Environmental Defenders Office NT Submission to the Independent Scientific Inquiry into Hydraulic Fracturing

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About the Environmental Defenders Office NT

The Environmental Defenders Office Northern Territory (**EDONT**) is a non-profit community legal centre specialising in public interest environmental law. The EDONT has recognised expertise in environmental law and is the only organisation in the NT, which provides free legal assistance to members of the community in relation to public interest environmental matters.

The EDONT has specific expertise in relation to the regulation of the petroleum industry in the Northern Territory. We have (and do) act for traditional owners with respect to applications made under the *Petroleum Act* and have provided extensive community legal education in relation to hydraulic fracturing, including making presentations to the Full Council of the Central and Northern Land Councils.

The EDONT's reputation is built on:

Successful environmental outcomes using the law. With over 20 years' experience in environmental law, EDONT has a proven track record in achieving positive environmental outcomes through law.

Broad environmental expertise. EDONT is an acknowledged expert when it comes to the law and how it applies to the Territory environment. We help the community to solve environmental issues by providing legal advice, community legal education and advocating for better laws.

Independent and accessible services. As a non-government and non-profit community legal centre, our services are provided without fear or favour. Anyone can contact the EDONT to get free legal advice about an environmental problem. Many of our services are targeted at remote parts of the Northern Territory.

Submitted to:

The Independent Scientific Inquiry into Hydraulic Fracturing
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Introduction

At a speech in Adelaide in 2016, environmentalist, David Suzuki, gave of examples where the passage of time and increased scientific understanding has found things that were thought to be safe were in fact not safe. Among other matters, he referred to the discovery of DDT pesticides:

> "We all thought DDT pesticides were fantastic until Rachel Carson's book (*Silent Spring)* came out. And for me as a scientist what stunned me was the realisation that science can be very powerful, but we don't know enough to anticipate all of the unknown things in nature that we can't expect to be affected. When DDT began to be used on a wide scale, it was only when eagles in the United States began to disappear that scientists tracked it down and discovered a phenomenon called biomagnification. Up the food chain you concentrate DDT hundreds of thousands of times until you get to the shell glands of birds or the breasts of women. How could we have managed DDT properly when we only discovered biomagnification after eagles began to disappear? And that has happened over and over again.[1]

He went on to reference CFCs and their impact the ozone layer and the phenomenon called radioactive fallout, unknown when nuclear bombs were dropped on Japan during World War II. There are countless other examples, asbestos, thalidomide and the introduction of cane toads to name three.

The reason we refer to these matters is because high volume horizontal Hydraulic Fracturing is a relatively new process, both in Australia and Internationally. The science in relation to many of its impacts is unsettled. It is for this reason that we urge the Panel to consider as the most important part of this submission, our discussion about the precautionary principle and how best to "operationalize it" within the regulatory framework for shale gas activities in the NT.

This submission is designed to extend and support the previous work of our office in its responses to the 2014 Hawke Inquiry and our comment on the Discussion Draft of the *Petroleum (Environment) Regulations*. In preparing this report, we have had the benefit of four expert reports, which are attached as part of this submission. We are extremely grateful to those experts for dedicating the time to assist the EDO in the preparation of this submission

1 http://www.abc.net.au/radionational/programs/scienceshow/david-suzuki:-changing-climate-the-ultimate-crisis-for-our-spec/8132944

2 Issues paper, page 12.

3 See for example, the Colorado Oil and Gas Conservation Act, principles of ESD are incorporated into the EPBC Act,

Executive summary & Recommendations

This report is set out in two parts. Firstly we address the two themes of greatest importance for the purposes of regulatory reform, (1) operationalization of the precautionary principle and (2) the type of regulation that should apply to a shale gas industry. Secondly, we address the risk themes identified in the Issues Paper.

Throughout this report, the EDO makes various recommendations for regulatory reform in the NT should the current moratorium be lifted. The recommendations are supported by evidence and, in particular, by reference to the four expert reports, which are submitted with this submission as attachments, and to international best practice.

There is a great deal of room for improvement in the current NT regulatory regime. Particularly we conclude that while the enactment of the *Petroleum (Environment) Regulations* are a vast improvement on the previous regime, little confidence can be taken from their existence when viewed in light of the NT's particular context, namely its appalling environmental assessment regime, poor track record of cowboy operators and ad hoc and lax enforcement of environmental laws.

The EDO makes 34 recommendations which can be briefly summarised as follows:

Recommendations to operationalize the precautionary principle

1. The inclusion of ESD principles (including the precautionary principle) as a legal objective in the Act and requiring application of the principles.
2. The inclusion of objective based decision-making criteria in the regulatory regime.
3. The consideration of Play based regulation (PBR) to address the cumulative impacts , landscape scale impacts and stakeholder engagement issues associated with a shale gas industry
4. Reversing the burden of proof so that industry must demonstrate its safety.
5. The inclusion of third party merits review rights in the NT regulatory regime.

Recommendation in relation to the type of regulatory regime in place

6. That the NT regulatory regime move to a hybrid model of regulation which contains minimum standards for well construction and design, aquifer interference, disclosure of chemicals and reporting of incidents

Recommendations addressing the Issue Paper's risk themes

Baseline data

7. Legislative requirement for obtaining baseline data
8. Independent operators to be used for baseline data testing at the operators expense

No go zones

9. No go zones underpinned by scientific research included in legislation
10. Strategic planning mechanisms to identify and protect high value land included in the legislation

Protection of water resources

11. Application of the *Water Act* licencing provisions to shale gas operations
12. Sustainable yields set by application of the precautionary principle
13. Shale gas operators should receive low security water licences
14. No-go zones or buffers in legislation to protect water resources from spills
15. Stringent spill reporting obligations on industry
16. Prescriptive requirements for well integrity
17. Groundwater impacts reports & Aquifer Interference Policy
18. Reverse onus provisions for water pollution offences
19. Specific requirements for 'make good' agreements to be included in the legislation.
20. Publicly available waste management plans to be included in all applications
21. Prohibition on the storage of fracturing fluids and flow back water in evaporation ponds.

Public Health

22. The requirement for full public disclosure of the chemical make up of frac-fluids.

Aboriginal people and their culture

23. Secondary right of veto for traditional owners of ALRA land prior to the issue of a production permit. (Alternatively more comprehensive consultation requirements at the exploration stage)
24. Extended timeframes for consultations with Indigenous stakeholders
25. Mandatory requirement for operators to obtain a sacred sites certificate
26. Culturally appropriate and independently developed consultation materials
27. Requirement for security bonds and a non-refundable levy on operators.

Compliance and enforcement

28. Chain of responsibility provisions be included in the NT regulatory regime
29. Decision makers must consider whether an operator is a fit and proper person and their environmental history

Regulatory capture

30. The Department responsible for promotion of the shale gas industry and the receipt of royalties should not be responsible for compliance and enforcement activities.

Cumulative impacts

31. Decision makers are required to have regard to detailed consideration of cumulative impacts before granting approvals under the Act or Regulations.
32. Specific information requirements for edge impacts and habitat fragmentation and a an obligation on decision makers to specifically impacts on landscape function.
33. The NT regulatory regime should include prescriptive measures setting emissions limits and air quality parameters for methane and (as noted above) require baseline testing to occur prior to operations commencing.
34. The NT should develop a code of practice (or other guideline) for the detection and reporting of emissions from wells.

Definitions section

The Act – means the *Petroleum Act* 1984 (NT)

The Regulations – means the *Petroleum (Environment) Regulations* (2016)(NT)

ALRA – means the *Aboriginal Land Rights (Northern Territory) Act* 1976 (Cth)

EPBC – means the *Environment Protection and Biodiversity Conservation Act* 1999

Issues Paper – means the *Background and Issues Paper* published by the Inquiry on 20 February 2017.

Department – means the Department of Primary Industry and Resources or its predecessor, the Department of Mines and Energy.

EDO – means the Environmental Defenders Office (NT) Inc.

FPIC – means free, prior and informed consent.

HVHF – means High volume hydraulic fracturing

Landholder – Unless stated otherwise a reference in this submission to a landholder or landholders includes the lessee of a pastoral lease under the *Pastoral Leases Act* (NT), a person with freehold title to land, the Government in respect of Crown Land and the Aboriginal Land Trust responsible for land held as Aboriginal Freehold under the *Aboriginal Land Rights (Northern Territory) Act* 1976 (Cth).

EDO Hawke Report – means the EDO's October 2014 report titled *Report to the Commissioner – Best Practice Regulatory Frameworks for Hydraulic Fracturing Operations* provided to the 2014 Independent Inquiry into Hydraulic Fracturing, chaired by Dr Allan Hawke. (Attachment A to this submission)

EDO Comment – means the EDO's comment on the Discussion Draft – *Petroleum (Environment) Regulations*, provided on 22 April 2016. (Attachment B to this submission).

The current NT regulatory regime

The current regulatory regime in the NT is described in the Issues Paper.[2] As identified in the Issues Paper, the principal piece of legislation that regulates the petroleum industry in the NT is the *Petroleum Act* 1984 (NT).

The Act

The objective of the Act is:

> **3 Objective**
>
> (1) The objective of this Act is to provide a legal framework within which persons are encouraged to undertake effective exploration for petroleum and to develop petroleum production so that the optimum value of the resource is returned to the Territory.
>
> (2) …

A basic rule of interpreting legislation is to do so in such a way as to give effect to the legislation's purpose or object. That is problematic in the current situation as the objective of the Act is clearly intended to emphasise economic development above environmental protection and intergenerational equity.

Best practice regulatory regimes in this field include in their objectives explicit recognition of the importance of environmental protection and the application of principles of ecologically sustainable development.[3]

There are a great many other problems with the Act as it is currently drafted. A number of those are detailed in the *EDO Hawke Report,* which is Attachment A to this report. Below is a summary of some of the major problems with the current Act:

- The term *good oilfield practice* continues to be used. As noted in the *EDO Hawke Report* the terms is broad, vague and, given the vast variation in oilfield practices around the world lacks any type of certainty and would be difficult to enforce

- The Act does not ensure that the process required by the Regulations is followed. A direction issued under the Act allows the Minister to issue an approval without first requiring an application to go through the requirements of the Regulations.

  In fact, it is the EDO's understanding that the most recent example of HVHF that occurred in the Territory did exactly that.[4] The Department informed the EDO that the reason the requirements under the Regulations were not imposed on that application was because it was received before the enactment of the Regulations. The technical programme requirements of the application were instead imposed by direction under s 71 of the Act.

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2 Issues paper, page 12.

3 See for example, the Colorado Oil and Gas Conservation Act, principles of ESD are incorporated into the EPBC Act,

4 The EDO is referring to the approval for Origin Energy Resources Ltd to stimulate and test an exploration well (Amungee NW-1H) in the Beetaloo Sub-Basin.

- The Schedule (where the majority of the NT's prescriptive requirements are found) is imposed on gas operators by way of direction. The EDO understands that the intended way forward is to remove the Schedule and instead rely on the Regulations. As we discuss below, some prescriptive requirements (particularly in relation to well integrity and impacts to water) should form a part of the legislative regime.

- The Act fails to include a 'fit and proper' person test or a requirement for the consideration of *environmental history*.[5]

- The Act does not include third party merits review rights, nor does it provide any open standing provision for judicial review.

- Compensation for landowners is currently inadequate and there are no provisions requiring the negotiation of 'make good agreements'.

- There is no legislative requirement which provides for the access arrangements for shale gas companies to enter onto land.[6]

The Regulations

The Regulations brought about substantial improvement to the NT's regulatory regime. The Regulations make specific provision for the principles of ecologically sustainable development to be taken into account, make provision for increased transparency and promote greater stakeholder engagement.

Despite these major improvements, the EDO remains critical of some aspects of the Regulations. Those matters are discussed throughout this submission and specifically in the EDO comment, which is Attachment B to this submission.

The Assessment Regime

The regulatory regime for environmental assessment of projects in the Northern Territory is provided for by the *Environmental Assessment Act* 1982 (NT). The Act is 6 pages long and its substantive details are left to the subordinate *Administrative Procedures* which are determined by the Administrator, following publication on notice in the Government Gazette.

The problems with the NT environmental assessment regime are well summarised in the 2016 Northern Territory Environment Protection Authority document, *'Draft Advice regarding Dr Allan Hawke's Review of the Northern Territory's Environmental Assessment and Approval Processes.*

5 For an example definition see the EPBC Act.

6 Here we are clearly referring to non-Aboriginal land. Access arrangements for access to Aboriginal Land are provided for by the ALRA.

The two underlying themes

The Precautionary Principle

The EDO, while not possessing scientific expertise in this area, has made a good attempt to read broadly from the scientific literature on the subject. The overwhelming impression that we have gleaned from that material is that there is a great deal of uncertainty with respect to the impacts of HVHF.

The law has developed a mechanism for dealing with this kind of uncertainty; the precautionary principle. There are many iterations of the precautionary principle, and the one below is taken from the United Nations Rio Declaration:

> *If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reasoning for postponing measures to prevent environmental degradation. In the application of the principle…decisions should be guided by:*
>
> *(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and*
>
> *(ii) an assessment of risk-weighted consequence of various options.*[7]

A plain English way of stating the precautionary principle was given by Carolyn Raffensperger, namely:

> *[the precautionary principle] "has three building blocks. One is scientific uncertainty. The second is the likelihood or the plausibility of harm. The third element is precautionary action. The mandate of the Precautionary Principle is to take preventative action in the face of uncertainty to prevent harm. The focus is not on measuring and managing harm, but preventing harm.*[8]

It is important to recognises that in almost all iterations of the precautionary principle that can be found there is a requirement that the potential harm be serious, irreversible or both. Groundless fears or baseless assertions of impacts are insufficient to warrant the application of the precautionary principle. The threat of harm must be based on information rather than mere conjecture or speculation.

Knowledge gaps and uncertainty with HVHF

When discussing the precautionary principle, it is important to recognise that many of matters, which will potentially be affected by HVHF, are not currently well understood. This includes the NT's geology, hydrogeology and distribution of flora and fauna.[9]

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7 United Nations Environment Program (UNEP). "Rio Declaration on Environment and Development".

8 http://multinationalmonitor.org/mm2004/09012004/september04interviewraffen.html

9 See for example - Collof, M (2017) Submission to the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory, at p 1 "Because development of shale gas in the Northern Territory is still in its exploratory phase, with few commercial wells, there is a lack of empirical evidence on the environmental impacts of hydraulic fracturing", at p 3 "to the north of Newcastle Creek is an extensive, but poorly documented, series of waterhole refugia extending to the Carpentaria Highway in the north and the Tablelands Highway to the East. Environmental values of these refugia are not known because they have not been surveyed", at p 5 "given that recharge and discharge rates from such systems are very poorly known, there is a risk

The CSIRO Northern Australia Sustainable Yields Project summarised the knowledge of groundwater resources as follows:

> *Groundwater data are very sparse for most aquifers across the project area [north of the arid zone] and there are large uncertainties regarding the volume that might be safely extracted. This uncertainty is greater than the variability inherent in any possible changes due to climate change. Increased extraction will have impacts downstream that cannot be fully evaluated.*[10]

The NT Government recently announced a multi-million dollar *Mapping the Future* program. That program has been put in place to help guide future development of the NT by addressing some of the gaps that currently exist in understanding the geology and hydrogeology of the NT, and the distribution of native flora and fauna.[11]

There is also uncertainty about whether HVHF in the NT has had adverse environmental impacts. While the 2014 Hawke Report stated that there haven't been "demonstrated environmental impacts" from HVHF in the NT, it also found that no "publicly accountable, transparent procedure for the monitoring assessment and reporting of [environmental] impacts" associated with hydraulic fracturing operations exists in the NT.[12] As Collof states in his report to this Inquiry, "absence of evidence of environmental impact does not constitute evidence of absence of environmental impact". [13]

There is a lack of scientific consensus in Australia and Internationally about many of the major potential impacts of the industry including the potential for water contamination, the impacts of chemical use and the extent of methane emissions. In oral submissions to the Inquiry in Darwin, Dr David Close from Origin noted that scientists have come to different conclusions in relation to water contamination.

> *On the question of the EPA, it is very difficult to stay current with the substantial number of studies in cleared claims and competing counter-claims that are made by the USGS, EPA, government surveys. In Pavilion, Wyoming, for instance, over the course of five, or six, or seven years, five or six different conflicting studies, all legitimate, all scientists with good credibility, best of intents with different interpretation, different understandings of history, and different context*[14]

Different jurisdictions (and indeed different inquiries) have dealt with this uncertainty in different ways. Many jurisdictions have decided that, despite the uncertainties, HVHF can be undertaken safely through implementation of a robust regulatory regime.[15] That was the conclusion of the 2014 Hawke Report. On the other hand, numerous jurisdictions have now banned HVHF.[16] The New York Department of Public Health, which in 2014 recommended a moratorium on HVHF did so largely on the basis of

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that extraction of groundwater for fracking could cause groundwater-dependent aquatic refugia to dry permanently or for periods considerably longer than hitherto".

10 CSIRO (2009) Water in Northern Australia – Summary of Reports to the Australian Government from the CSIRO Northern Australia Sustainable Yields Project – accessible here: Sustainable Yeilds Project at p 9

11 http://newsroom.nt.gov.au/mediaRelease/23051

12 2014 Hawke Report, at pp 81-82

13 Collof, M (2017) Submission to the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory , p 4.

14 https://frackinginquiry.nt.gov.au/submission-library/?a=414041 Transcript of the submission of Origin Energy to the Inquiry, p 15

15 For example, NSW (in relation to CSG), New Zealand, Canada

16 For example, Victoria, Scotland, New Brunswick State – U.S, New York State – U.S, Maryland State – U.S, France

application of the precautionary principle, as opposed to some specific evidence suggesting that public health impacts of HVHF were assured. The study's author stated:

> *As with most complex human activities in modern societies, absolute scientific certainty regarding the relative contributions of positive and negative impacts of HVHF on public health is unlikely to ever be attained. In this instance, however, the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of the some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF to all New Yorkers and whether the risks can be adequately managed, DOH recommends that HVHF should not proceed in New York State.*[17]

The precautionary principle in legislation

The precautionary principle is often, laudably, included in the objective provisions of legislation (that is the case with the Regulations, although not the Act). While somewhat beneficial, for the precautionary principle to actually achieve what it is intended to, it must be "operationalized" in some way. One of the criticisms levelled at the precautionary principle is that it has simply become part of legislative decision-making process, a tick a box, as opposed to a rule that produces a particular outcome.

The Regulations are an example of legislation that makes the precautionary principle one of a number of boxes that must be ticked during decision making. In the case of the Regulations, the Minister must tick the precautionary principle box (by taking into account principles of ESD) before approving an Environmental Plan under r 9(2) of the Regulations. The Regulations fail to meaningfully operationalize the principle.

Andrew Edgar, in his 2013 article *Institutions and Sustainability: Merits Review Tribunals and the Precautionary Principle* makes a powerful case for "operationalizing" the precautionary principle through the inclusion of third party merits review rights in legislation. Among the points made in his article, Edgar notes the following:[18]

- the precautionary principle requires that decision-makers should impose measures to prevent degradation where there is scientific uncertainty and the potential for serious or irreversible environmental harm.[19]

- Application of the precautionary principle requires preventative measures and therefore imposes more onerous requirements than the norm under environmental assessment processes, which generally proceed on the basis that a project can go head as long as the impacts are acceptable and mitigated.[20]

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17 Zucker, H. (2014) A public health review of High Volume Hydraulic Fracturing for Shale Gas Development https://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf

18 Edgar, A. (2013) Institutions and Sustainability: Merits Review Tribunals and the Precautionary Principle, The Australian Journal of Natural Resources Law and Policy [Vol. 16, No.1, 2013]

19 Ibid at p 63

20 Ibid

- The factual and discretionary aspects of a decision are beyond the scope of judicial review which makes it a largely unsuitable vehicle to assess whether the precautionary principle has been properly and meaningfully applied.[21]

- Third party merits review are a "particularly useful institution for examining the precautionary principle in practice"[22] and "merits review has institutional characteristics that make it highly suited to operationalizing precautionary decision making".[23]

- Merits review tribunals are particularly well placed to interpret statutory terminology in a manner that is transparent and holds primary decision makers accountable for their interpretation of laws.[24]

Professor Alan Randall PhD, in his 2012 article *Coal seam gas – Toward a risk management framework for a novel intervention* argues for a precautionary approach to risk management in relation to CSG operations. He states that "faced with a novel intervention that presents extraordinary risk, uncertainty and/or gross ignorance about future consequences, intuition suggests that we can stay the course and attend later to harmful outcomes in the cases where they occur, or we can try and get ahead of the game by taking precautions before the full potential for harm has been characterised".[25]

Randall's central arguments are that:

- Ordinary Risk Management (**ORM**) is not well suited to *novel interventions* (which he characterises CSG as being) and their poorly specified, low-probability but high consequence threats.[26]

- ORM, like standard environmental assessment procedures proceeds on the basis of "safe until proven harmful" and has a tendency to defer risk-management intervention until the innovation has been implemented and harmful consequences have been established.[27]

- ORM is not well suited to complex risks and if applied to them will systematically understate the extent of the risks involved.[28]

- Novel interventions such as CSG require a precautionary approach to risk management because of the potential cumulative impacts arising from its demand for water, usage of chemicals and its intrusion on the landscape.[29]

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21 Ibid at p 67

22 Ibid at p 63

23 Ibid at p 61

24 Ibid at p 72

25 Randall, A (2012) Coal seam gas – Toward a risk management framework for a novel intervention, 29 Environment and Planning Law Journal 152 at p 157

26 Ibid at 158

27 Ibid

28 Ibid at 159

29 Ibid at 161

- A "slow down and learn" approach to CSG is a desirable model, taking elements of the screening, testing, surveillance (STS) approach applied in the introduction of new genetically modified crops. In relation to this approach, Randall states "*if this approach seems rather banal, compare it with adaptive management, which seems to be the Australian regulatory answer to the issue of unpredictable impact. Adaptive management is essentially reactive. It is all about waiting until problems reveal themselves and seeking to restore them by trial and error – basically, standing aside while the lights go out and then feeling our way in the dark.*[30]

The tendency of the NT to apply a standard ORM to the HVHF industry is well illustrated by an approach recommended in the 2014 Hawke Report in relation to ground water impacts:

> *the NTG, with the support of industry, should improve knowledge of aquifers and ground water systems in regions where current knowledge is poor and where development of the gas extraction industry is most likely to occur, in order to support evidence-based water allocation as the industry develops over the next two decades. Relevant data collected by industry during exploration and extraction should contribute to building this knowledge base.*[31]

Operationalizing the precautionary principle within the NT's regulatory regime.

