amungee NW-1, Amungee NW-1H

18.5 Appendix 5 – HFS chemical disclosure

Full listing of fracture stimulation fluid additives as planned and pumped at Amungee NW-1H

18.6 Appendix 6 – Oil spill response plan

Origin Energy Stimulation and Well Testing Oil Pollution Emergency Plan

18.7 Appendix 7 – Radiation Professionals report

Radiation Professionals report on cuttings obtained from Beetaloo exploration wells

18.8 Appendix 8 – Well failure statistics

Data used in well failure analysis

Notice of Violation and wells drilled database