Taking into account the above, the EDO recommends five approaches to regulatory reform to "operationalize" the precautionary principle.

Recommendation 1: Including ESD principles (including the precautionary principle) as a legal objective in the Act and requiring application of the principles.

The first step to operationalizing the precautionary principle is to enshrine principles of ESD in the objectives of the Act. The second is to require decision makers to apply the principles, rather than merely take them into account.

Recommendation 2: Objective based decision making criteria

To reverse the tendency to for decision makers to interpret ESD principles in a way that prioritises short-term economic outcomes over longer-term principles, the Act and Regulations should introduce specific objectives or criteria based tests for environmental outcomes that must be applied by decision makers.

Recommendation 3: Play based regulation (PBR)

The Inquiry should consider the utility of play-based regulation in the NT, as a way of moving from ORM to implement the kind of precautionary risk management urged by Randall. PBR is discussed in the cumulative impacts section of this submission.

30 Ibid at 161

31 The 2014 Hawke Report, at p 110.

Recommendation 4: Reversing the burden of proof

The fourth mechanism we argue to have included in the NT regulatory regime to "operationalize" the precautionary principle is to reverse the burden of proof for demonstrating that the activity is safe. That is, if the principle applies – a decision maker must assume the threat of serious or irreversible environmental damage is a reality [and] the burden of showing this threat … is negligible (after mitigation strategies are imposed) reverts to the proponent…[32]

Recommendation 5: The inclusion of third party merits review rights.

There are many benefits to including third party merits review rights in environmental legislation. Those benefits are discussed at length (albeit in relation to NSW planning laws) in the EDO NSW report *Merits Review in Planning in NSW*.[33] In summary the benefits of merits review include:

- Enhancing the quality of the reasons for decisions;
- Providing a forum for full and open consideration of issues of major importance;
- Increasing the accountability of decision makers;
- Clarifying the meaning of legislation;
- Ensuring adherence to legislative principles and objects by administrative decision makers (including the precautionary principle where included);
- Focusing attention on the accuracy and quality of policy documents, guidelines and planning instruments; and
- Highlighting problems that should be addressed by law reform.[34]

In addition to those benefits are the particular strengths, which Edgar identifies which merits review rights possess in terms of "operationalizing" the precautionary principle. For example, Edgar found that:

- Studies have recognised merits review to be a rich source of precautionary decision making;[35]
- Merits review allows the factual basis for a decision to be fully examined and tested by the parties. This, according to Edgar, is particularly important for the application of the precautionary principle since it is designed to guide decision making in the context of scientific uncertainty;[36] and
- In a merits review the body with jurisdiction can consider fresh evidence and, therefore, the information base can be supplemented by more detailed information and the contributions of experts. In this respect, Tribunal's (or courts) provide a better forum for detailed examination of complex evidence than the initial departmental decision-making process.[37]

32 Telstra Corporation Limited v Hornsby Shire Council, Justice Preston at [51]-[55]

33 Accessible here: Merits Review in Planning in NSW

34 Preston B and Smith J, (1999) "Legislation need for an effective Court" in Promises, Perception, Problems and Remedies, The Land and Environment Court and Environmental Law 1979 – 1999, Conference proceedings, Nature Conservation Council of NSW, 1999 at 107.

35 Ibid 18 at p 66

36 Ibid at p 67

37 Ibid

Objective based vs prescriptive regulation – or a hybrid approach?

The EDO's major submissions in relation to the merits of a purely objective based approach are largely contained with the *EDO comment on the Draft Regulations*. In that comment we note the strong arguments in favour of this type of regulation, which are clearly articulated by Black, Hooper and Band in *Making a success of Principles-based regulation* and Dr Tina Hunter. [38] We agree that solely prescriptive based regulations have the potential to fail to keep pace with scientific and technological developments, lead to gaps and provide opportunities for "creative compliance".

Despite the clear benefits of a purely principle-based approach, the EDO's experience in the NT has led us to form the conclusion that a hybrid approach to regulation (one with objective based elements and prescriptive based elements) would perform better in terms of both environmental protection, effective compliance and community confidence.

Our concerns with a purely objective based approach to regulating the shale gas industry can be conveniently summarised as follows:

- There is an increased reliance on "high quality" operators;
- Environmental impacts may not be known until a distant point in the future (making an assessment of whether an operator has reached the required standard difficult or impossible).
- Companies will be able to take a calculated risk about the lowest cost option, without necessarily being the safest long-term option.
- Object based regulations have been shown to be ineffective when used in the wrong context (this is particularly true when dealing with recalcitrant operators).
- The regulator is put at a comparative disadvantage (with comparison to prescriptive regulations) in relation to compliance and enforcement.

Arguments, which fall in favour of prescriptive based regulations, are:

- The provision of certainty and a clear standard of behaviour that must be met.
- Regulations are easier to apply consistently.
- They are easier to enforce.

During the oral submissions before the Inquiry, Panel Members raised questions about how the "hybrid" approach that we recommend would operate in practice. Specifically, some concerns were raised about companies experiencing confusion in demonstrating compliance with objective based requirements, where they form part of a hybrid scheme.

We believe that having prescriptive requirements alongside objective requirements actually helps to provide clarity of expectations for operators. But, more importantly, it provides for greater ease of use by regulators in the NT. For example, compulsory design specifications for well integrity will allow all operators, regardless of their sophistication, to know exactly what is required of them. By contrast, objective based requirements provide a far less certain level of direction and are far more complicated to assess and enforce.

38 Black, J. Hooper, M. Band, C (2007) Making a success of Principles-based regulation, Law and Financial Markets Review, May 2007, p 191 – 206 at p193, 2016 Hunter Report at p 13.

The combination in essence has the effect of imposing both minimum standards and a requirement to go over and above that minimum as the science evolves.

In a situation, which may arise, where a company says that they've got a new technology which is leading practice, but is a departure from the minimum standards there should be flexibility in the Regulations for that company to use that process, so long as they are able to establish to the satisfaction of the regulator that the process is superior to the minimum standard.

Hybrid regulations have both "goal/object" elements and "prescription elements". In practice that may look something like as follows:

The object based element

A submitted Environmental Management Plan must:

9(c) demonstrate that the activity will be carried out in a manner by which the environmental impacts and environmental risks of the activity will be reduced to a level that is:

(i) as low as reasonably practicable; and
(ii) acceptable.

One of the prescriptive elements

An interest holder undertaking drilling activities must comply with the requirements of the Code of Practice for Well Integrity.

Recommendation 6: That the NT regulatory regime move to a hybrid model of regulation which contains minimum standards for well construction and design, aquifer interference, disclosure of chemicals and reporting of incidents.

The Background & Issue Paper
Regulatory Framework - Risk Themes

Failure to protect the environment

Baseline data

Baseline testing of groundwater, surface water, soil and sediment quality and air quality should be obtained prior to the commencement of shale gas activities. This is not a legislated requirement in the NT (unless imposed by direction under the Act – which is totally non-transparent).

Dr Scott Wilson has identified the following gaps in relation to baseline testing in the NT which should be mandated:

> *Baseline health impact assessment should be further defined as to pertaining to human and/or environmental health aspects;*
>
> *Baseline biological surveys of surface water and groundwater, with particular reference to stygofauna should be specified; and*
>
> *Ecotoxilogical data using locally relevant and condition specific species should be included.*

Baseline testing is now a feature of the legislative regimes that we identify as best practice. For example, in Colorado the *Colorado Oil and Gas Conservation Commission Rules-Series Safety Regulations,* Rule 609 requires operators to obtain baseline groundwater samples:

Initial baseline samples and subsequent monitoring samples shall be collected from all Available Water Sources, up to a maximum of four (4), within a one-half (1/2) mile radius of a proposed Oil and Gas Well, Multi-Well Site, or Dedicated Injection Well. If more than four (4) Available Water Sources are present within a one-half (1/2) mile radius of a proposed Oil and Gas Well, Multi-Well Site, or Dedicated Injection Well, the operator shall select the four sampling locations based on the following criteria:

> *(1) Proximity. Available Water Sources closest to the proposed Oil or Gas Well, a Multi-Well Site, or Dedicated Injection Well are preferred.*
> *(2) Type of Water Source. Well maintained domestic water wells are preferred over other available Water Sources.*
> *(3) Orientation of sampling locations. To extent groundwater flow direction is known or reasonably can be inferred, sample locations from both downgradient and up-gradient are preferred over cross-gradient locations. Where groundwater flow direction is uncertain, sample locations should be chosen in a radial pattern from a proposed Oil and Gas Well, Multi-Well Site, or Dedicated Injection Well.*
> *(4) Multiple identified aquifers available. Where multiple defined aquifers are present, sampling the deepest and shallowest identified aquifers is preferred.*
> *(5) (5) Condition of Water Source. An operator is not required to sample Water Sources that are determined to be improperly maintained, nonoperational, or have other physical impediments to sampling that would not allow for a representative sample to be safely collected or would require specialized sampling equipment (e.g. shut-in wells, wells with confined space issues, wells with no tap or pump, non-functioning wells, intermittent springs).*

Baseline testing for water quality was a major recommendation of the Natural Gas Steering Committee in New Brunswick (before HVHF was banned). The steering committee recommended as follows:[39]

- *Water samples from all potable wells within (an appropriate distance) of a gas well must be collected and analysed before drilling operations begin.*
- *This is not a process undertaken by the company, but instead by a third party engaged by the Government at the cost of the operator.*
- *Testing is analysed in government laboratories.*
- *Testing is to occur prior to clearing a well pad.*

Baseline testing for air quality is also critically important, particularly in light of the increasingly reported uncertainties around fugitive methane emissions.[40] Best practice jurisdictions in relation to air quality are North Dakota and Colorado, which place explicit requirements on operators in relation to fugitive emissions, ambient air quality testing an flaring requirements.[41]

In his report to the Inquiry (attached as Attachment F) Dr Scott Wilson, states, "*to understand and mitigate the risks associated with fracking and associated activities, collecting baseline data is imperative. This should be conducted ideally over several seasons to account for natural weather, climatic and lifecycle fluctuations/perturbations".*[42]

Further Dr Wilson encourages the use of "*a broad scale monitoring design that includes both multiple reference and potential impact sites*".[43]

Recommendation 7: Legislative requirement for obtaining baseline data

Baseline testing for groundwater, surface water, soils, sediments and air quality be undertaken prior to shale gas activities. Baseline testing should be required to occur over several seasons as recommended by ecotoxicologist, Dr Scott Wilson.

Recommendation 8: Independent operators for baseline data testing

In line with best practice jurisdictions, operators should not undertake baseline testing. Baseline testing should instead be undertaken by independent third parties at the cost of the operator.

No-go zones

The importance of large areas of undisturbed land is critical for the maintenance of species, biodiversity and landscape function. The benefits of reserves are well

39New Brunswick Natural Gas Group (2012) Responsible Environmental Management of Oil and Gas Activities in New Brunswick, at p 37 – accessible here: http://www2.gnb.ca/content/dam/gnb/Corporate/pdf/ShaleGas/en/RecommendationsDiscussion.pdf

40 Melbourne Energy Institute (2016) A review of current and future methane emissions from Australian unconventional oil and gas production – accessible at: MEI Review - Methane Emissions

41 See the EDO Hawke Report for further details of the North Dakota and Colorado regulatory regimes.

42 Dr Wilson, S (2017) Expert Advice – Scientific Inquiry into Hydraulic Fracturing in the Northern Territory – Attached as attachment F at p 4

43 Ibid

understood and are "increasingly being recognised as a cornerstone for biodiversity conservation especially in the era of climate change".[44]

The shale gas industry has the potential to industrialise large remote parts of the NT, with consequent impacts on flora and fauna through *edge effects* and *habitat loss and fragmentation*. The potential impacts of the shale gas industry on the landscape values of the NT a set out clearly by Bali (attachment D) and Collof (attachment E). They include, increased potential for weed infestation, changed fire regimes, habitat fragmentation, road mortality, human access, aquatic impacts and edge effects.[45]

Dr Renata Bali, in her submission to this Inquiry (Attachment D) notes:

> *As part of their assessment of the ecological impacts of shale gas extraction in Australia, Eco Logical (2013) cautioned that there are likely to be 'areas of extreme risk' (i.e no go areas) due to the presence of key threatened species populations, places of scenic beauty or cultural significance or iconic wetlands. ACOLA (2013) also noted that, while current approaches may allow shale gas developments to co-exist with other land uses, 'no go' zones may need to be included.*

Dr Bali further discusses no-go priority areas stating:

> *It is reasonable to assume that existing parks and reserves should form the cornerstone of any proposal for priority no go areas. In general, the infrastructure associated with large scale shale gas development is not compatible in areas where conservation management is a priority or in those areas containing significant scenic or cultural values.*

The EDO notes that the current Act does not provide automatic protection for Parks or Conservation reserves, the values of which would seem inconsistent with gas extraction activities. The EDO is currently engaged by traditional owners of Watarrka (Kings Canyon) National Park to try and obtain heritage status for that area to prevent any further applications being made for exploration for gas within the park. The EDO also notes that exploration for oil and gas has occurred within at least one Territory National Park, namely Limmen National Park.

Importantly, Dr Bali's report and its attached tables, demonstrates that a great deal of the ecological value and biodiversity of the NT is not well represented by the NT's current Parks and Reserves system.[46] What this means is that the NT will need to consider a far vaster network of no-go zones to adequately protect various threatened species and assist in protecting landscape function.

Our discussion of the precautionary principle above noted the significant data gaps which exist in relation to the NT's geology, groundwater and distribution of flora and fauna. This lack of knowledge is relevant to the establishment of no-go zones. Detailed understanding of groundwater systems, distribution of flora and fauna and fault areas that may make gas extraction more risky should underpin the designation of no-go zones.

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44 Dr Bali, R Expert Advice – Scientific Inquiry into Hydraulic Fracturing in the Northern Territory (attached at Attachment D, p 22).

45 See the discussion of Bali (attachment D) at p 8 – 16 and Collof (attachment E) at p 7 -8.

46 See the discussion of no-go zones by Bali, R – Attachment D at p 22

As an example, there is considerable lack of data with respect to wetlands in the NT. Collof, in his report to this inquiry (attached as Attachment E) notes, "it is likely that unsurveyed wetland systems exist in some shale gas regions such as the Beetaloo Sub-basin"[47]

It is significant that these data gaps exist. Closing the knowledge gaps, identifying the no-go zones and giving them legislative protection seems a necessary precondition to industry activities if the moratorium is lifted.

Recommendation 9: No go zones in legislation based on science

Vast no-go zones be identified and enshrined in legislation prior to the moratorium on exploration and production being lifted. The absence of any provision for strategic planning in the current NT act is of concern (particularly when viewed in the context of the Territory's woeful environmental assessment regime).

Recommendation 10: Strategic planning mechanisms in legislation

Outside of the network of "no-go zones" identified for conservation purposes, the legislative regime should still include strategic planning assessment provisions, such as those found in NSW under the *Strategic Regional Land Use Policy,* to identify areas of land in the NT (outside of no-go zones) that are unsuitable for HVHF, for example because of their high agricultural or cultural values.

Protection of ground and surface water

The current regulatory regime fails to adequately protect water resources and the ecosystems that rely on them[48]. As it currently stands the NT community can have little confidence in the regulatory regimes ability to ensure avoidance of reductions in both the quality of surface water and the quality and quantity of groundwater.

The evidence does not provide consensus about the potential impacts on groundwater from HVHF. For example, a number of studies have found elevated levels of methane in water sources located close to shale gas activities in the United States[49] and the US EPA has observed instances of contamination, but has not found the issue to be systemic. Because the HVHF industry is in its infancy in the NT, there is very little (if any) data about ground water contamination.[50]

Dr David Close of Origin made the point in his oral submission to the Inquiry that the NT operates in a very different context to that of the Marcellus Play, namely because the

47 Collof, M – Attachment E at p 4.

48 See for example, Wilson (attachment F) at p 6

49 See for example, Osborn SG, Vengosh A, Warner NT, Jackson RB (2011) Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. Proceedings of the National Academy of Sciences USA 108 (20):8172-8176, Jackson RB, et al. (2013) Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction, Proceedings of the National Academy of Sciences USA 110(28): 11250-11255.

50 The EDO notes that it was provided with anecdotal evidence of reduced quantity of groundwater in the vicinity of the Meerenie Gas Field with our clients telling us of a spring which existed near there which no longer runs.

NT does not have to contend with the decades of conventional production which have left "literally thousands, and in many is tens of thousands of wells through these areas".[51]

Quantity of groundwater

Understanding of Groundwater resources of in the NT is in its infancy. It is true that baseline studies, being undertaken by the CSIRO and others, is occurring, but our understanding is that there is much to be done. The evidence provided to the Inquiry previously is that the water that will be used for HVHF in the NT is likely to be, for the most part, water of a quality good enough to use for domestic or stock use.

HVHF requires significant amounts of water.[52] As noted in the report of Collof, reductions in the quantity of groundwater can have significant adverse environmental impacts, particularly in arid and semi-arid regions. Collof states in relation to HVFH's use of water:

> *In arid and semi-arid regions, access to sufficient water for fracking could add to existing competition for current and future water resources from environmental, urban, pastoral and agricultural uses.*
>
> *Extraction of groundwater for fracking may draw down aquifers to that springs that feed freshwater refugia no longer flow. Springs are sites at which water from underground aquifers is discharged. Typically, springs occur where porous rock overlies an impermeable one, for example at a series of discharge sites along the base of the Western MacDonnell Ranges. Such springs may try temporarily during dry periods when the aquifer is not being recharged by rainwater infiltration. The volume of water extracted from an aquifer that will cause a spring to dry may be relatively small, depending on the volume of the aquifer, its recharge characteristics and the location of the spring in relation to the aquifer.*

Recommendation 11: Application of the *Water Act* licencing provisions to shale gas operations

No further licences (of any kind) should be issued under the Act until the necessary legislative amendments are made to require shale gas operators to obtain a groundwater extraction licence under the *Water Act*.

Recommendation 12: Sustainable yields must be set by application of the precautionary principle

In light of the uncertainties and knowledge gaps in relation to ground water resources in the NT (outlined in the Precautionary Principle Section above) a legislative requirement should in place (under the *Water Act*) requiring the sustainable yields and corresponding extraction limits for aquifers to be set having specific regard to the precautionary principle.

Recommendation 13: Low security licences

51 https://frackinginquiry.nt.gov.au/submission-library/?a=414041 Transcript of the submission of Origin Energy to the Inquiry, p 15

52 See Collof, (attachment E) at p 7

The shale gas industry is a new industry in the NT and is seeking to take its place among pre-existing uses (agricultural, cultural, environmental, stock and domestic). Because of that, any water licences issued to the shale gas industry should be issued as low security licences. That is, the water entitlements for the shale gas industry should be the first to be removed during dry periods.

Quality of groundwater

Recommendation 14: No-go zones to protect from spills

The importance of mitigation measures to manage spills cannot be understated, a 2015 journal article considering the pathways for HVHF operations to adversely impact water sources in the Marcellus Shale in the U.S. found that surface spills were statistically the most significant (compared with other possible pathways, namely "lateral transport from faulty wells" and . "t*he data support a transport mechanism of diesel range organic compounds to groundwater by accidental release of fracturing fluid chemicals derived from the surface rather than subsurface flow of these fluids from the underlying shale formation*".[53]

The report further concluded that "*irrespective of the reporting nuances, it is clear that surface release of fracturing fluids are usually accidental. Therefore, it is not necessarily the hydraulic fracturing process (i.e. the fluid injection) that can lead to groundwater contamination, but rather, the existence of the operation itself. (i.e., the inherent risk associated with mechanical failure and human error in industrial practice*."[54]

Spills are likely to occur and, when they do, evidence from the Marcellus shows that there are measureable impacts on water quality, with the highest concentrations being observed within 1kim of a well.[55] With that knowledge, it should be assumed that one impact of the shale gas industry will be spills and corresponding adverse impacts to water quality. Anywhere where that risk or inevitability would be unacceptable because of its impacts on the environment or public health should be excluded from HVHF operations.

Recommendation 15: Stringent spill reporting obligations

A 2017 study reported by the American Chemical Study analysed the risks, mitigation priorities and state reporting requirements for spills occurring during HVHF operations in the U.S (across 4 states). One of the findings of that report was that "*the differences in reporting requirements [between States] determine the quantity, quality and usability of data received by the states*".[56]

That report finds particularly there is value in:[57]

53 Drollette, BD et al (2015) Elevated levels of diesel range organic compounds in groundwater near Marcellus gas operations are derived from surface activities, Proceedings of the National Academy of Sciences, vol 112 no. 43, 13184-13189

54 Ibid.

55 See for example, Osborn SG, Vengosh A, Warner NT, Jackson RB (2011) Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. Proceedings of the National Academy of Sciences USA 108 (20):8172-8176, Jackson RB, et al. (2013) Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction, Proceedings of the National Academy of Sciences USA 110(28): 11250-11255.

56 Patterson, LA (2017) Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements, published American Chemical Society, Environ Sci Tehcnical 2017, 51, 2563-2573

57Ibid, p 2570

- low minimum volume thresholds for reporting requirements
- that the cumulative impacts of low volume spills are difficult to predict in the absence of such reporting.
- Reporting should include spills, which do not breach the secondary containment on a well pad.
- Reporting should include the pathway of the spill.
- Reporting must be contemporaneous with the spill.
- Making spill data accessible to it can be readily analysed by a variety of stakeholders including industry, academia, regulators and NGOs

As to the final finding of the report relating to accessibility of data, the EDO reiterates its oral submission that there is a difference between accessible data and digestible data. The Government should strive to have publicly available data presented in a fashion that makes it easily navigable.

Recommendation 16: Prescriptive requirements for well integrity

The current Regulations and the Schedule provide insufficient safeguards to ensure well integrity and are not best practice. The NT regulatory regime should include prescriptive requirements to ensure well integrity. This could be achieved through the formulation of a code of practice for well integrity, such as that found (for the purposes of CSG operations) in NSW.[58]

Prescriptive regulations providing mandatory standards for well design and construction are now the norm in most states in the United States. The regulations can provide a flexible approach to allow for innovation, as outlined in our discussion of prescriptive vs objective based regulation above.

Recommendation 17: Groundwater impacts reports & Aquifer Interference Policy

Amend, Schedule 1 to the Regulations to require applications for a approval to conduct a *regulated activity* to include a ground water impacts report. The report should include details of the company's groundwater extraction licence and the specific baseline testing results conducted prior to regulated activities occurring and a detailed appraisal of how the requirements of the AIP are met.

Recommendation 18: Reverse onus provision

Oil and gas industry representatives have expressed a high level of confidence in their processes and ability to manage the potential impacts of their industry on water resources.[59] Given that, the EDO expects that Industry would support our recommendation for legislation to include a rebuttable presumption that gas operators are liable for water pollution.

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58 NSW Code of Practice for Well Integrity

59 See for example, Matt Doman, APPEA – submission to the Inquiry, https://frackinginquiry.nt.gov.au/submission-library/?a=414036 at p2: "Around Australia thousands of wells have been drilled and over a thousand fracked with no significant impact on the environment or ground water resources", Rohan Richardson, SANTOS – submission to the Inquiry, https://frackinginquiry.nt.gov.au/submission-library/?a=414049 at p 11: "We have, like Bill said, over 4,000 wells in the Cooper basin, 1500 independent frack jobs and not one primary barrier has ever failed throughout pumping a fracture stimulation job. To my knowledge we have not had a primary barrier failure onshore Australia through fracture stimulation when executing the job.

This would not be a unique legislative provision. The *Illinois Hydraulic Fracturing Regulator Act* includes a reverse onus provision for water pollution events in areas where oil and gas operations have taken place:

> **Section 1-85 Presumption of pollution or diminution**[60]
>
> (a) This section establishes a rebuttable presumption for the purposes of evidence and liability under State law regarding claims of pollution or diminution of a water source and for use regarding the investigation and order authority under Section 1-83.
>
> (b) Unless rebutted by a defence established in subsection (c) of this Section, it shall be presumed that any person conducting or who has conducted high volume horizontal hydraulic fracturing operations shall be liable for pollution or diminution of a water supply if:
>
> 1. the water source is within 1,500 feet of the well site;
> 2. water quality data showed no pollution or diminution prior to the start of high volume hydraulic fracturing operations; and
> 3. the pollution or diminution occurred during high volume horizontal fracturing operations or no more than 30 months after the completion of the high volume hydraulic fracturing operations.
>
> (c) To rebut the presumption established under this Section, a person presumed responsible must affirmatively prove by clear and convincing evidence any of the following:
>
> 1. the water source is not within 1,500 ft of the well site;
> 2. the pollution or diminution occurred prior to high volume horizontal hydraulic fracturing operations or more than 30 months after the completion of the high volume horizontal hydraulic fracturing operations; or
> 3. the pollution or diminution occurred as the result of an identifiable cause other than the high volume horizontal hydraulic fracturing operations.

The Natural Gas Steering Committee in New Brunswick recommended that oil and gas companies be presumed to be responsible for replacing or restoring water supply where that supply was "diminished in quality" or "reduced in capacity".[61] HVHF was ultimately banned in that State. The Steering Committee recommended the inclusion of definitions of "*diminished quality*"[62]and of "*reduced capacity*"[63]

60 Accessible from: http://www.ilga.gov/legislation/publicacts/98/PDF/098-0022.pdf

61 New Brunswick Natural Gas Group (2012) Responsible Environmental Management of Oil and Gas Activities in New Brunswick, s 10.2 at p 49.

62 "diminished in quality" means a reduction in water quality based on the chemical parameters that could potentially be affected by seismic testing or by the drilling and hydraulic fracturing of an oil or gas well, (as evidenced by a comparison between pre- and post activity water well sampling), that is outside the normal range of variation in water quality for the aquifer under consideration, with reference to information sources such as the Department of Environment's background water quality program and the New Brunswick Groundwater Geochemistry Atlas.

Recommendation 19: Make good agreements

A legislative requirement requiring make good agreements to be entered into between companies and the relevant landowner, the following requirements should be include:

- proponents to pay a landholder's reasonable costs in engaging a hydro geologist for the purposes of negotiating a make good agreement.
- Proponents to be responsible for the costs of any alternative dispute resolution in the make good agreement negotiation process.

Bioregional planning & Cumulative Impact Assessments

See our discussion of cumulative impacts in a later section of the report.

Transport, treatment and disposal of waste

Recommendation 20: Waste management plans

All EMPs should be required to include a waste management plan to be submitted and made publicly available. Waste management plans should include (at a minimum)

- Consideration that has been given and actions taken to minimise and manage waste
- A description of the types of waste that will be generated (including radioactive isotopes)
- A description of how waste will be handled and stored from cradle to grave.
- A description of the methods and locations of waste treatment, re-use or disposal.
- Confirm that there will be no on-site disposal of waste.

Recommendation 21: Prohibition on the storage of fracturing fluids and flowback water in evaporation ponds.

Best practice jurisdictions prohibit the use of evaporation ponds.[64] In Illinois there is a general requirement that all frac fluid, flowback and produced water be stored in above-ground tanks until removed for proper disposal.[65] A ban on the use of evaporative ponds has been implemented (re CSG produced water) in NSW.[66] Storage of waste in ponds can assist in eliminating contamination arising from leakage or spills from open ponds and also reduce air quality issues associated with evaporation of noxious gases

63 "reduced capacity" means local or regional lowering of water table or reduction in aquifer capacity not attributable to climatic variations or increased activity unrelated to the oil and gas exploration or production.

64 See for example Illinois Hydraulic Fracturing Regulator Act 2013, s 1-75(c), we also note the STRONGER Guidelines recommend a move away from storage in open ponds: http://www.strongerinc.org/wp-content/uploads/2015/08/2015-STRONGER-Guidelines.pdf

65 Ibid

66 http://www.resourcesandenergy.nsw.gov.au/landholders-and-community/coal-seam-gas/the-facts/protections-and-controls

The presumption that various fluids not be stored in open ponds is particularly important during times of the year in the NT, where extreme rainfall events occur.

Climate change

Our discussion in relation to climate change is addressed in the cumulative impacts section of this submission below.

Land access

The EDO's primary concern relates to the legal framework as it applies to ensure protection of the environment. Having said that, because of the weaknesses in our current regime, Land Council's have used their veto and agreement rights to "upgrade" the environmental obligations companies are subject to by way of provisions in agreements.

That is an entirely undesirable way of achieving good environmental outcomes and there is a great deal of unfairness (both for industry and landowners) associated with contractually based environmental regulation.

A much better way is to have in place a regulatory regime, which provides adequate safeguards for the environment. Our submissions in relation to land access on ALRA land, and in relation to the rights of traditional owners on Native Title Land, are expressed below under the section discussing Aboriginal people and their culture.

With respect to land access on pastoral and freehold land, we bring to the Inquiry's attention the *Agreed Principles of Land Access* document signed by Santos, AGL and representatives of various farming peak bodies in NSW. The document, which is stated, to be based on values of "respect, integrity and trust" essentially gives farmers a right of veto, albeit not under legislation, to prevent gas activities on their land.

Given that situation, one might reasonably ask why giving a right of veto to landowners would be opposed by government or by industry. Particularly as it would give great comfort to a land-owner to know that they have that power in legislation and would assist in redressing a power imbalance that many see as existing between shale gas companies and other land owners.

Public Health

Full disclosure

Recommendation 22: The NT regulatory regime should require full disclosure provisions for the make up of frac-fluids. Public disclosure should be done in such a manner that it is easily accessible, easily understood and

The impacts of chemicals used in HVHF operations are uncertain, controversial and frequently debated. For example a 2013 report examining the regulation of chemicals in the U.S, referred to a study by the Endocrine Disruption Exchange (TEDX) which conducted a study to determine the chemical make up of frac fluids. The study identified 632 different chemicals being used in HVHF operations and found that "more than 75 % of the chemicals identified had known impacts on the skin, respiratory system and/or gastrointestinal system and further 50% had known impacts on the nervous system, immune system and/or cardiovascular/circulatory system".[67]

The current NT regulatory regime does not require full public disclosure of all chemicals used in the HVHF process. We note that the Regulations require the description of a *regulated activity* to include details of the chemicals to be used,[68] and the *Guiding Principles* document released by the NT Government in 2015 did state that BTEX chemicals would not be permitted.

The absence of full disclosure provisions is contrary best practice both in respect of protection of the environment and the accrual of 'social licence'. The obvious impact of less than full disclosure, from a community standpoint, is a decreased level of transparency, which is undesirable. In terms of environmental protection, full disclosure allows for better monitoring of waterways for potential contamination, can potentially assist in assessing potential reactions of fluid additives with natural sources and can assist in the management of the industry.[69]

The EDO notes that there appears to be some inconsistency within the industry about the approach to chemical disclosure. Origin Energy, for example, has a full disclosure policy and makes the composition of their fracturing fluid publicly available. This is at odds with the position expressed by Halliburton in oral submission, which preferred that proprietary chemicals remain unavailable publicly.[70]

The EDO also notes that the *Guiding Principles* document contemplates a full disclosure document, which would require:

- Public release of specific information regarding chemicals used in the fracturing process.
- Clear identification of chemicals including the Chemical Abstracts Service (CAS) number.
- Details about the concentrations of chemicals used.

67 Maule, LA. et al, (2013) Disclosure of Hydraulic Fracturing Fluid Chemical Additives: Analysis of Regulations, New Solutions, Vol. 23(1) 167-187, 2013

68 Regulations, Schedule 1, cl 1(d).

69 Bately, EG & Kookana, RS (2012) Environmental issues associated with coal seam gas recovery: managing the fracking boom: CSIRO publishing.

70 Independent Scientific Inquiry into Hydraulic Fracturing, transcript of the oral submissions of Halliburton.

Aboriginal people & their culture

It not the EDO's function or intention to make statements about what activities should or should not occur on Aboriginal Land or land subject to Native Title. The EDO is however well placed to make general submissions about the regulatory framework for Hydraulic Fracturing, having represented many Aboriginal groups and individuals across the Northern Territory in relation to various environmental issues, including, specifically, in relation to hydraulic fracturing proposals.

The Act is but one of a number of pieces of legislation that will govern the environmental and cultural aspects of shale gas activities (including HVHF), which occur on Aboriginal and Native Title land in the Northern Territory. Shale gas operations will be influenced and regulated by –

Northern Territory Legislation

- *Environmental Assessment Act*
- *Heritage Act*
- *Petroleum Act*
- *Sacred Sites Act*
- *Waste Management Pollution Control Act*
- *Water Act*

Commonwealth Legislation

- *Environment Protection & Biodiversity Conservation Act* 1999 *(Where a matter of National Environmental Significance may be affected)*
- *Aboriginal and Torres Strait Islander Heritage Protection Act*
- *Aboriginal (Land Rights) Northern Territory Act*
- *Native Title Act*

The confusion about HVHF has been well documented.[71] The EDO's Principal Lawyer's experience, when consulting and undertaking CLE in remote parts of the Territory, confirms this confusion. The EDO has spoken with many people who were – even after government, land council and industry consultation – unable to explain the differences between CSG and shale gas, the differences between mining and shale gas operations, the difference between conventional and unconventional gas extraction. That says that current consultations are failing to ensure that people are properly informed about the process.

Cultural and language barriers and the NT's geographic size and climate mean that undertaking proper consultation is challenging, time consuming and expensive. It is, however, necessary. The need for industry to garner confidence in communities likely to be affected by a shale gas industry is recognised in a number of reports, including *the ACOLA report*:

71 See for example, the Hawke Report at pii.

> *Many of the most prospective areas for shale gas are subject to Native Title or are designated Aboriginal Lands and it will be important to ensure that traditional owners are aware of the nature and scale and the possible impact of shale gas developments from the start.*[72]

Industry and government have been strong on rhetoric in relation to consultation, but the failure to achieve meaningful understanding of the process in many of the remote communities visited by the NT demonstrates that the rhetoric has not translated to proper consultation. Because of this, consultation should be underpinned by stringent legislative requirements.

Free, prior & informed consent & Veto Rights

Indigenous Peoples' right to free, prior and informed consent (FPIC) has been recognised in a wide range of international conventions – including the *United Nations Declaration on the Rights of Indigenous people* - and by many intergovernmental organisations, international bodies and the Australian Government.[73]

In 2013, the UN Special Rapporteur on the rights of Indigenous Peoples, James Anaya produced a report on '*Extractive Industries and indigenous peoples'*. That report found that:

> *The worldwide drive to extract and develop minerals and fossil fuels (oil, gas and coal), 1 coupled with the fact that much of what remains of these natural resources is situated on the lands of indigenous peoples, 2 results in increasing and ever more widespread effects on indigenous peoples' lives. As has been amply documented in previous reports by the Special Rapporteur (see, for example, A/HRC/18/35, paras. 30-55), indigenous peoples around the world have suffered negative, even devastating, consequences from extractive industries.*[74]

The importance of the principle of FPIC is brought into particular focus with an industry such as the shale gas industry. There are serious questions as to whether the current apparatus (primarily Land Council's and to a lesser extent AAPA) used to ensure FPIC are well equipped to manage the unique impacts of a shale gas industry. Anthropologist, Gareth Lewis, in his expert report for the purposes of this Inquiry states:

> *The potential scale of a fracking industry and its difference in scale and scope to mineral exploration and mining would in my view challenge the intent of the provisions of ALRA to effectively ensure that Aboriginal people were able to give free, prior and informed consent on fracking projects. Being required to consent at the exploration phase to unknown scales of production and associated potentially landscape changing impacts would be unconscionable.*[75]

The Central Land Council on their website also note the burdensome nature of having to either consent or not consent to an activity at the exploration stage:

> *Once consent is given by traditional owners to exploration, they cannot refuse any subsequent mining.*

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72 See for example, Australian Council of Learned Academies (2013) Engineering Energy: Unconventional Gas Production – A study of shale gas in Australia, at p 26 accessible at: ACOLA report

73 See for example, The United Nations Rights of Indigenous Peoples

74 James Anaya, (2013) UN Special Rapporteur on the Rights of Indigenous People, Extractive Industries and Indigenous Peoples, accessible at: http://unsr.jamesanaya.org/docs/annual/2013-hrc-annual-report-en.pdf

75 Lewis, G (2017) Fracking Inquiry, Anthropologist's Report to the Environmental Defenders Office NT – Attachment C to this Report at page 6.

> *An agreement for mining must be made to allow mining to proceed. Mining generally involves substantial impacts to the environment and can affect neighbouring communities. The decision, therefore, that traditional owners are required to make at the exploration licence application is quite onerous.*
>
> *This is the earliest point in the development process when the least information is available on the nature of any possible development. In this context the CLC is required under the Land Rights Act to ensure traditional landowners are informed as far as practicable when making decisions.*[76]

At the time of its drafting, the ALRA would not have contemplated the potential landscape scale impacts of a shale gas industry in the Northern Territory. That has seen it be an inappropriate vehicle to ensure FPIC in relation to this industry.

Amendments to improve the ALRA with respect to shale gas operations might be possible, but fall outside the scope and jurisdiction of this Inquiry. Because of the current failings of the Commonwealth law to ensure FPIC with respect to shale gas operations, it is incumbent upon the Northern Territory to amend the Act so as to provide those safeguards.

Recommendation 23: Right of veto at two stages

The *Petroleum Act* (NT) be amended to provide the traditional owners of Aboriginal Land held under the *Aboriginal Land Rights (Northern Territory) Act* 1976 with a right to veto shale gas development before a production licence is issued.

Alternative Recommendation 23A: Enhanced consultation at the exploration stage

In the event it is deemed inappropriate to provide a second right of veto then shale gas operators should be required, at the exploration stage, to outline with a high level of precision what a production scale gas field would look like. Consultation materials (in addition to standard exploration consultations) should be required to include as a minimum:

- Sources of water under a production licence.
- Maximum amount of water required under a production.
- Visual aids detailing the impact of a shale gas field under production.
- Discussion of cumulative impacts, habitat fragmentation and edge impacts.

Recommendation 24: Extended timeframes for consultations

The *Petroleum Act* should provide for extended timeframes for consultation with Aboriginal groups and traditional owners to address the concerns, raised by Lewis, in respect of the unknown risks associated and low levels of understanding associated with this new method of extraction.[77]

76 Central Land Council website – Making Agreements on Aboriginal Land: Mining & Development http://www.clc.org.au/articles/cat/mining/

77 See Lewis, G (2017) Expert Report (Attachment C) at p 3

Sacred sites

The current *Northern Territory Aboriginal Sacred Sites Act* (NT)(NTASSA) provides a mechanism for the protection of sacred sites through the use of a combination of 'Authority Certificates' (clearances) and offence provisions for damage to sacred sites not permitted by a certificate.

Sacred sites are many and varied in the Northern Territory, Lewis in his expert report states:

> *Across the Northern Territory, sacred sites and other areas of cultural significance for Aboriginal People are places associated with actions and presence of various creative ancestors. Features of the landscape are often instantiations of the bodies, bodily essences or 'shades' of such creative ancestors or the product or an imprint of their actions or movements. Aboriginal sacred sites manifest as almost any feature present in the environment and interconnect with each other in a variety of ways based on their particular cosmologies.*[78]

Relevantly for the shale gas industry, the sub-surface domain and underground connectivity of water through aquifers and rivers is of particular cultural significance for many groups. Lewis in his expert report states:

> *In my experience, many Aboriginal groups emphasise the importance of the subsurface as a domain beneath the ground where connections between, at times, distant sites and dreamings can occur – sometimes described as tunnels, roots, or wires, and sometimes seen a zone (sic) through which the dreamings themselves travel and communicate. Drilling and fracking works may be considered in some areas as interference or disturbance to this domain and the dreamings associated with it. Environmental change detected even at locations a considerable distance from such works may be considered by Aboriginal people to be caused by the works even if there are other likely causes.*[79]

A number of issues arise in relation to this scheme. Firstly, as noted by Lewis, "authority certificates for sacred site protection and management are voluntarily sought by developers over areas determined in their applications".[80] Therein lies the first issue, certificates are not a mandated requirement and an unscrupulous operator could "take their chances" if they deemed it more economically expedient to avoid the sometimes lengthy consultation requirements involved in obtaining a certificate.

Lewis notes some further issues with the NTASSA which arise particularly because of the nature of HVHF operations:

- Firstly, *"[authority certificates] are sought for areas which applicants are seeking coverage or indemnity over, and typically this will be for a footprint covering known of likely works. In the context of fracking, impacts of works and possible damage to sacred sites could occur outside of areas applied for in an Authority Certificate, despite the works being conducted within the subject land and in accordance with the conditions of the Authority Certificate. The ability for the AAPA to identify and attribute*

78 See Lewis, G (2017) Expert Report (Attachment C) at p 3

79 Ibid at p 4

80 Ibid at p 6

damage back to a source in such circumstances could be extremely difficult thereby limiting the NTASSA's ability to act as a deterrent.[81]*;* and

- Secondly, "*The NTASSA does not protect areas of significance to Aboriginal people that are not sacred sites. Areas of resource value, and areas of cultural significance, such as dreaming tracks connecting sacred sites are not afforded protection under the NTASSA.*"

Recommendation 25: Mandatory requirement to have obtained an authority certificate

Providing a sacred site authority certificate, issued under the *Northern Territory Aboriginal Sacred Sites Act* (NT) is a mandatory requirement for all applications under the *Petroleum Act*.

Authority certificates should be required to be in place for the entirety of their licence areas, or for the extent of their potential impacts, not simply for the surface works and infrastructure.[82]

Recommendation 26: Culturally appropriate independent consultation materials

As recommended by Lewis, the NT regulatory regime should require, "comprehensive, culturally appropriate and fully independent consultation materials be resourced and developed with appropriate anthropological, technical and cultural expertise to assist Aboriginal communities in understanding and developing their views regarding fracking and the scale and nature of its impacts".[83]

81 Ibid

82 Ibid at p 7

83 Ibid

Economic impacts

The EDO's submission in relation to this risk theme is confined to discussion in relation to security for rehabilitation and transparency in relation to the rehabilitation process. Discussion about royalties and compensation payable to landowners is outside the scope of this submission.

Security for rehabilitation

Collof, in his report outlines the legacy issues associated with well closure:

> *This issue is about integrity of wells no longer in use, including separation of the well from the strata and aquifers it intersects. Multiple cycles of fracturing along the horizontal well bore, often ten or twenty times, can increase stresses on steel and cement casings Failures in casings can lead to contamination of aquifers with methane and other chemical components within the shales and fracture spaces. While such events may be rare, they cannot be excluded, and the wells will be in the landscape for ever. If decommissioned wells do not retain their integrity there is a future risk of connections between strata which may contain confined, connected aquifers and water-bearing materials with very different chemical composition could lead to unforseen impacts. The long term integrity of decommissioned wells is poorly understood (Hawke, 2014, p. xvi).*[84]

The current NT regime does not make adequate provision for the potential for legacy or orphaned wells, which later have an impact on the environment of public health. The NT regulatory regime should impose as a minimum an "orphan well" levy and a security bond on all operators to insure for immediate and future environmental damage.

The Alberta approach[85]

The Alberta Energy Regulators approach orphan wells and legacy issues appears to be novel and is a relatively recent development:

1. Instead of the traditional bond model for subsequent reclamation (as in effect in some U.S. states) the AER conducts an ongoing risk assessment based on proportionate share of sector liability as determined by the Licensee Liability Rating (LLR) program and the Oilfield Waste Liability (OWL) program. This means that the clean-up costs for a number of legacy sites has been moved away from the government and onto industry. It also means that as infrastructure becomes older and liability risk increases, the contribution to the funds increases during the lifespan of the mine.

2. Companies must submit reclamation plans when they apply under the Environmental Protection and Enhancement Act for any energy development—regardless of size—to specify how they will return the land to an equivalent land capability. As a result, the AER requires that the land will be able to support the various uses that existed before the project began.

84 Colloff (Attachment E) at p 9

85 https://www.aer.ca/rules-and-regulations/acts-and-rules

Recommendation 27: Imposition of security bonds and a non-refundable levy on operators.

The NT regime include both security bonds and a non-refundable levy to insure across the industry for potential future impacts of the industry. The NT should investigate the desirability of the approach recently implemented in Alberta, however, given the different scale of the industry currently in the NT a standard levy and bond approach may be the most appropriate.

Compliance and enforcement

It is trite to say that the best regulatory regime in the world will not have its desired effect if it is not enforced. To that extent the EDO has significant concerns about the ability of the NT government to adequately regulate a production scale gas industry. The NT has difficultly attracting and retaining staff with adequate expertise and the small population and revenue base of the NT sees the Department and NTEPA compliance teams far smaller than those that exist in other states and territories.

The NT is also a difficult place to run compliance operations. Much of the NT is effectively cut off during the wet season and, even during the dry the vast scale of the Territory make it impossible to keep close checks on operators.

To assist in this regard, the EDO does support the introduction of a South Australia type approach looking to characterise operators as either low or high risk, based on past behaviour. This has the dual effect of allowing compliance teams to triage their operations and also rewards companies that continually do the right thing.[86]

Much of what we have to say about compliance and enforcement is captured in an earlier section of this submission and in the EDO comment, which both discusses the pro's and con's of a purely objective based approach to regulation in the Northern Territory. Many of our concerns with that approach relate to compliance and enforcement issues.

Chain of responsibility provisions

Recommendation 28: Chain of responsibility provisions be included in the NT regulatory regime

The challenges faced by Governments (in various jurisdictions) in ensuring compliance with environmental obligations on sites operated by companies in financial difficulty are well documented.[87] The problems are not confined to the mining industry. For example in 2014 ASX listed gas company Santos was fined $1,500 by the NSW Land and Environment Court for breaches of environmental obligations that occurred under the watch of the previous owner Eastern Star Gas a small company that was in financial difficulty.[88]

Queensland has attempted to address this challenge by the introduction of the *Environmental Protection (Chain of Responsibility) Amendment Act* 2016. The scheme broadly provides for the Department to issue environmental protection orders to related persons of companies undertaking activities under the Queensland *Environmental Protection Act* and 'high risk' companies, which are defined under the Act.

The policy objectives of the Queensland scheme are achieved a range of regulatory tools, which include:

86 See the Petroleum and Geothermal Energy Act (2000) which regulates both operators and activities differently according to their level of assessed risk.

87 See for example, the explanatory notes to the Environment Protection (Chain of Responsibility) Amendment Bill 2016 (Qld) – accessible at: Chain of Responsibility Bill - Explanatory Notes

88 http://www.abc.net.au/news/rural/2014-01-10/santos-fine/5194320

The policy of facilitating greater environmental protection for sites in financial difficulty and avoiding costs being incurred by the State for the environmental management and clean-up of such sites is achieved by:

- *allowing environmental protection orders to be issued to a party that has some relevant relationship to the company that is in financial difficulty (which may include, for example, a parent company or executive officer).*

- *providing that if one of these environmental protection orders is issued, and the recipient fails to comply with it, the Department of Environment and Heritage Protection may require the recipient to pay the costs of taking action stated in the order or monitoring compliance with the order.*

There are strong arguments for introducing a similar scheme in the NT that would apply to the shale gas industry.

Environmental history & proper person tests

In it's oral submission to the Inquiry, APPEA's Matt Doman, noted, "there are many companies that don't have any oil or gas expertise or experience that hold petroleum exploration licences".[89] Given the heavy reliance placed on operators to do the right thing in the NT, particularly with an objective based set of regulations, this is a major concern.

The regulatory regime should impose requirements on decision makers to consider whether an operator is a fit and proper person and their environmental history. Objective based criteria to guide decision makers should be developed.

Recommendation 29: Requirement to consider whether an operator is a fit and proper person and their environmental history

89 https://frackinginquiry.nt.gov.au/submission-library/?a=414036 at p 12.

Regulatory capture

Unfortunately, all the leadership in the world cannot avoid the perception problem created by having one Department responsible for both the promotion and regulation of the gas industry.

This conflict has been realised and addressed through the separation of compliance functions and promotion and revenue collecting functions in the Canadian Arctic Offshore Drilling Program and in the United Kingdom and Norway.[90]

A similar separation of responsibilities is appropriate in the Northern Territory. The EDO understands that this separation is underway with respect to mining, but it is unclear whether it applies also to shale gas operations.

Recommendation 30: The Department responsible for promotion of the shale gas industry and the receipt of royalties should not be responsible for compliance and enforcement activities.

90 Dagg, J. et al (2011) Comparing the Offshore Drilling Regulatory Regimes of the Canadian Arctic, the U.S., the U.K., and Norway, published The Pembina Institute, Alberta at p 22.

Cumulative risk

The Ecological report usefully summaries the meaning of *cumulative impacts* and *cumulative environmental change* describing them as:

> *The phenomenon of temporal or spatial accumulation of change in environmental systems in an additive or interactive manner.*
>
> *A change in the environment resulting from multiple initiatives of the past, present and reasonably foreseeable future, which combine in an additive, amplifying or discontinuous manner.*[91]

The Northern Territory's regulatory regime is currently inadequate to address cumulative impacts generally. This is particularly true for the cumulative impacts of the shale gas industry, which are likely to occur over vast "landscape scale" areas of the NT.

The Act and the environmental assessment regime have no specific provisions or requirements for the assessment of cumulative impacts. The Regulations do require an EMP submitted to the Minister to include:

> Schedule 3(2)*(b) as far as practicable – any cumulative effects of those impacts and risks when considered both together and in conjunction with other events that may occur in or near the location of the activity. (our emphasis)*

However, confining the requirement for consideration of cumulative impacts to other "events" that may occur "in or near the location of the activity" unnecessarily narrows the scope of the requirement on proponents to consider and outline the potential cumulative impacts of their activity and, consequently, reduces the information that must be considered by the Minister in relation to cumulative impacts.

Recommendation 31: Require detailed consideration of cumulative impacts before granting approvals under the Act or Regulations.

The regulatory regime should include specific requirements for the consideration of cumulative impacts at a landscape scale and in particular in relation to three specific impacts of the shale gas industry, which warrant particular measures to address their cumulative risk/impact.

The definition of cumulative impacts should encompass the direct and indirect effects of the past, present and likely direct and indirect effects of the future.

1. *Water usage*

Noting the "relatively large volumes of water required for drilling and hydraulic fracturing"[92] for shale gas, managing the cumulative impacts of water use by the industry will be a critical challenge for the government, as the regulator, and for the industry.

91 The Ecological Report at p 34

92 See the Ecological Report at p 4

The EDO notes that some NT aquifers are already "over-extracted" and others are over licenced.[93] This is great concern. HVHF is a new industry being introduced to a system that is not well understood and will place further pressures on a system that may already be experiencing stress. Additionally, the previous Country Liberal Government abandoned the *National Water Initiative* requirement to set aside water as strategic indigenous reserves for future indigenous economic development which means that even less water might be available.

The EDO is attracted to the idea of managing water impacts by way of PBR, outlined below and, obviously a key requirement of the legislative reforms is to require gas operators to obtain groundwater licences under the *Water Act.*

2. *Habitat fragmentation and consequent loss of landscape function*

Recommendation 32: Operators should be required to provide specific information about edge impacts and habitat fragmentation of their operations and the mitigation measures they have used to address them. Decision makers should have to specifically consider the impact of a proposal on landscape function.

The shale gas industry's new technique of placing multiple wells on a single (albeit larger) well pad will see a positive decrease in the industries footprint. Despite that, the Ecological Report concluded that habitat fragmentation due to shale gas extraction was "unavoidable" and assessed the risk of fragmentation and consequent loss of landscape function as "high".[94]

When the Inquiry considers the impact of the shale gas industry on the landscape it should not confine itself to a consideration of the percentage of an area to be cleared. As is made abundantly obvious from the expert report of Renata Bali (Attachment D), habitat fragmentation and edge impacts from the shale gas industry may far exceed the impacts of a conventional mining project, albeit potentially through a smaller amount of land clearing.

3. *Emissions of methane and the shale gas industry's contribution to climate change*

The Northern Territory's regulatory regime should make specific provision for the assessment and management of the shale gas industry's contribution to climate change through fugitive emissions of methane.

The EDO notes the growing body of work discussing methane emissions from the unconventional gas industry.[95] This growing body of work has found some evidence that methane emissions from unconventional gas operations are "underestimated".[96]

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93 https://denr.nt.gov.au/__data/assets/pdf_file/0006/253563/O31_O33_amended_NOD_SOD_signed_12_March_2015.pdf at p 2 under the discussion of s 90(1)(ab)

94 See the Ecological Report at p ii, and p 29.

95 See for example, Caulton, R. et al (2014) Towards better understanding and quantification of methane emissions from shale gas development. Proceedings of the National Academy of Sciences USA. 111 (17) 6237-6242, and Melbourne Energy Institute (2016) A review of current and future methane emissions from Australian unconventional oil and gas production – accessible at: MEI Review - Methane Emissions

96 The Australia Institute (2017) Submission to the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory

The EDONT draws the Panel's attention to section 7.2 of the Melbourne Energy Institute Report, *A review of current and future methane emissions from Australian unconventional oil and gas production*. That section notes that no current Australian jurisdictions place limits on the amount of methane that can be emitted by the oil and gas industry.

Further, the MEI report notes that best practice jurisdictions in the U.S. and Canada are quickly moving to address the impacts of fugitive emissions from oil and gas activities.[97]

The EDO Hawke Report, noted in its review of best practice regulatory regimes that in both North Dakota and Colorado place explicit requirements on operations in relation to fugitive emissions, ambient air quality testing, baseline data requirements and flaring requirements.[98]

The need to obtain air quality baseline testing was reference earlier in this report, but not specifically in relation to cumulative impacts. The MEI report provides a useful analysis of the necessity for baseline measurements of methane emissions and the process that might be followed.[99]

Additionally, QLD has developed a Code of Practice for CSG well head emissions detection and reporting. The NT should develop a similar guidance document and compliance with the reporting requirements should be enforceable through legislative provision.

Recommendation 33: The NT regulatory regime should include prescriptive measures setting emissions limits and air quality parameters for methane and (as noted above) require baseline testing to occur prior to operations commencing.

Recommendation 34: The NT should develop a code of practice, or other guideline, for the detection and reporting of emissions from wells.

Play based regulation

During the EDO's oral submissions we referred to a trial of 'Play based regulation' (**PRB**), which took place in Alberta, Canada. That pilot program was undertaking in the Fox Creek area of Alberta to trial a new approach to govern unconventional oil and gas development.

> The PRB pilot tested a single, integrated application that allows energy companies to submit one application for all activities under an energy development project, instead of submitting separate applications for each activity.[100]

The Alberta Energy Regulator (**AER**), which ran the trial, required an integrated application approach, which required energy companies to work together to engage

97 Melbourne Energy Institute (2016) A review of current and future methane emissions from Australian unconventional oil and gas production – accessible at: MEI Review - Methane Emissions at p74

98 See for example, the North Dakota Air Pollution Control Rules – Chapter 33-15-20 'Control of Emissions from Oil and Gas Well Production Facilities. Accessible at: North Dakota - Air Pollution Control Rules

99 Ibid 58, at p 76

100 https://www.aer.ca/about-aer/spotlight-on/pbr-pilot-project

stakeholders and put forward a plan for the entire play. The PRB came about following a 2012 discussion paper *Regulating Unconventional Oil & Gas in Alberta.*[101]

The AER considered this holistic approach to gas development across an entire play would allow the AER "to better understand the broader impacts of energy development projects [they] can ensure steps are taken to minimize potential impacts on the environment, communities and stakeholders". Play-focused regulation are "*tailored to an entire "play" to achieve specific environmental, economic and social outcomes*".[102]

The trial of play-based regulation was promoted as a departure from the status quo in Alberta (and most other jurisdictions) were development is assessed and regulated on a project by project or well by well approach. Play-focused regulation sees areas formally declared as "plays", "based on their unique qualities and the level of risk that development of a play could pose".

The trial saw the use of a performance-based regulatory approach to the development of '*Play development plans'*. The approach was based on the premise that multiple operators across a play would develop plans that demonstrate how "play-specific" outcomes are achieved.

Play development plans were required to demonstrate (1) how water would be managed across the entire play, (2) how surface infrastructure would be minimised (3) how short and long term resource recovery was maximised across the play (4) how stakeholder engagement would take place for the entire project (5) life-cycle wellbore integrity.[103]

In June 2016, the AER released a document titled *Evaluation of the Alberta Energy Regulator's Play-Based Regulation Pilot.* [104] That document outlines the performance of the pilot against its objectives. Some relevant findings of the evaluation were:[105]

- Pilot participants see a benefit in spending more time up front to prepare a single project application with certainty of a longer-term approval instead of submitting individual applications for each activity under the current regulatory regime.
- The requirement to submit the single applications were not sufficiently detailed and clear, making it challenging for pilot participants to develop their applications.
- Pilot participants were able to more effectively plan the location and size of energy development infrastructure. The planning in turn decreased the amount of associated infrastructure (e.g., access roads and pipelines) and reduced cumulative surface disturbance.
- General information about the pilot provided by the AER to stakeholders was insufficient, leading to a limited understanding of the PBR pilot and its outcomes.
- Stakeholders see a benefit in having a broader view of energy development plans; however, they did not feel that pilot participants provided them with enough

101 Energy Resources Conservation Board (2012) Regulating Unconventional Oil & Gas in Alberta: A discussion paper accessible at: AER Discussion paper

102 Ibid at p 2

103 Ibid at p 3

104 Accessible here: https://www.aer.ca/documents/about-us/PBR_EvaluationReport_June2016.pdf

105 See Alberta Energy Regulator (2016) Evaluation of the Alberta Energy Regulator's Play-Based Regulation Pilot, executive summary

information to fully understand the project plans or their potential impacts over the long term.

The EDO's view of PRB

The EDO finds arguments for a play-based approach to regulation to be compelling. PRB could be particularly effective at avoiding unacceptable "landscape scale" or "cumulative impacts" if it is combined with precautionary risk management approach in relation to the many information gaps identified in other parts of this submission.

Should the NT consider this approach a desirable one, it would be important to learn from the experience in Alberta, particularly addressing the factors where the trial was deemed to fall short of expectations. See for example, the Norton Rose Paper - Play Based Regulation Evaluation

As the AER notes "a critical aspect of play-focused regulation will be planning".[106] Taking a PRB approach to the Beetle-loo sub-basin for example may require more short-term investment by industry, but may ultimately result in better environmental, social and economic outcomes.

Some potential benefits of a play-based approach could include:

- Upfront information gathering and baseline work across a play could be done collaboratively by various operators and allow for the establishment of no-go zones prior to 'on-ground' activities.

- Far greater ability to assess and predict likely cumulative impacts (including surface and sub surface impacts) across an entire play.[107]

- Efficiency for industry in terms of potential reductions in the amount of surface infrastructure needed due to a collaborative approach between operators.

- Orderly development at a landscape scale and greater certainty about landscape scale impacts and corresponding reduction of landscape function.

- Enhanced industry collaboration. Including the idea that industry will act as a check and balance on itself as major players like Santos and Origin will have to work with smaller operators and their reputational risk will be intertwined with others in their industry.

- Far more effective stakeholder engagement, particularly the ability for people in remote areas to view a plan as it exists across an entire landscape. This will assist in removing some of the barriers to achieving FPIC noted above and discussed by Lewis in his expert report.

- Greater likelihood of achieving a social licence to operate.

106 Ibid 54 at p 10.

107 The AER defines "play" to be "an area of oil and gas development that is determined mainly by geology, geographic area, the properties of the resource, and the technology required to develop that resource".

Report attachments

Attachment A:

EDONT Report to the Commissioner – Best Practice Regulatory Frameworks for Hydraulic Fracturing Operations. (EDO Hawke Report)

Attachment B:

EDONT Comment of the Draft Petroleum (Environment) Regulations

Attachment C:

Expert Report, Anthropological – Gareth Lewis

Attachment D:

Expert Report, Linear Infrastructure Impacts – Renata Bali

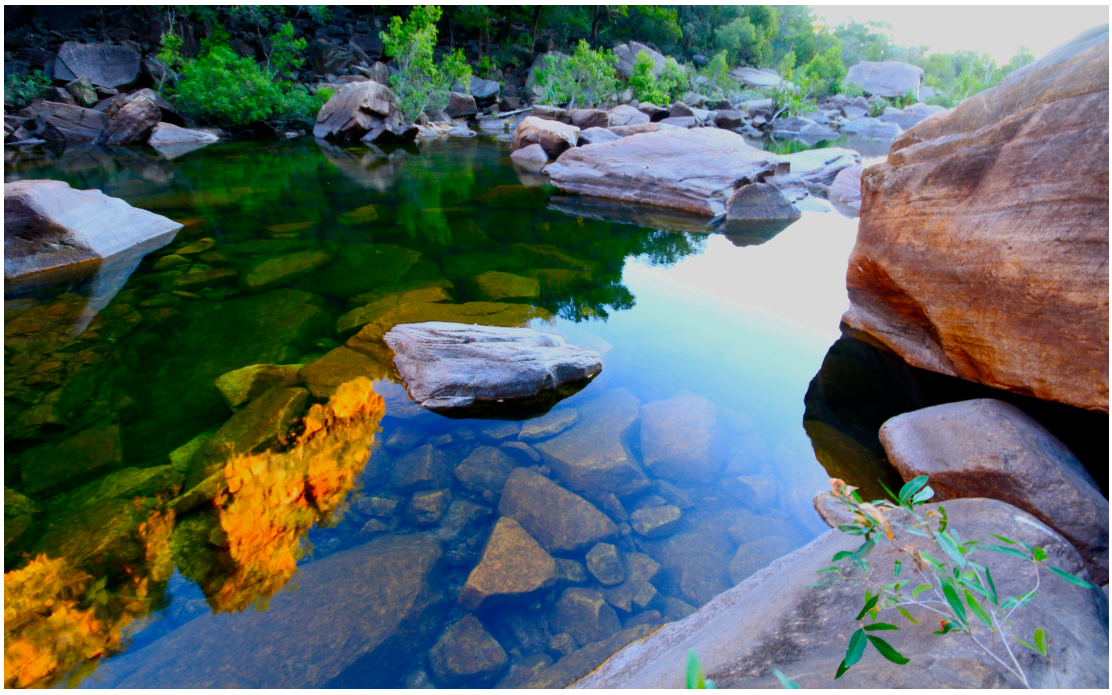
Attachment E:

Expert Report, Ecosystem function, Ecology, Groundwater dependent ecosystems, water resource development and use, climate change - Matthew Collof

Attachment F:

Expert Report, Ecotoxicology - Dr Scott Wilson

Northern Territory Government: Inquiry into Hydraulic Fracturing:



EDO Northern Territory Report

Best Practice Regulatory Frameworks for Hydraulic Fracturing Operations.

31 October 2014

ENVIRONMENTAL
DEFENDERS OFFICE (NT) INC.

Northern Territory Government: Inquiry into Hydraulic Fracturing:

*EDO Northern Territory Report**

Best Practice Regulatory Frameworks for Hydraulic Fracturing Operations.

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*The Environmental Defenders Office NT wishes to acknowledge the contribution Charles Darwin Environmental Law Students, Matilda Stickels, Eileen McGovern, Jared Ivory, Henry Boeck, Suzie Zakis and Claire Powell who assisted in the preparation of this report.

Executive summary

Recently, the pros and cons of having an intensified natural gas industry in the Northern Territory (NT) have been widely debated throughout the community. Central to this debate has been the controversial process of hydraulic fracturing 'fracking'. Community division over the issue and concerns about the practices potential impacts on public health, the environment and water resources led the NT Minister for the Environment, The Hon Peter Chandler, to recommend an independent inquiry. In March 2014 the NT Hydraulic Fracturing Inquiry was established.

This report provides a comparative analysis of regulatory regimes for 'fracking' operations used throughout other jurisdictions in Australia and highlights some examples from the United States of America and Canada. This report does not indicate that the Environmental Defenders Office NT (EDONT) supports the use of 'fracking' in the NT. On the contrary, EDONT believes that the NT Government should be supporting renewable energy options wherever possible. Having said that, if 'fracking' operations are to occur in the NT they should be overseen by the strongest possible regulatory regime, learning from the experiences in other jurisdictions. It has become clear during the research and analysis presented in this report that any assertion that the NT has a 'best practice' or 'strong' regulatory regime cannot be maintained. The NT's regulatory regime is characterised by strong reliance on operator self-management, subjective regulator or Ministerial decisions and a lack of transparency. In EDONTs view, the NT's regulatory regime fails to establish international best practice in relation to permitting, well construction, water management and monitoring, chemical use and disclosure and public participation.

Overall conclusion

Having completed an extensive review of regulatory regimes, both in Australia and internationally, which apply to operations utilising hydraulic fracturing it is our overarching conclusion that the Northern Territory regulatory regime applying to petroleum requires a complete overhaul. The regime in the Northern Territory, as it currently stands, is apt to be flouted by any unscrupulous operators that are granted a permit.

Given the above, it is our strong recommendation that a moratorium on petroleum operations, utilising hydraulic fracturing, be put in place until such time as a new regulatory regime is put in place. In our view, the benefits of waiting until strong regulatory protections are put in place, far outweigh any economic benefits that may be derived from pushing ahead with the current weak regulatory regime.

The recommendations below, are recommended amendments to current legislation, however, they are equally applicable to any new legislation created as an overhaul of the regime for petroleum exploration and production in the Northern Territory.

Specific concerns:

- The *Petroleum Act*'s objects seek to place economic interests above environmental protection. Most jurisdictions in Australia now recognise that environmental protection should be an object of petroleum legislation. Additionally, there is no specific requirement for the Minister to consider the need to preserve and protect the environment.

- The absence of a mandated requirement in the NT for operators to undertake baseline testing and post operation testing. Best practice jurisdictions in the United States, like Colorado now mandate this kind of sampling, detail how sampling is to be undertaken and at what timeframes.

- The absence of a defined policy dealing with the protection of underwater water resources. In NSW the *Aquifer Interference Policy* (AIP) sets out objective factors to assess potential impacts on aquifers. For projects assessed under the NSW Gateway process, reports under the AIP are to be made public.

- The absence of a strategic planning assessment of areas of land in the NT which may be unsuitable for 'fracking' operations. This can be compared with the approach taken in NSW under the *Strategic Regional Land Use Policy.*

- The absence of mandated requirements for emissions and air quality from 'fracking operations in the NT. Best practice jurisdictions in the United States, like North Dakota and Colorado place explicit requirements on operators with relation to fugitive emissions, ambient air quality testing and flaring requirements. (see North Dakota 'Ail Pollution Control Rules).

- That operators in the NT are required to act in accordance with 'good oilfield practice', rather than mandated codes of practice or regulations.

- The absence of mandated requirements for chemical disclosure. EDONT notes that a chemical disclosure list is found on the Department of Mines and Energy website, however, this would appear to be a policy of the government, rather than a legislative requirement.

- The fact that application documents, technical programmes (or at least environmental management plans) are not publically available. This can be compared with the comprehensive requirements for public information in Western Australia, which requires public disclosure of all environmental management plans. In Illinois, all documents submitted as part of an application are viewable by the public.

- The fact there are no third party appeal rights in relation to any permits or licences granted under the *Petroleum Act*.

- That evaporation pits are able to used in the NT, despite the obvious challenges associated with large parts of the NT being subject to wet season high rainfall activity. We note that this practice has been banned in NSW and the STRONGER guidelines encourage a move away from this practice.

- The absence of mandated and specific technical requirements for the construction of any pit, tank or other facility designed to store produced or waste water. In most other jurisdictions, these requirements are detailed at great length. For example, see section 1-75 of the *Illinois Hydraulic Fracturing Regulatory Act*.

- The failure to take any steps in the NT to classify operators and activities by their level of risk. This can be compared with the procedure under the South Australian *Petroleum and Geothermal Energy Act* (2000) which regulates both operators and activities differently, according to their assessed level of risk.

- The fact that the NT regulatory regime does not appear to have specifically designed requirements to manage the impacts of the NT's unique climatic features on fracking operations. These conditions, if imposed, are done so via permit or licence conditions. This is at odds with the recommendations in the STRONGER guidelines.

- The fact the NT regulatory regime, particularly, the *Petroleum Act* does not require consideration of cultural matters. This can be compared with the NSW approach, at section 74, which requires the Minister to consider certain matters, including features of Aboriginal interest, before granting a permit.

Context and Recommendations

Definition of 'environment'

EDONT considers the definition or concept of '*environment'* to include:

a) ecosystems (whether marine or terrestrial) and their constituent parts, including people and communities;
b) the ecosystems existing within a bioregion or sub-bioregion[1];
c) natural and physical resources; and
d) the qualities and characteristics of locations, places and areas; and
e) heritage values of places; and
f) the social, economic and cultural aspects of a thing mentioned in (a)(b)(c)(d) and (e) above.[2]

EDONT notes the particular importance of taking a bioregional approach to assessments for activities involving hydraulic fracturing.

> *A bioregional assessment is a scientific analysis of a particular area including its ecology, hydrology, geology and hydrogeology, with explicit assessment of potential direct, indirect and cumulative impacts of coal seam gas and large coal mining development on water resources.*[3]

Recommendations

1. OBJECTS OF THE ACT

The Act's objectives be amended completely to shift the priority of the Act from economic development to environmental protection: This should be achieved by:

a. Making the primary object of the Act to provide for development of petroleum resources in the Territory in a way that ensures the Territory's unique environment is not adversely affected.

b. Requiring that the Minister and all agencies and persons involved in the administration of the Act must have to, and seek to further, the primary objective.

c. Explicitly requiring decision makers to take into account the principles of ecologically sustainable development.

d. Requring that decision makers take into account cumulative impacts, or potential cumulative impacts of petroleum operations.

2. INTEGRATED APPROVAL PROCESS

The Act should be amended to specifically reference the relevant provisions of the associated legislation with which approvals must comply.

3. AIR QUALITY

[1] httpf://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra
[2] definition of environment adapted from the definition in s 528 of the *Environment Protection and Biodiversity Conservation Act* 1999 (Cth)
[3] *http://www.csiro.au/Organisation-Structure/Flagships/Water-for-a-Healthy-Country-Flagship/Water-Resource-Assessment/Bioregional-Assessments.aspx*

Regulations or a Code of Practice[4], with legislative force, must be incorporated into the regulatory regime and provide for permissible standards of air quality. The Code should set out standards of equipment required to be used and methods and requirements for monitoring and testing of air quality. The Code or Regulation should provide objective (enforceable) measures for:

a. fugitive emissions;

b. ambient air-quality; and

c. flaring.

4. PROTECTION OF GROUNDWATER

Regulations or a Code of Practice[5], with legislative force, must be incorporated into the regulatory regime and provide for greater protection of groundwater resources. The Code should:

a. set out objective factors in relation to groundwater that must be considered prior to the issue of a petroleum permit;

b. ban the use of open evaporation pits as a method of disposing of waste water;

c. set out permissible proximity of wells to underground water sources;

d. set out the type, frequency and location of baseline water sampling and its reporting and periodic monitoring requirements; and

e. mandate case-by-case assessment of the implications of proposed fracking on groundwater quality and quantity. This assessment should take into account hydrogeological conditions at a site and then specify the level of engineering and oversight required to manage, monitor and maintain well integrity and zonation throughout the life of the operation.

5. TECHNICAL SPECIFICATIONS

The technical specifications in the *NT Schedule of Onshore Petroleum Exploration and Production Requirements* should be updated, expanded and put into a code of practice or regulations with legislative force. Objective specifications should be set for:

a. well casings;

b. well monitoring and reporting;

c. pressure testing and reporting;

d. reporting of seismic activity;

e. tank specifications (and pond specifications for use in emergency only);

f. well abandonment specifications; and

g. well and operation area rehabilitation requirements.

6. WATER USE & WASTEWATER MANAGEMENT

[4] Regulations and Codes of Practice with specific requirements should replace the ambiguous and unenforceable requirement to act in accordance with 'good oilfield pratice.
[5] As above, at 4.

Petroleum activities should be more strictly regulated and transparent in terms of their water use, this should be achieved by:

a. amending the *Water Act* to remove Petroleum activities exemption from the requirement to obtain groundwater extraction licences;

b. mandatory requirements for all Petroleum applications to include a publicly available water management plan detailing:

    i. the expected quantity of water required;

    ii. location of the water source to be used;

    iii. details of the groundwater extraction licence held by the company;

    iv. details (prior to commencement of operation) of how waste water will be dealt with during and on completion of a well.

c. requiring public reporting on all completed activities, detailing the actual amount of water used, and the methods used to dispose of waste water.

7. STRATEGIC LAND-USE PLANNING

The regulatory regime should identify areas of high value land where petroleum operations should not be permitted, or are required to undergo additional / more stringent assessment. This should be achieved by:

a. Developing objective criteria for the assessment of high value reserved areas; this will avoid subjective Ministerial decision-making;

b. Permitting members of the public and other local councils to make applications for certain areas to be reserved from petroleum activities.

8. INDEPENDENT SCIENTIFIC EXPERTISE

Given the significant knowledge gaps that remain, relating to underground water resources, the impacts of climate change and the long term impacts of hydraulic fracturing operations, the Northern Territory government should have recourse to an independent scientific advisory body to ensure decisions are informed by the best available science. We recommend:

a. That an independent scientific body be established, similar to the *Independent Expert Scientific Committee on Coal Seam Gas and Large Mining Development,* to provide expert, independent scientific advice to decision makers on the impact of shale gas projects that may impact on the Northern Territory's water resources;[6] and

b. The establishment of an independent Northern Territory Petroleum Commission which, similar to the State Review of Oil and Gas Regulation, should be a multi stakeholder body which should assist the Northern Territory Government in the periodic review of the regulatory regime for petroleum in the Northern Territory. Its first task would clearly be to assist in the complete overhaul of the current regulatory regime for petroleum operations.

9. TRANSPARENCY

[6] The most sensible way to achieve this may be via an amendment to the Commonwealth *Environment Protection and Biodiversity Act* 1999 to expand the water trigger at s 24D to include shale gas projects.

Measures should be put in place to ensure that the regulation of petroleum operations in the Northern Territory is a transparent process. The EDONT recommends that:

a. the Act be amended to provide rights for third parties to seek merits review of decisions made under the Act at the Northern Territory Civil and Administrative Tribunal;

b. that the Act be amended to mandate that all environmental management plans, and all parts of technical programmes that are not commercial in confidence be made available to the public;

c. the the Act be amended to require the Department of Mines and Energy to keep a publicly available register of the security held for the rehabilitation of each well; and

d. that the Act be amended to provide for mandatory reporting of chemicals used and their quantities.

10. REGULATION AND ENVIRONMENTAL COMPLAINCE

The environmental compliance regime under the Act should be completely overhauled by:

a. amending the Act to give the Northern Territory Environmental Protection Authority (NTEPA) responsibility for:

    i. environmental assessments and approval of environmental management plans;

    ii. compliance actions in relation to breach of environmental obligations.

    The NTEPA should be given sufficient resources to effectively oversee these new powers and responsibilities.

b. providing for private prosecutions; and

c. by including a provision which provides that a petroleum operator bears the onus of proving that any water contamination/pollution within a certain proximity of its operations were not caused by it.

11. OPERATOR STANDARDS

The Act should provide stronger provisions for the assessment of operator suitability by:

a. requiring an assessment by the Minister of whether an applicant is a fit and proper person. The test should set objective criteria that must be assessed by the Minister in coming to his conclusion about whether an applicant is a fit and proper person; and

b. classifying operators as either low or high risk (with a corresponding level of regulatory oversight/scrutiny), depending on their experience and track record. EDONT notes that a provision of this kind will only be effective if the regulator is adequately resourced.

Shale gas extraction by way of hydraulic fracturing in the Northern Territory – A legislative review

Northern Territory: Overview

The regulatory framework for the shale gas industry in the Northern Territory can be easily broken down into a number of separate components:

1. In relation to obtaining tenure and permits for exploration and production:

    - Exploration and production of petroleum (shale oil/gas) by way of hydraulic fracturing ('fracking') operations are approved under the *Petroleum Act* (**the Act**) and the *Petroleum Regulations* (**Regulations**). The Minister for Mines and Energy is responsible for making decisions about whether or not to approve petroleum mining on land and inland waters in the Northern Territory.[7]

    - Where an application for a permit is over land in a declared Northern Territory park, reserve or wilderness zone, the Minister must comply with provisions in the Act, which require consultation between Department of Mines and Energy (**DME**) and the Minister administering the *Territory Parks and Wildlife Conservation Act*.[8]

2. In relation to environmental assessments:

    - Environmental Impact Assessment (**EIA**) of petroleum operations in the Northern Territory, whether exploration or production activities, is done under the *Environmental Assessment Act* (**EA Act**) and *Environment Assessment Administrative Procedures* (**EAAP**).

    - Despite EIA's being undertaken by the NTEPA under the EA Act, the Minister for Mines and Energy is ultimately responsible for approval of an exploration permit or production licence, and for imposing any conditions on that licence to fulfil any needs identified during the EIA process. The Act does not explicitly require the Minister to consider the outcomes of any environmental assessment under the Act. However, under s 8A of the EA Act, if the Minister decides to act contrary to an Environment Assessment Report under the EA Act, the Minister must give written reasons to the NTEPA and table a notice in the Legislative Assembly.

3. In relation to compliance and enforcement:

    - Petroleum activities, which cause environmental harm on a mine site, are regulated under the Northern Territory Act.[9] The Northern Territory Department of Mines and Energy (DME) is responsible for regulation and compliance on petroleum mine sites.

    - The *Waste Management Pollution Control Act* and the *Water Act*, administered by the NTEPA, regulate impacts from petroleum activities, which occur off a mine site.

The technical requirements of fracking operations are set out in the approved technical works programme submitted with the application for exploration or production. Operators are also required to employ good oilfield practices.[10] The technical requirements of a fracking operation are guided by the *NT Schedule of Onshore Petroleum Exploration and Production Requirements* and conditions imposed on an exploration permit or production licence.

Environmental protection elements of a fracking operation are submitted as part of an application for a production licence. The measures proposed are not made public. There is no requirement to submit a specific environmental management plan, but must include

[7] Petroleum Act, s 25, s 34 and s 47.
[8] Petroleum Act, s 15.
[9] Petroleum Act, Part V, Division 2.
[10] Petroleum Act, s 58(b)

"proposals for the protection of the environment, including proposed measures to be undertaken by the applicant for the rehabilitation of the licence area or other affected areas".[11]

Acts, Regulations and Codes

- *Petroleum Act* 1984 (NT)
    - *Petroleum Regulations* 1994 (NT)
        - *Petroleum Exploration Permit Guidelines;*
        - *NT Schedule of Onshore Petroleum Exploration and Production Requirements; and*
        - *NT Petroleum Exploration Reporting and Data Submission Guidelines*
- *Environmental Assessment Act* 1982 (NT)
    - *Environmental Assessment Administrative Procedures*
- *Aboriginal Land Rights (Northern Territory) Act* 1976 (Cth)
- *Native Title Act 1993 (Cth)*
- *Waste Management Pollution Control Act* 2007 (NT)
    - *Waste Management Pollution Control (Administration) Regulations*
- *Territory Parks and Wildlife Conservation Act* 1980 (NT)
- *Water Act* 1992 (NT)
    - *Water Regulations* 1992 (NT)

The Regulatory Framework – in more detail

1. *The Petroleum Act, subordinate legislation and 'fracking' operations in the Northern Territory*

The object of the Act is clearly intended to emphasis economic development above environmental protection and intergenerational equity. Under section 3 the object of the Act is *"to provide a legal framework within which persons are encouraged to undertake effective exploration for petroleum and to develop petroleum production so that the optimum value of the resource is returned to the territory*".[12] The Act does state that the legal framework provides for, among other things, "the reduction of risks, so far is reasonable and practicable of harm to the environment during activities associated with exploration or production of petroleum" (which includes fracking).[13]

Section 58 of the *Petroleum Act* sets out the general conditions of exploration permits and licences granted under the Act. In relation to ensuring protection of the environment, the following subsections are relevant:

- s58(b) requires operations to be undertaken with reasonable diligence, in accordance with good oilfield practice and the approved technical works programme;
- s58(c) carry out the technical works programme causing as little disturbance as practicable to the environment;
- s58(d) not allow escape of petroleum, without approval; and
- s58(f) comply with any lawful directions of the Minister in relation to protection of the environment.

We note that under section 5 of the Act, *good oilfield practice* is defined as 'in relation to the exploration for, or operations for the recovery of, petroleum, means all those practices and procedures that are generally accepted as good and safe in the carrying on of that exploration or those operations, as the case may be. This is an unacceptable standard. It is broad, vague, does not recognise the need for geographic specific requirements and, given the vast

[11] Petroleum Act s 45
[12] Petroleum Act s 3.
[13] Petroleum Act s 3(2)(f)

variation in oilfield practice around the world lacks any type of certainty.

The Regulations have no bearing on environmental protection.

2. *Guidelines and Codes of Practice in the Northern Territory.*

The Northern Territory has guidelines which influence 'fracking' operations. We note that these guidelines do not automatically have legislative force, and require the Minister to give notice to a permittee or licensee. Any codes or guidelines for petroleum activities in the Northern Territory should have legislative force and not require Ministerial actions to ensure they do.

There are three 'guideline' documents in the Northern Territory, namely:

- The *NT Schedule of Onshore Petroleum Exploration and Production Requirements (**the Onshore Schedule**).*

  The Onshore Schedule contains some of the requirements you would normally expect to find in regulations. The Onshore Schedule does not appear to be an issued 'guideline' in accordance with section 21E of the Act, and would therefore only have legislative force via the provisions of section 58, or as conditions imposed on a permit or licence. This is convoluted, nonsensical and confusing.

  Key sections to note:

  - **s 109 Protection of the Environment.**

    The holder of a title shall ensure that employees and contractors comply with an approved Code of Environmental Practice or with the Australian Petroleum Exploration Association Code of Environmental Practice 1983 [note – no requirement for a code to be as stringent as the APEA Code. Additionally, the APEA Code is not a public document].

    We note that the code that the Onshore Schedule may mean to refer to is the APPEA (Australian Petroleum Production and Exploration Association) Code of Environmental Practice.

  - **s 112 Containment of Petroleum and Waste Fluids**

    Petroleum recovered shall be confined to tanks, gasholders, pipes or other receptacles in accordance with good oil field practice and, except as a temporary measure during an emergency, petroleum shall not be placed or kept in an earthen pit. However, formation water or other waste fluids produced from a well shall be disposed of in a manner acceptable to the Director [no standard/consistent homogenized requirement, no detailed requirements in terms of lining, materials and depth], and in no case be allowed to risk public health or safety, or to contaminate water or land not specifically designated for waste disposal.

    All waste materials from work on a well or produced from a well (whether or not contaminated with oil) shall, unless otherwise removed from the well site to a satisfactory storage, be dumped or drained to a waste sump. Waste sump is to be adequately fenced and shall incorporate every reasonable precaution to prevent pollution of surface and underground water through seepage.

  - **s 289 Reporting escape or ignition of petroleum or other material**

    Operators are only required to report spills of over 300 liters in areas not in areas

of inland water. There is no definition of 'areas of inland waters'

Operators are only required to report any uncontrolled escape or ignition of petroleum or other flammable or combustible material in circumstances where that causes a potentially hazardous situation.

- **Part V 501 – Approval to Drill**

  Approval is required prior to drilling a new exploration, development or appraisal well. An application to drill must be made one month prior to commencement of operations or 3 months if the drilling is to occur in an environmentally sensitive area. The section requires a statement of proposed environmental protection and rehab measures, detail of the drilling program including particulars of the casing program (with designs for safety factors for burst, collapse and tension) complete casing cementation program, drilling fluid and formation evaluation procedures.

  Issues:

  There is no definition of an environmentally sensitive area, this provides a confusing problem for operators who have to, presumably, decide for themselves whether they are proposing to drill in an environmentally sensitive area

  There is no requirement to provide (a) an estimated amount of water to be used during drilling; (b) details in relation to plans for disposal of wastewater; (c) reports about the depth of freshwater subsurface sources.

- **s 506 casing**

  The maximum performance properties shall be those indicated as minimum performance properties in API Bull 5C2 "Bulletin on Performance Properties of Casing Tubing and Dill Pipe".

  Consideration (only) required to the setting of an intermediate casing string. Compared with other jurisdictions that require intermediate casing strings to be in place in certain situations. For example see Washington State Legislature WAC 332-17-110 *Casing Requirements* which requires intermediate casing whenever anomalous pressure zones, cave-ins, washouts, abnormal temperature zones, uncased fresh water aquifers, uncontrollable lost circulation zones, other drilling hazards are present or occur.[14]

- **s 507 Cementing in accordance with good oil field practice.**

  The section outlines some requirements for cementing of casing, including the requirement that all casing string cementations shall be carried out in accordance with good oil field practice and the details of cementing operations shall be recorded in the driller's log and the daily drilling report.

- **s 525 Protection of Aquifers**

  "All reasonable steps shall be taken during well or production operations to prevent communications between, leakage from or the pollution of aquifers that serve, or could serve, any useful purpose.

- **s 529 Abandonment of a well.**

  Sets out the requirements for cement plugs on abandoned wells.

[14] http://app.leg.wa.gov/wac/default.aspx?cite=332-17-110

- **s 531 Disposal of Produced Oil and Gas**

  The section states that any oil or gas that is circulated out of or produced during a drilling, testing or repair operation, and is not flowed through the well's flowline to a gathering facility, it shall be flowed through an appropriate manifold and properly staked temporary flow line to a storage tank or flare.

- **S 619 Approval to Vent or Flare**

  Venting and flaring must be approved as part of an operation or plan, unless in an emergency.

- The *Petroleum Exploration Permit Guidelines (***Exploration Guidelines***)*

  The Exploration Guidelines are issued under section 21E with a stated purpose of providing guidance to industry about their statutory obligations in the Northern Territory. The Exploration Guidelines state that the Department's "*over-arching objective is to manage the NT's petroleum resources and acreage in a manner consistent with the long-term viability of the industry and best return for the Territory*".

- The *Northern Territory Petroleum Exploration Reporting and Data Submission Guidelines* (**the Reporting Guidelines**).

  The Reporting Guidelines are not a tool to ensure that petroleum operations in the Northern Territory are undertaken in a way that ensures protection of the environment. The Reporting Guidelines are essentially a tool utilized to furnish the government with information about petroleum resources that may be located during operations.

3. Environmental Assessment of Petroleum Activities in the Northern Territory

The laws that control if, when and how an environmental assessment takes place are separate from the petroleum mining laws.

For petroleum exploration and mining activities on land or within three nautical miles of the Northern Territory coast, environmental impact assessment of a proposed petroleum mine only takes place if the Northern Territory Environment Protection Authority is of the opinion that the mining activities are likely to have a significant environmental impact.[15]

There is no explicit requirement for the Minister for Mines and Energy to consider the outcome of an environmental impact assessment when deciding whether or not to grant a petroleum approval. Having said that, if an environmental assessment has occurred the Minister is required to follow the recommendations of the assessment report, or table a notice in the legislative assembly.[16]

The only time when the Minister must consider the environment is when granting petroleum activities proposed to take place in a Territory park or reserve or a wilderness area.

If the exploration and mining of oil and gas is likely to have a significant impact on a matter of national environmental significance, the proposed exploration would require an approval under Australia's national environmental laws: the *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999 (Cth)

[15] *Environment Assessment Act (NT)* s 4
[16] *Environment Assessment Act (NT)* s 8A

Petroleum activities on Aboriginal Land and Native Title land in the Northern Territory

See Appendix A and B to the Petroleum Exploration Permit Guidelines

Regulatory frameworks for hydraulic fracturing within Australia

Case Study A – New South Wales

Summary of the New South Wales regulatory framework for shale gas extraction (using hydraulic fracturing): Overview

The legal regime regulating 'fracking' activities in NSW can be described as a tripartite framework:

1. Coal Seam Gas (CSG) activity regulated under the *Petroleum (Onshore) Act* 1991 (**the Act**) and *Petroleum (Onshore) Regulation* 2007 and Codes of Practice made under the Act.
2. Impacts on the Environment, regulated under the *Environment Planning and Assessment Act* 1979 (**EP Act**).
3. Management of specific water issues under the *Water Management Act* 2000, specifically via the *Aquifer Interference Policy*.

Section 23 of the Act provides for conditions to be imposed on petroleum titles, either by the Minister or by the regulations. In NSW two codes of practice apply as conditions imposed on titles:

- NSW Code of Practice for Coal Seam Gas Fracture Stimulation Activities (**Stimulation Code**); and
- NSW Code of Practice for Coal Seam Gas Well Integrity (**Integrity Code**).

The Stimulation Code sets out measures to ensure that fracture stimulation activities are conducted in a safe manner that ensures protection of the environment, water resources and communities.[17] The Stimulation Code sets out mandatory requirements for Management Plans, Stakeholder Consultation, Fracture Stimulation Design, Risk Assessment, Safety, Use of Chemicals in Fracture Stimulation, Water Resource Protection, Management of Flowback water, Monitoring, Incident and Emergency Response, Completion Reports and Record Keeping.

The Integrity Code sets out specific design requirements for construction, production, maintenance and ultimate abandonment of CSG wells in NSW.[18] The Integrity Code provides minimum requirements for well design, casing, cementing, wellheads, drilling fluids, monitoring and maintenance and abandonment of wells.

The NSW regulatory regime also includes State Environmental Planning Policies made under the EP Act. The *SEPP (Mining, Petroleum Production and Extractive Industries) 2007* aims to provide for the proper management and development of mineral, petroleum and extractive mineral resources for the social and economic welfare of the State. The Policy establishes appropriate planning controls to encourage sustainable development through the environmental assessment and sustainable management.

The *Strategic Regional Land Use Policy* provides a 'gateway assessment process'[19] for fracking developments in recognition of:

- The importance of agricultural resources;
- To ensure protection of strategic agricultural land and water resources;
- To ensure a balanced use of land by potentially competing industries; and
- To provide for the sustainable growth of mining, petroleum and agricultural industries.

[17] https://www.nsw.gov.au/sites/default/files/csg-fracturestimulation_sd_v01.pdf
[18] https://www.nsw.gov.au/sites/default/files/csg-wellintegrity_sd_v01.pdf
[19] http://www.planning.nsw.gov.au/en-us/planningyourregion/strategicregionallanduse/gatewayassessmentandsiteverification.aspx

Acts, Regulations, Policies and Codes

Principal components of the NSW regulatory regime applying to environmental protection from fracture stimulation activities are:

Acts and Regulations

- *Petroleum (Onshore) Act 1991* (NSW)
    - *Petroleum title conditions*
- *Petroleum (Onshore) Regulation 2007* (NSW)
    - *Schedule of Onshore Petroleum Exploration and Production Safety Requirements*
- *Environmental Planning and Assessment Act 1979* (NSW)
- *Water Management Act 2000* (NSW)
- *Protection of the Environment Operations Act 1997* (NSW)

Policy under the Environmental Planning and Assessment Act 1979

- *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*
- *State Environmental Planning Policy (State and Regional Development) 2011*

Policy

- *Aquifer Interference Policy*
- *Strategic Regional Land Use Policy*

Codes of practice

- *NSW Code of Practice for Coal Seam Gas Fracture Stimulation Activities*
- *NSW Code of Practice for Coal Seam Gas Well Integrity*

Guidelines

- *ESG2: Environmental Impact Assessment Guidelines*
- *Part 5 REF Requirements for petroleum prospecting*

Key provisions

Petroleum (Onshore) Act 1991 (NSW)

- Policy under the Act that prohibits the use of BTEX compounds[20]

- Policy under the Act that bans the use of evaporation ponds for storing water used in the production process. [21]

- *Section 24A - Fit and proper person consideration in making certain decisions about petroleum titles.*

  Section 24A provides the NSW Minister with the discretion to consider numerous factors in relation to an applicant for a petroleum title.

[20] http://www.trade.nsw.gov.au/policy/TI-O-120
[21] http://www.resourcesandenergy.nsw.gov.au/landholders-and-community/coal-seam-gas/the-facts/protections-and-controls

- Section 42(2)(b) – Grant of a production lease

  Under the NSW regulatory regime, the Minister must not grant a production lease where to do so would contravene the *Environmental Planning and Assessment Act* 1979 (NSW).

- Requirement to obtain a development consent (under Part 3A or Part 5.1 of the EP & AA – Section 67

- Councils, Government Departments, Statutory authorities and the Director of Planning can object to the grant of a production licence.

- Section 74 – Specific requirement that the Minister must take into account the need to conserve and protect (a) the flora, fauna, fish, fisheries and scenic attractions; and (b) the features of Aboriginal, architectural, archaeological, historical or geological interest, in or on the land over which the petroleum title is sought.

SEPP (Mining, Petroleum Production and Extractive Industries) 2007

- The SEPP prohibits CSG development:

  - On or under land in and within 2km of a residential zone or future identified residential growth area; and
  - On or under land which is a critical industry cluster (CIC).

  The CIC's are concentrations of highly productive industries and contribute the identity of that region and provide significant employment opportunities.[22] Two CICs have been identified, namely, the Upper Hunter CIC and the Viticulture CIC. The Planning and Environment Department provides CIC maps which identify CSG exclusion zones.

- Development consent for exploration

  Under the SEPP, petroleum exploration is exempt from Development Consent, however, drilling or operating petroleum exploration wells requires Development Consent unless it is a set of 5 or fewer wells that are more than three km from any other petroleum well in the same title.

  CSG development is prohibited on land within a CSG exclusion zone and land within a buffer zone.

- Development standards for mining

  Sets non-discretionary development standards for mining. Of particularly implication for 'fracking' developments – the SEPP requires adherence to the *NSW Aquifer Interference Policy.*

Strategic Regional Land Use Policy

- All CSG proposals on land identified or verified as Strategic Agricultural Land will be considered under an independent Gateway assessment process. Key elements of the policy are the identification and mapping of Strategic Agricultural Land, the Aquifer Interference Policy to inform the Gateway Panel, the establishment of a new Land and Water Commissioner, the requirement for an Agricultural Impact Statement (for both exploration and production proposals).

[22] http://www.planning.nsw.gov.au/critical-industry-clusters-in-the-upper-hunter

Case study B – Queensland

Summary of the Queensland regulatory framework for shale gas extraction (using hydraulic fracturing): Overview

The *Petroleum Act* 1923, the *Petroleum and Gas (Production and Safety) Act* 2004 (**PGPS Act**) and the *Petroleum and Gas (Production and Safety) Regulations* (**PGPS Regulations**) form the core of the regulatory regime for petroleum exploration and production by way of hydraulic fracturing in Queensland.

The PGPS Act and PGPS Regulations provide a comprehensive list of requirements for operators of projects using hydraulic fracturing. These include requirements for the construction and abandonment of petroleum wells. The Queensland regulatory regime goes further, however, and imposes mandatory and preferred standards for operators. These standards are given legislative force under section 7, and schedule 1 of the PGPS Regulations.

> *Section 7 of the PGPS Regulations states:*
>
> *(1) A standard, code or other document listed in schedule 1, column 1 is prescribed as a safety requirement for the activity or thing stated opposite the document in column 2 of the schedule.*
>
> *(2) The document is a mandatory or preferred standard for the safety requirement as stated in column 3 of the schedule opposite the document.*
>
> *(3) If a document is a **mandatory standard** for a safety requirement, a person must comply with the document in order to comply with the safety requirement.*
>
> *(4) If a document is a **preferred standard** for a safety requirement –*
>
> *a. a person who complies with the document complies with the safety requirement; but*
>
> *b. a person may comply with the safety requirement without complying with the document if –*
>
> *i. the person gives the chief inspector a notice that the person is not complying with the document; and*
>
> *ii. the person has written evidence showing the level of risk for the activity or thing to which the safety requirement applies is equal or less than the level or risk that would be achieved by complying with the document.*
>
> *…*

The PGPS Regulations makes it mandatory for operators to comply with the:

- *Code of Practice for coal seam gas well head emissions detection and reporting;*
- *Code of Practice for construction and abandoning coal seam gas wells and associated bores in Queensland.*

The PGPS Regulations make it a preferred standard that operators comply with:

- *18 International Standards for Petroleum and Natural Gas, published by the International Organization for Standardization.*

Rights to use water in fracking operations in Queensland are regulated under the *Water Act* 2000 (**Water Act**).

In addition to the approvals required under the 'Petroleum legislation', outlined above, additional environmental specific approvals are required under the *Environmental Protection Act* 1994 (EP Act). The EP Act approvals regulate the environmental impacts of fracking operations, this includes management of wastewater.

The Coal Seam Gas Water Management Policy 2012 states, "in all but exceptional circumstances, evaporation dams have been banned as a management option for CSG water. Existing CSG operators are required to continue the decommissioning or conversion of any remaining evaporation damns".[23]

Acts, Regulations and Codes

- *Petroleum Act 1923*
- *Petroleum and Gas (Production and Safety) Act 2004*
    - *Petroleum and Gas (Production and Safety) Regulation 2004*
        - *Code of Practice – for construction and abandoning coal seam gas wells and associated bores in Queensland.*
        - *Code of Practice – for well head emissions*
        - *Land Access Code*
- *Water Act 2000*
- *Water Supply (Safety and Reliability) Act 2008*
- *Gasfields Commission Act 2013*
- *State Development and Public Works Organisation Act 1971*
- *Environment Protection Act 1994*
    - *Environmental Protection Regulation 2008*
        - *Coal Seam Gas Water Management Policy 2012*
- *Forestry Act 1959*

The Regulatory Framework:

1. Coordinated v non-Coordinated Projects

Fracking projects in Queensland are regulated via two different processes, depending on whether or not a project is a "Coordinated Project" as defined under the *State Development and Public Works Organisation Act* 1971 (Qld) (**The SDPWO Act**).[24] The two processes are summarised below:

1) *Coordinated Projects*

   A "Coordinated Project" under the SDPWO Act is directed by the Coordinator-General under the provisions of the SDPWO Act. Coordinated Projects tend to be large-scale projects with considerable amounts of infrastructure.

[23] *Coal Seam Gas Water Management Policy* 2012, pp v
[24] SDPWO Act, Schedule 2

Final approvals (such as tenure pursuant to the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) and Environmental Authorities (EAs) pursuant to the *Environmental Protection Act 1994* (EP Act), or any other approval required from any other relevant Queensland Government department) will be sought from the relevant departments.[25] To inform their decisions, the Coordinator-General will provide to the relevant Departments a detailed "assessment report".[26] The project applicant is also required to make an application to the relevant individual government departments.[27]

The Coordinator-General can impose key operating conditions for the project, which cannot be changed by later approvals by those other departments. As an example, the Coordinator General has imposed conditions on Coal Seam Gas operations requiring operations to develop and implement a Social Impact Management Plan.

2) <u>*Non – Coordinated Projects*</u>

A non Coordinated Project is regulated completely by the Department of Natural Resources and Mines (**DNRM**) and the Department of Environment and Heritage Protection (**DEHP**) and the respective legislation, regulation and policies they administer.

Non-Coordinated Projects tend to be once off projects with no significant associated infrastructure or they might be expansion applications to existing projects (such as extra pipelines or wells).

2. Environmental Authority (EA) Regulatory Framework

<u>*Environmental Impact Assessment:*</u>

Prior to a decision being made as to whether or not to grant an EA, an EIS (prepared by the proponent of the project) *may* be required. The EIS processes involve public submissions and consultation. An EIS will be undertaken pursuant to one of two pieces of Queensland legislation:

a) State Development and Public Works Organisation Act 1971 (Qld):

If a resource activity is declared a Coordinated Project, the Coordinator-General will at the same time decide whether an EIS is required under the SDPWO Act per s 26(1).

If the Coordinator-General decides that an EIS under the SDPWO is not required, they must, pursuant to s 26(2)(a), ensure that an EIS will take place under another Act. In other words, a Coordinated Project will always have an EIS undertaken pursuant to one of the relevant Acts, contributing to the EA process.

An EIS under the SDPWO Act will be undertaken pursuant to Division 3 of the Act, after which the Coordinator-General will prepare a report evaluating the EIS (s 35) which will be made available to the various departments for approval consideration (such as an EA).

The Coordinator General's report may state/impose conditions for the undertaking of the project (s 47C(1), s 54B), and if it does, there is a statutory obligation to give a copy of the report to the minister administering the EP Act (s

[25] Department of Natural Resources and Mines (DNRM), Department of Environment and Heritage Protection (DEHP)
[26] *SDPWO* Act, s 54W
[27] ibid, s 54U

47C(2)). If there is an inconsistency between conditions imposed by the Coordinator General and DEHP in the EA, the condition imposed by the Coordinator General prevails to the extent of the inconsistency (s 54E).

The Coordinator General's EIS process has been recently reformed in order to streamline the process and the following documents have been produced:[28]

- Standardised outcome-focused conditions for resource projects;
- Generic draft terms of reference;
- Social Impact Assessment guidelines.

b) Environmental Protection Act 1994 (Qld):

Resource activities which are either ***not*** a Coordinated Project or ***is*** a Coordinated Project where the Coordinator-General determines that an EIS pursuant to SDPWO Act is not required, may undergo an EIS under Chapter 3 of the EP Act. DEHP have published a "trigger criteria" document, based on the EP Act, which helps specify the circumstances in which a project will be required to undergo an EIS under the Act.[29] Typically, it will be major projects that will need to undergo an EIS under the Act, however, a proponent may voluntarily prepare an EIS regardless of its status with the approval of DEHP (s 37(1)(d)).

Low and medium level projects generally do not undergo an EIS, as there are other procedures in place to assess the environmental considerations in respect of granting an EA for these types of projects. This includes published eligibility criteria for standard conditions (low risk projects only),[30] and the requirement of an environmental management plan.

Environmental Authority from Department of Environment and Heritage Protection

Whether the resource activity is a Coordinated-Project or not, it (any "environmentally relevant activity" (ERA)) will always require the grant of an EA from DEHP. EAs and the associated processes are described in Chapter 5 of the EP Act. Of note is that there is a prohibition on BTEX chemicals as a standard condition of all application types (s 206). There are three different types of application for an EA:

1. Standard Applications:

'When an applicant can meet the eligibility criteria and all the standard conditions associated with an ERA. This application type is only permitted for low risk activities and as such, there is no assessment by DEHP.'[31] Eligibility criteria and standard conditions exist for the following:

- Petroleum exploration;
- Petroleum survey;
- Petroleum pipeline;
- Geothermal exploration.

[28] Available at: Queensland Government, *Streamlining the EIS process* (02 July 2014) Department of State Development, Infrastructure and Planning <http://www.dsdip.qld.gov.au/streamlining-the-eis-process/coordinator-general-projects/assessments-and-approvals/streamlining-the-eis-process.html>.
[29] Available at: Lindsay Delzoppo, '*Triggers for environmental impact statements under the Environmental Protection Act 1994 for mining and petroleum activities* (10 February 2014) Department of Environment and Heritage Protection <http://www.ehp.qld.gov.au/management/impact-assessment/pdf/eis-guideline-trigger-criteria.pdf>.
[30] Available at: Queensland Government, '*Environmental Authorities*' (4 April 2014) Department of Environment and Heritage Protection <http://www.ehp.qld.gov.au/management/non-mining/environmental-authority.html>.
[31] Ibid.

2. Varied Applications:

'When an applicant can meet the eligibility criteria but needs to change one or more of the standard conditions for an ERA. The impacts from these changes are assessed by DEHP and standard conditions are varied'.[32] This assessment framework will be discussed below.

3. Site Specific Applications:

'When an applicant does not meet the eligibility criteria for the ERA or where there are no eligibility criteria in existence. These applications are subject to a whole-of-project assessment and include public notification. Standard conditions may be used in these approvals however it is likely that site-specific conditions will also be needed to protect environmental values'.[33] All Coordinated Projects are site specific. Site specific applications are generally higher risk projects. The assessment framework will be discussed below.

3. Assessment of Environmental Impacts and Conditions (Varied & Site Specific Applications)

DEHP assess the impacts a project will have on the environment against environmental objectives, performance standards and other criteria relating to impacts on the environment:

- *Environmental Protection Regulation 2008* Sch 5;
- *Environmental Protection (Air) Policy 2008*;
- *Environmental Protection (Noise) Policy 2008*;
- *Environmental Protection (Water) Policy 2009*.

The assessment will be based on the EIS or environmental management plan. In practice, there is a lot of communication and discussion between the project proponents and DEHP throughout the process. Essentially, the proponent proposes all the ways they will manage the environmental impacts of a project, and the DEHP, if satisfied that those proposals will meet the requirements of the policies and regulations – that the environmental outcomes are going to be met - an EA will be granted, with relevant conditions.

[32] Ibid.
[33] Ibid.

Examples of leading practices from other Australian states

National practices

The National Harmonised Regulatory Framework for Natural Gas from Coal Seams 2013. Standing Council on Energy and Resources.

- Focuses on four key areas of operation which cover the lifecycle of development: Well integrity, water management and monitoring, hydraulic fracturing and chemical use.
- The framework is designed to provide guidance to the states in developing regulatory regimes that ensure that development of the petroleum industry is managed sustainably.
- The framework established 18 leading practices.

Victoria

- The Victorian State Government endorsed the *National Harmonised Regulatory Framework for Natural Gas from Coal Seams* (**National Framework**) in early June, but is still in the process of deciding whether additional regulation is required at the State level.
- The *Resources Legislation Amendment (BTEX Prohibition and Other Matters) Bill* 2014 prohibits the use of BTEX chemicals in hydraulic fracturing.[34]

Western Australia

- The *Schedule of Onshore Exploration and Production Requirements* 1991 contains the types of provisions generally found in regulations, including requirements for well construction, drilling, regulation of production and reporting requirements.
- The Western Australian government commissioned Dr Tina Hunter to review its regulatory framework for unconventional gas in 2011 (as did the Northern Territory).[35] Her report recommended legislative amendment to provide for:
    - strengthened enforcement provisions;
    - full disclosure of all chemicals; and
    - public release of approved environmental management plans.
- The *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012* (WA) requires all environmental management plans to be publicly disclosed. This includes a requirement to disclose all chemicals or other substances, which may be, used 'down-hole'.[36]
- Resource Management and Administration Regulations for Petroleum Activity were closed for public comment on 30 May 2014. These regulations "will provide a risk based management scheme for the exploration for, and production of petroleum and other geothermal energy resources.[37]

[34] *Resources Legislation Amendment (BTEX Prohibition and Other Matters) Bill* 2014 (Vic) s 25.
[35] http://www.corrs.com.au/publications/corrs-in-brief/the-regulation-of-unconventional-petroleum-exploration-and-production-in-western-australia/
[36] http://www.corrs.com.au/publications/corrs-in-brief/an-emerging-new-world-for-the-environmental-regulation-of-unconventional-gas-projects-in-western-australia/
[37] http://www.dmp.wa.gov.au/19487.aspx

- The Western Australia gas industry has a document entitled *Western Australian Onshore Gas Code of Practice for Hydraulic Fracturing.* This Code carries no legislative force.

South Australia

The primary regulatory tool in South Australia is the *Petroleum and Geothermal Energy Act (2000)* (SA) (**GEA**). A number of key provisions of the GEA are interesting to note:

- Section 10 of the GEA defines *regulated activities,* in relation to petroleum these include exploration and production.

- Section 74 – A licence must include mandatory conditions dividing the regulated activities to be carried out under the licence into:
    - activities requiring high level official surveillance; or
    - activities requiring low level official surveillance.

  Activities are to be classified as requiring high-level official surveillance unless the licensee satisfies the Minister that, in the view of the licensee's demonstrated competence to comply with the requirements of the GEA and the conditions of the licence the activities should be classified as requiring low level official surveillance.

  The implications of having activities classified as high surveillance are quite large. High surveillance activities require the prior written approval of the Minister and fees for low surveillance activities are reduced by half.

  The *Petroleum and Geothermal Energy Regulations* (2013) (**Regulations**) set out specific factors that the Minister must consider when classifying an operators activities as low or high surveillance activities.

- Section 95 – The Minister must, have regard to, and seek to further, the objects of the *Natural Resources Management Act* 2004 (SA)

- Section 97 – An environmental impacts report must be prepared for regulated activities in accordance with the Regulations. Importantly, an environmental report must take into account cultural, amenity and other values of Aboriginal and other Australians insofar as those values are relevant to the assessment.

- Section 98 requires the Minister to classify an activity as either low, medium or high impact. In making the classification, the Minister must consider the cumulative effects of the activities. The classification impacts on the level of environmental impact assessment required.

- The *Petroleum and Geothermal Energy Regulations* (2013) (**Regulations**) set out objective criteria for the assessment of the environmental impacts of regulated activities.

Regulatory frameworks for shale gas extraction (using hydraulic fracturing) within the United States of America

Case study A - North Dakota

North Dakota, United States of America: Overview

The North Dakota regulatory regime for hydraulic fracturing is overseen by the North Dakota Industrial Commission (NDIC), Oil and Gas Division. The control of oil and gas resource operations in the state are primarily regulated under chapters 38 of the *North Dakota Century Code* (**NDCC**) and Title 43 of the *North Dakota Administrative Code* (**NDAC**).

The NDCC contains the currently effective laws of North Dakota, chapter 38 relates to "Mining and Gas and Oil Production". The NDAC is a published codification of the rules of all state administrative agencies, including NDIC.

The North Dakota Department of Health (**Department**) has the responsibility to safeguard the quality of North Dakota's air, land and water resources. All discharge of wastes, on surface, are administered under Chapter 33 of the NDAC 'Standards of Quality for Waters of the State' (**Standard**). All air emissions from hydraulic fracturing operations are administered under the 'Air pollution Control Rules' (**Rules**) established by Chapters 33-15-07 and 33-15-20 of the NDAC. The rules set out requirements for tank emissions, and emissions from dehydration units, treater flares and pneumatic pumps.

The Rules include important provisions aimed at reducing fugitive emissions from fracking operations via flaring. Contrary to Colorado, the North Dakota regulations do not mandate testing regulations specific to shale/fracking operations.[38]

There is Federal legislation, which applies throughout the United States and forms part of the regulatory regime in North Dakota.

Acts, Regulations and Codes

Applicable Federal legislation:

- Clean Water Act (CWA)
- Clean Air Act (CAA)
- National Environmental Policy Act (NEPA)

Applicable State regulations:

- *NDIC Rules and Regulations (Contained in chapter 38 of the NDCC and Title 43 of the NDAC).*
- *Chapter 23-25 of the NDCC – Air Pollution Control*
- *Chapter 33-15 of the NDAC – Air Pollution*
- *Chapter 33-16 of the NDAC - Standards of Quality for Waters of the state*
- *Chapter 38 of the NDAC - North Dakota Air Pollution Control Rules*

North Dakota applies the American Petroleum Institute Standards.

Key provisions for environmental protection from hydraulic fracturing operations

1. The control of oil and gas resources

- Waste of oil and gas is prohibited (38-08-03)

[38] http://www.alsglobal.com/en/Our-Services/Life-Sciences/Environmental/Capabilities/North-America-Capabilities/USA/Oil-and-Gasoline-Testing/Oil-and-Gas-Production-and-Midstream-Support/Fracking-Regulations-by-State

- The commission has the authority to enter into contracts for mitigating a problem if the well, equipment, pipeline or associated pipeline facility is likely to cause a serious threat of pollution or injury to the public health and safety (38-08-04.4)

- A drilling permit is required if the drilling of a well is for oil or gas. Unless waived by the owner, a permit will not be issued for an oil or gas well that will be located within 500 feet of an occupied dwelling. If a permit is issued within 1000 feet of an occupied dwelling, the commission may impose conditions on the permit (38-08-05)

- Hydraulic fracturing is designated as an acceptable recovery process. Hydraulic fracturing is a mechanical method of increasing the permeability of rock to increase the amount of oil and gas produced from the rock (38-08-25)

The damage compensation for oil and gas production is found in Chapter 38-11.1 and subsurface exploration damages is in Chapter 38-11.2

- If there is any damage to domestic, livestock, or irrigation water supply of any person who owns property within one mile of an oil or gas well site, that person is entitled to recover any costs (38-11.1-06)

- The well site is subject to inspections to ensure compliance with applicable environment protection laws (38-11.2-02)

- Any drilling operations must be notified (38-11.2-03)

- The owner of the well shall conduct an inventory of water wells within one mile of the site and conduct a certified water quality and quantity test within one year preceding the commencement of mineral production operations (38-11.2-07)

2. Air Pollution

- Chapter 33-15-20 of the NDAC – Control of Emissions from Oil and Gas Well Production Facilities

  Requires operators to submit reports to the Department within 90 days of the completion or recompletion of a well. The report must contain sufficient information to allow the Department to determine if the oil or gas well has complied with the Chapter.

  The Chapter sets limits on the amount of emissions (including, but not limited to, hydrogen sulfide and sulfur dioxide) from oil and gas wells and requires operators to provide information demonstrating that emissions from the facility do not significantly contribute to exceeding ambient air quality standards. The Chapter also places an obligation for operators to install equipment necessary to ensure that ambient air quality standards are met. The Chapter also provides specific requirements for flare stacks.

3. Water and waste management

- *Chapter 33-16-02 of the NDAC –*

  The section provides that no untreated industrial waste or other waste that may endanger public health or degrade the water quality of water shall be discharged into waters of the state.

- *Artilce 33-20 (Solid Waste Management and Land Protection)*

- *Article 33-24 (Hazardous Waste Management)*

- *Chapter 43-02-03-19.3 of the NDAC (Earthen pits and open receptacles)*

Except as otherwise provided in section 43-02-03-19, no saltwater, drilling mud, crude oil, waste oil or other waste shall be stored in earthen pits or open receptacles except in an emergency and upon approval by the director.

- *Chapter 43-02-03-53 of the NDAC – Saltwater handling facilities*

  Sets out the requirements for storage of water produced with oil and natural gas. Surface facilities, such as wastewater ponds/pits are able to be used in North Dakota, provided they are:

  - Devoid of leaks and are constructed of materials resistant to the effects of the wastewater stored in them. Dikes must be erected around any wastewater tank or other surface facility (wastewater ponds).

4. Casing and well requirements

- All wells shall be completed with strings of casing which are properly cemented at sufficient depths. Drilling of the surface hole shall be with freshwater-based drilling mud or other method approved by the director. The surface casing shall be set and cemented no less than 50 feet below the base and all strings of casing shall stand cemented under pressure for at least 12 hours (43-02-03-21)

- The director may prescribe pre-treatment casing pressure tests designed to protect wellhead and casing strings during treatment operations for fracturing wells and if fracturing results in irreparable damage, the commission may require the operator to plug the well (42-02-03-27)

- There are guidelines for a hydraulic fracture stimulation performed through a frac string run inside the intermediate casing string (43-02-03-27.1)
  - The frac string must be either in a liner or run with a packer at no less than 100 feet below the top of the cement
  - The frac string must be pressurised and monitored during operations, a tested pressure relief must be utilised on treatment lines with suitable valve checks and an adequately sized diversion line must be utilised to divert flow from the intermediate casing to a pit.

- The construction requires all injection wells to be cased and cemented to prevent movement of fluids into an unauthorised zone or into drinking water. For determining the casing and cement requirements, the estimated fracture pressure, the depth, fluid pressure and physical and chemical characteristics of the injection zone will be taken into account. Appropriate tests shall be conducted during the drilling and construction of injection wells (43-02-05-06)

5. Chemicals and reporting

- Within 60 days after hydraulic fracturing, the operator must post on the chemical disclosure registry, all elements used during operations. These are viewable by the public.

- There are reporting and monitoring requirements for injections wells in that monthly reports must be given to the commission. Upon completion of an injection well for formation fracturing, a report must be filed within 30 days outlining the reason for the work, dates, shots per foot, quantity of sand and chemicals, results of tests and any other information (43-02-05-12)

Case study B - Colorado

Colorado, United States of America: Overview

The primary piece of legislation governing oil and gas development in Colorado is the *Oil and Gas Conservation Act*. The Act's intentions are as follows: [39]

> *It is declared to be in the public interest to foster the responsible, balanced development, production, and utilisation of the natural resources of oil and gas in the state of Colorado in a manner consistent with protection of public health, safety, and welfare, including protection of the environment and wildlife resources.*
>
> *…*
>
> *plan and manage oil and gas operations in a manner that balances development with wildlife conservation in recognition of the state's obligation to protect wildlife resources and the hunting, fishing, and recreational traditions they support, which are important part of Colorado's economy and culture.*

Colorado Oil and Gas Conservation Commission (a division of the Colorado Department of Natural Resources) is the body responsible for regulation of the oil and gas industry in Colorado. The rules and regulations which regulate the manner and form of oil and gas developments within Colorado are the Commission's Complete Rules (100-1200 Series) (**the Rules**). Some of those rules are specific to hydraulic fracturing and are outlined below. The rules provide comprehensive requirements for operators using hydraulic fracturing including standard forms that cover many issues associated with fracking operations such as air emissions and water management.

Like North Dakota, the responsibility for ensuring that oil and gas operations do not impact on air and water quality is the responsibility of the Colorado Department of Public Health and Environment (Department).

The Department administers air, water and waste requirements that must be met by operators using hydraulic fracturing.

Colorado is widely recognised as the state in America with the toughest air quality regulations for fracking operators. Air quality is regulated by the Colorado Air Quality Control Commission (AQCC) Recently the AQCC adopted stronger requirements for emissions from fracking operations. Notably the new regulations set requirements and reporting obligations in relation to methane and required all wells to comply with America's strongest leak detection program.[40] Colorado has fully adopted the U.S EPA 'Standards of Performance for Crude Oil and Natural Gas Production, Transmissions and Distribution'.[41]

Operators are required to comply with emissions requirements[42] and use Department forms to report on air emissions from fracking operations. Operators are also required to comply with the Department's Water Quality Control Commission regulations.

Acts, Regulations and Codes

- Oil and Gas Conservation Act (Colorado).
    - Colorado Oil and Gas Conservation Commission Complete Rules (100-1200 Series)

[39] s34-60-102 Oil and Gas Conservation Act (Colorado)
[40] http://www.denverpost.com/environment/ci_25213661/colorado-adopts-tougher-air-rules-oil-gas-industry http://www.edf.org/blog/2013/11/25/colo-sets-national-precedent-air-quality-and-climate
[41] https://www.colorado.gov/pacific/cdphe/summary-oil-and-gas-emissions-requirements
[42] https://www.colorado.gov/pacific/cdphe/emissions-requirements-oil-and-gas-industry

- COGCC Groundwater Rulemaking 2012 – Statewide Groundwater Baseline Sampling and Monitoring.

- Colorado Habitat Stewardship Act 2007

- Colorado Air Quality Control Act

  - Colorado Air Quality Control Commission Regulations[43]

    - Regulation No. 3 – Stationary Source Permitting and Air Pollutant Emission Notice Requirements 5CCR 1001-5

    - Regulation No. 6 – Standards of Performance for New Stationary Sources 5 CCR 1001-8

    - Regulation No. 8 – Control of Hazardous Air Pollutants 5 CCR 1001-10 (incorporates the National Emission Standard for Equipment Leaks)

Key provisions of the Rules, which apply specifically to Hydraulic Fracturing:

- *Rule 205 – Inventory chemicals*

  Operators are directed to keep records of operations, which are available for inspection by the Commission for five years and in the case of chemicals for five years after cessation of the operation. Specifically from 1/5/2009 a chemical inventory must be kept of chemicals used in fracturing, including details of use of any amount exceeding 500 pounds of any chemical by well site.

- *Rule 205A – Disclosure*

  (1) Vendors and service providers must disclose the chemical composition of fracturing additives to operators unless protected by trade secrecy provisions in which case specific conditions apply. (2)Operators must register hydraulic fracturing treatment chemicals usage within 60 days of conclusion of operations or no later than 120 days after commencement and the registry information is available to public inspection on the Commission's website. Required details include volume of water used, volume of base fluid, depth of well, concentration of each chemical additive.

- *Rule 305.e.(1)A – Landowner Notice of Intent to Hydraulic Fracture*

  Directs the operator to notify surface land owner and supply Commission's Form 2A – Oil and gas location assessment, information sheet on fracturing where it is to be used, and to inform landowner that the full application may be viewed on the Commission's website and that they may provide comments to the Director of the Commission. The landowner must also be given the opportunity to consult the operator on surface use, where relevant, and notified of the expected date of commencement of operations.

- *Rule 316C 48-Hour Notice of Treatment to Local Government Designee*

  The operator must give 48 hours advance written notice of treatment at any well with the Commission then providing electronic notification to the local government designee.

- *Rule 317 Well casing and cementing; cement bond logs.*

  Details technical, safety and notification requirements for drilling
  - (a) Blow out prevention equipment (BOPE) Operator must supply details in its application of the working pressure of proposed BOPE, to exceed those of subsurface conditions. Director may specify condition specific requirements.

[43] https://www.colorado.gov/pacific/cdphe/aqcc-regs

- Drilling permit to prominently displayed at the site
- Casing requirements (d) to prevent oil, goes or water leakage to be approved prior; (e)(f) surface casing to protect all know and reasonably expected ground water; (g) to protect aquifers by stage commenting where required 50ft below and above or by other approved method; (h) technical specification of casing cement
- Flaring of gas (i) to be carried out at a safe distance and with notification to emergency services
- Disposal zones to be evaluated for hydrocarbon (n)
- Requirement for remedial cementing may be directed (p)

- *Rule 317B setbacks and precautions near surface waters and tributaries that are sources of public drinking water.*

  Controls operations in public water system surface water supply areas as shown in Commission's maps and details the application of appropriate buffer zones. Operations are not permitted within the internal buffer (300ft) without approval, where the criteria are:

  - demonstrated best management practice and equivalent demonstrated protection of drinking water;
  - that conducting operations outside the buffer would pose greater risks; or
  - that to conduct operations beyond the internal buffer would be impractical and prevent to exercise of mineral rights.

  Operations within the intermediate buffer zone (301-500 ft) must be conducted using pitless drilling and contained flowback and within the outer buffer (501-2460 ft) either pitless drilling or contained flowback. Baseline data on surface water composition to be supplied and an emergency response program must be in place.

- *Rule 341 Bradenhead monitoring during well stimulation operations*

  The rule requires all wells to be equipped with a Bradenhead. Bradenhead pressure is the pressure that builds between casing strings of a well (the annulus). The primary concern addressed by monitoring and recording bradenhead pressure is the existence of pressure in the annular space between the surface casing string and the intermediate or production casing string. The casing strings are designed and constructed to contain fluids under pressure while protecting water resources that have been penetrated by the wellbore. The monitoring requirements allow operators to monitor downhole conditions for the entire life of the well.

  Requires continuing monitoring and recording of bradenhead annulus pressure during well stimulation. Any increases of more than 200 psig are to be verbally reported to the Director as soon as practicable and no later than 24 hours after the event. Written notice is to be supplied with 15 days of corrective action. The pressure in the annulus between the intermediate casing and the production casing is also to be monitored and recorded where present. Records must be available for inspection for five years. The operator has the right to apply for variation of these conditions.

- *Rule 608 special requirements for CBM wells.*

  - *Assessment, monitoring and reporting on plugged and abandoned wells within ¼ mile of proposed CBM wells*
  - *Water well sampling of the two closest wells within ½ mile of proposed CBM including for cations, anions, total dissolved solids, minerals and methane*
  - *coal outcrop and coal mine monitoring for gas seepage.*

- *Rule 609 Statewide groundwater baseline sampling and monitoring*

  The rule sets out the requirements for operators to obtain baseline groundwater samples. The requirements are for initial sample to take place within 12 months prior to setting a conductor pipe in a Well or the first Well on a Multi-Well site. Subsequent monitoring is

required at the initial sampling location between 6 and 12 months and a second subsequent sampling event is to be undertaken between 60 and 72 months following completion of a Well.

- *Rule 903 pit permitting, lining, monitoring & secondary containment.*

  Approval must be granted for production pits, special purpose pits, drilling pits, multi-well pits; and within 30 day of construction for emergency response and flare pits.

- *Rule 904 lining monitoring and secondary containment*

  Sets out the requirements for lining of pits on federal land. These include requirements for:

  - Materials i.e. (must be impervious, have high puncture and tear strength, be resistant to ultraviolet light, weathering, hydrocarbons, aqueous acids, alkali, fungi or other substances in the produced water).
  - Thickness of lining
  - Foundation construction

  The rule also allows the Director to require a leak detection system for the pit. Other protective measures that can be required are increased record-keeping requirements, underlying gravel fill sumps and lateral systems. The Director must consider the surface and subsurface geology, the use and quality of the potentially affected groundwater, the quality of the produced water, the depth to groundwater and distance to surface water.

- *Rule 906*

  Details the requirements for notification, prevention and remediation and releases of E&P wastes and produced waters.[44]

- *Rule 907 Drilling Fluids, recycling and reuse, treatment and disposal and Oily wastes*

  Details the proper management of exploration and production wastes, including the storage, handling, transportation, treatment, and disposal of waste, including drilling fluids and produced water.[45]

- *Rule 908 Centralized E&P Waste Management Facilities*

- *Rule 910 Concentrations and Sampling for Soil and Ground Water*

[44] http://www.epa.gov/epawaste/nonhaz/industrial/special/oil/state_summaries_040114.pdf
[45] http://www.epa.gov/epawaste/nonhaz/industrial/special/oil/state_summaries_040114.pdf

Case study C – Illinois

Illinois, United States of America: Overview

In June 2013, the *Illinois Hydraulic Fracturing Regulator Act* (**IHFRA**) came into force. This piece of legislation forms the core of the regulatory regime for gas extraction by way of hydraulic fracturing (fracking) in Illinois.

The Act contains provisions, which are aimed at ensuring water quality, transparency and public involvement in the process of hydraulic fracturing. The IHFRA represents, in our view, one of the most comprehensive regulatory regimes for fracking in America.

Key provisions in the IHFRA include:

- A prohibition of open-air ponds for wastewater storage. This is an important provision and one that should be given serious consideration in the Northern Territory due to its tropical climate.
- A comprehensive set of water monitoring requirements, with baseline testing and post-fracking testing of surface water and groundwater sources near fracking wells required.
- Presumption of liability for water pollution. The IHFRA imposes on fracking operators the burden of proving that contaminated water near fracking wells was not caused by fracking. This reverse onus provision is a powerful measure that will have the effect of ensuring that only best practices are used.
- Best practice engineering requirements for well construction, casements and maintenance.
- Strong chemical disclosure provisions, including the ability for the public to challenge trade secret designations.
- A requirement that fracking operators have a water management plan that details the source and anticipated volume of water used in each well. Companies must also report to the Department of Natural Resources the total water used in fracking and locations from where water was drawn.
- The ability for "anyone adversely affected" to request a public hearings which allows evidence to be presented and cross-examination of witnesses.
- The ability for environmental groups to sue fracking companies for violations of the act and the Department of Natural Resources for failure to perform its duties under the Act.

Under section 1-99 of the IHFRA, a Task Force is required to be created to prepare a report to the General Assembly as to whether further legislation is needed to regulate hydraulic fracturing in Illinois.

Acts, Regulations and Codes

- *Illinois Hydraulic Fracturing Regulator Act* 2013
- *Illinois Oil and Gas Act*
    - *Illinois Administrative Code, Title 44-Part 610 and Title 62 – Parts 240 and 250.*
- *Illinois Environmental Protection Act*
    - *Groundwater rules*

Key provisions

- Section 1-20: The act applies retrospectively to all wells where high volume horizontal hydraulic fracturing operations (**fracking**) are planned, have occurred, or are occurring.

- Section 1-25: Setback provisions

  The general rule is that no well site may be located:

  (1) in the absence of express agreement in writing from the owner, within 500 feet from any residence or place of worship;
  (2) within 500 feet of any school, hospital or licenced nursing home facility;

  (3) in the absence of express agreement in writing from the owner, within 500 feet of any existing water well or developed spring used for human or domestic animal consumption;

  (4) within 300 feet from the centre of any perennial stream or the high water mark of any river, natural or artificial lake, pond or reservoir.

  (5) within 750 feet of a nature preserve or site on the Register of Land and Water Reserves; and

  (6) within 1500 feet of a surface water or groundwater intake of a public water supply.

- Section 1-30: individual permits are required for all wells.

- Section 1-35: permit applications must include detailed information about the proposed operations. These details include the:

  - approximate depth, angle and direction of the well, approximate depth at which the well deviates from vertical, the estimated depth of lowest potential fresh water along the length of the wellbore, anticipated pressures in the wellbore;

  - total volume of water to be used, each anticipated additive, each anticipated chemical to be used and its anticipated concentration;

  - requirement to provide a certificate of compliance with the *Water Use Act* 1983

  - requirement to provide a freshwater withdrawal and management plan;

  - requirement to provide a plan for the handling, storage, transportation and disposal or reuse of hydraulic fracturing fluids and hydraulic fracturing flowback. This plan must describe the capacity of the tanks to be used for the capture and storage of flowback and of the lined reserve pit to be used, if necessary, to temporarily store any flowback in excess of the capacity of the tanks;

  - requirement to provide a casing and cementing plan.

  Applications are signed by the applicant with an acknowledgement that they do so under the penalty of perjury.

- Section 1-40: The permit application and notice of its receipt are posted on the Department's website. Importantly, the public is able to view all of the information above, in stark contract to the non-transparent procedures currently applied in the Northern Territory. Public notice is to occur once each week for two weeks. Any person having an interest that is, or may be adversely affected can request a public hearing.

- Section 1-45: 30 day period for public comment

- Section 1-50: Request for public hearings should contain a short and plain statement identifying the person and stating the facts demonstrating that the person has an interest that is or may be adversely affected. The Department must hold a public hearing upon a request, unless it is determines that the application:

    - lacks an adequate factual statement showing that the person is adversely affected; or
    - is frivolous.

  The public hearing is conducted in compliance with the contested case requirements of the *Illinois Administrative Procedure Act.*

- Section 1-53: High volume horizontal hydraulic fracturing permit determination: Judicial Review

  This section sets out mandatory criteria that must be met before a permit is granted. This increases the accountability of decision makers and represents a move away from subjective discretionary decision-making powers of the Department.

- Section 1-70 Well preparation, construction and drilling

  The IHFRA sets out specific requirements for the preparation, construction and drilling of wells. These requirements have legislative force. Of particular significance:

    - Section 1-70(d) provides that well casings, casing thread compounds, centralizers, and cement must comply with the current industry standards published by the American Petroleum Institute (see section ## of this report).

    - Section 1-70(d) sets out requirements for casing to protect fresh water resources.

    - Section 1-70(d) sets out requirements for pressure tests on wells.

- Section 1-75 High volume horizontal hydraulic fracturing operations

  Subsections of particular note are:

    - Section 1-75(c) Fluid and waste management, which requires the storage, at the well site, of hydraulic fracturing additives, hydraulic fracturing fluid, hydraulic fracturing flowback and produced water to occur in above ground tanks during all phases of the operations until removed for proper disposal.[46] The section outlines the requirements for the tanks and any temporary storage pits.

    - Section 1-75(e) Emissions controls, details requirements for well emissions, flaring and reporting.

    - Section 1-75(f) which requires operators to file a completion report. The completion report includes requirements to report on the chemicals used during operations, the total water used and all recorded pressures. The completion reports are considered public information and are required to be published on the Department's website.

- Section 1-77 Chemical disclosure, trade secret protection.

  Operators must provide a master list of chemicals and additives used during fracking to the Department. The master list is to be available to the public and published on the Department's website. Operators are able to apply to have master list details redacted on

[46] Reserve pits, approved by the Department, may be used for the temporary storage of hydraulic fracturing flowback where tank capacity is exceeded.

the grounds they are trade secrets, however, they must meet a statutory test. Members of the public can review a decision of the Department to grant trade secret protection.

- Section 1-80 Water quality monitoring

  Subsections of particular note are:
  - Section 1-80(b) prior to fracking operations beginning, operators must retain an independent third party to conduct baseline water quality sampling of all water resources within 1,500 feet of a well site, where there are none within 1,500 feet baseline testing must be conducted from samples from the aquifer at the closest groundwater well. Samples obtained by the independent third party are required to be tested by an independent laboratory.

  - Section 1-80(c) following baseline testing, all water sources are required to be sampled and tested again in the same manner 6 months, 18 months and 30 months after fracking operations have been completed.

- Section 1-83 Order Authority

  Any person who has reason to believe they have incurred pollution or diminution of a water source as a result of fracking operations is entitled to request that the Department undertake an investigation. The Department is required to investigate claims.

- Section 1-85 Presumption of pollution

  The section established a rebuttable presumption for the purposes of evidence and liability under State law regarding claims of pollution or diminution of a water source within 1500 feet of a fracking well up until 30 months after the operations concluded.

- Section 1-87 Water quality investigation and enforcement

  Illinois Environmental Protection Agency is responsible for investigation and enforcement under this section.

- Section 1-95 Plugging and restoration

- Section 1-102 Other relief

  This section allows any person having an interest that is or may be adversely affected to commence civil action on his or her own behalf to compel compliance with the IHFRA.

- Section 1-105 Violations, complaints and notice website.

  The Department shall maintain a detailed database that is readily accessible to the public on the Department's website. The database is required to detail, in plain language, each violation found by the Department in relation to fracking operations – the description is to outline in plain language any risks to public health, life, property, aquatic life and wildlife resulting from the violation.

- Section 1-110 Public information website

  All information submitted to the Department under the IHFRA is considered public information, unless it is deemed to constitute a trade secret.

State Review of Oil and Natural Gas Environmental Regulations

Overview:

The State Review of Oil and Natural Gas Environmental Regulations (STRONGER) is a non profit, multi-stakeholder organisation that assists member states in the United States of America in documenting environmental regulations associated with the exploration, development and production of crude oil and natural gas. The stakeholders involved in STRONGER include representatives from industry, states and environmental groups.

The group was created collaboratively by the U.S EPA and the Interstate Oil and Gas Compact Commission (IOGCC).[47] Member states are able to volunteer to have their regulatory regime reviewed by STRONGER.

STRONGER publishes guidelines for the regulation of oil and gas exploration and production wastes for member states. The latest edition of the STRONGER Guidelines were published in 2014.[48]

The STRONGER Guidelines are set out in 10 Sections, which provide, relevantly, for:

- *Section 3 – General*

  Key points to note:

  - An effective state program should contain a clear statement of the program's goals and objectives. Such goal should include, at a minimum, protecting human health and the environment from the mismanagement of E&P activities while recognizing the need for an economically viable oil and gas industry. When establishing regulations and policies for E&P waste management, states should use the waste management hierarchy set forth in section 5.3 to encourage waste minimization and source reduction.[49]

  - Programs should be developed to take into account an area's unique characteristics in terms of climate, meteorological patters, air quality compliance status, hydrology and geology. [50]

- *Section 4 – Administrative Criteria (Permitting, monitoring and enforcement)*

  Key points to note:

  - Recommends that agency records should be available for review by the public, including waste disposal records, pit location records and any required analytical data. Trade secret material should be segregated.[51]

  - Performance measures to monitor program effectiveness and compliance should be quantitative, wherever possible. [52]

- *Section 5 – Technical Criteria*

[47] http://www.epa.gov/epawaste/nonhaz/industrial/special/oil/state_summaries_040114.pdf
[48] http://strongerinc.org/sites/all/themes/stronger02/downloads/2014%20STRONGER%20Guidelines.pdf
[49] STRONGER Guidelines 2014, Section 3.2
[50] STRONGER Guidelines 2014, Section 3.3
[51] STRONGER Guidelines 2014, Section 4.2.2
[52] STRONGER Guidelines 2014, Section 4.2.3.2

Key points to note:

- Facilities and sites used for the storage or disposal of wastes derived from oil and gas operations should be operated and managed at all times to prevent contamination of groundwater and surface water, soil and air, protect public health, safety and the environment, and prevent property damage.[53]

- Generally, the choice of waste management option should be based upon the waste management hierarchy. Programs should include requirements of policies that encourage source reduction and recycling.[54]

- The STRONGER Guidelines provide for specific quantitative guidelines for some waste management practices. The numbers cited are considered to be conservative values for protection of human health and the environment.[55]

- There should be requirements for fencing, netting or caging to protect the public, and wildlife.[56]

- Construction standards for pits should take into account historical precipitation patterns. The Depth of any pits should not penetrate or adversely impact groundwater or surface water.[57]

- The use of production pits is declining in America because of concerns about potential contamination of air, soils and groundwater. In many instances, equipment consolidation, process modifications, or tanks can be used in lieu of pits. The use of alternatives is generally encouraged.[58]

- *Section 6 – Abandoned Sites*

  Key point to note:

  - A state abandoned sites program should provide for public participation. At a minimum the public should have (1) access to information about the program; (2) the opportunity to participate in any rulemakings associated with the program; and (3) a statutory or regulatory mechanism to petition the state agency to change a site's status on the inventory and/or the level of remediation required on a site.[59]

- *Section 7 – Naturally Occurring Radioactive Materials*

  Key point to note:

  - Naturally occurring radioactive material (NORM) is present above background levels at some oil and gas exploration and production facilities. Because of this, states should adopt a regulatory program for NORM that addresses, identification, use, possession, transport, storage, transfer, decontamination and disposal in a way that protects human health and the environment.[60]
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- *Section 8 – Stormwater Management*

[53] STRONGER Guidelines, section 5.1(a)
[54] STRONGER Guidelines, section 5.3
[55] STRONGER Guidelines, section 5.4
[56] STRONGER Guidelines, section 5.5.2
[57] STRONGER Guidelines, section 5.5.3
[58] STRONGER Guidelines, section 5.5.3
[59] STRONGER Guidelines, section 6.7
[60] STRONGER Guidelines, section 7.2

Key points to note:

- Stormwater management requirements should be adapted to regional characteristics. These should include the variations in topography, rainfall (annual average, episodic and seasonal), major soil types, proximity to surface waters, floodplains, seasonal and permanent swamps, wetlands and marshes, and vegetation cover.[61]

- States should have stormwater management plans for oil and gas operations.[62]

- Construction of well sites, access roads, pipelines, stream crossings and crossings of wetlands, swamps and marshes can result in the contamination of stormwater and/or adjacent surface waters. State agencies should develop standards or management practices appropriate for these activities.[63]

- Standards and management practices should be appropriate for the region.[64]

- States should consider which practices they will require as stormwater controls.[65]

- *Section 9 – Hydraulic Fracturing*

  Key points to note:

  - States should have standards to prevent the contamination of groundwater and surface water from hydraulic fracturing.[66]

  - Programs should include standards for casing and cementing to meet anticipated pressures and protect resources and the environment.[67]

  - The program should require monitoring and recording of annular pressures during hydraulic fracturing operations.[68]

  - Programs should consider baseline groundwater monitoring protocols.[69]

  - Regulator agencies should require appropriate notification including the identification of materials used, aggregate volumes of fracturing fluids and proppant used and fracture pressures recorded.[70]

  - A state should evaluate and address, where necessary, the availability of water for hydraulic fracturing in the context of all competing uses and potential environmental impacts resulting from the volume of water used for hydraulic fracturing. The use of alternative water sources, including recycled water, acid mine draining and treated wastewater, should be encouraged.[71]

- Section 10 – Air Quality

[61] STRONGER Guidelines, section 8.1
[62] STRONGER Guidelines, section 8.2
[63] STRONGER Guidelines, section 8.3.1
[64] STRONGER Guidelines, section 8.3.2
[65] STRONGER Guidelines, section 8.3.2
[66] STRONGER Guidelines, section 9.2
[67] STRONGER Guidelines, section 9.2.1
[68] STRONGER Guidelines, section 9.2.1
[69] STRONGER Guidelines, section 9.2.1
[70] STRONGER Guidelines, section 9.2.2
[71] STRONGER Guidelines, Section 9.3

Key points to note:

- As a result of increased development of oil and natural gas from shale formation in recent years, concerns about air emissions have become more focused.[72]

- On August 16, 2012, the U.S EPA published 3 final rules for the Oil and Natural Gas Sector. (NSPS OOOO, for the control of VOC and SO2 emissions; and NESHAP HH/HHH, for the control of hazardous air pollutant emissions). These rules require companies to reduce flowback emissions from hydraulically fractured and re-fractured gas wells by employing reduced emissions completions, control emissions from storage vessels by 95%, use low or no bleed pneumatic controllers in the production segment, use no bleed controllers at gas plants, replace reciprocating compressor seals every 26,000 hours of operation or three years, reduce wet seal centrifugal compressor emissions by 95%, and implement more stringent leak detection and repair programs at gas plants. [73]

- States should have standards to prevent contamination of air.[74]

- States should adopt an air quality permitting program for emission sources in the oil and gas industry that is legally and practically enforceable and harmonises with federal requirements.[75]

- State programs should contain procedures for the receipt, evaluation, retention and investigation of all notices and reports required of permittees.[76]

- State programs should have inspection and monitoring procedures that are independent of the information supplied by regulated persons. The program should have the capability to conduct regular inspections.[77]

- Regulated persons should be required by law to: establish and maintain records; make reports; install, use and properly maintain monitoring equipment, and use audit procedures, or methods; sample emissions in accordance with prescribed measures; provide stack test protocols and test reports; perform parametric monitoring where direct emissions measurement is impracticable and submit compliance certifications and other information required to demonstrate compliance. [78]

- State agency should have effective enforcement tools to address violations.[79]

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[72] STRONGER Guidelines, Section 10.1
[73] STRONGER Guidelines, section 10.1
[74] STRONGER Guidelines, section 10.2
[75] STRONGER Guidelines, section 10.2.3
[76] STRONGER Guidelines, section 10.2.4
[77] STRONGER Guidelines, section 10.2.4
[78] STRONGER Guidelines, section 10.2.4
[79] STRONGER Guidelines, section 10.2.5

American Petroleum Institute – Standards

Overview:

The American Petroleum Institute (**API**) provides the most commonly cited guidelines for water management and well construction. These API guidelines are referred to in the Northern Territory Onshore Schedule.

Summary of main API documents relating to Hydraulic Fracturing

- *API HF1, Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines*

  This guideline provides recommended practices for constructing onshore oil and gas wells (the cased drill hole used to access the underground oil and gas bearing shale rock). The intention is to provide recommendations through all stages of operations (start to completion) for management and engineering solutions to maintain their structural integrity. The purpose of the guidance is to ensure shallow groundwater aquifers are protected from fracturing whilst enabling viable petroleum development.

  The guidelines purpose is achieved by isolating the internal conduit of the well from the surface and subsurface environment to protect the surrounding groundwater from contamination from produced fluids (e.g. hydraulic fracturing chemicals and resultant liberated oil, gas and other solutes from the fractured rocks) and the surrounding surface environment by maintaining pressure gradients within the well and containing the produced fluids so that they are not free to escape to the surface under pressure. The API Standard is 5CT and coupling threads should meet API Spec 5B, together with fully designed engineered cementing of the casing for the life of the well.

- *API HF2, Water Management Associated with Hydraulic Fracturing*

  This guideline provides an overview of practices recommended to manage water produced from the well during drilling and production. Hydraulic fracturing involves the injection of fluids into the well in order to fracture the oil / gas bearing shale and liberate the oil/gas. Substantial amounts of water are required for this process that must be accessed, transported and stored in accordance with local regulatory requirements. Substantial amounts of water are also produced (flow back water) in the development and stimulation of the well and must be disposed of appropriately to protect the surrounding environment. Note that this water will contain fracture and stimulation fluids as well as hydrocarbons and other solutes from the surrounding subsurface rocks and as such must be actively managed.

  Purpose of guideline is to identify best practice (to minimise environmental impacts) used in the management, treatment and disposal of water. This is achieved by specific scientific data and planning considerations for the management of operations during different phases of operations with a key focus on material selection, performance requirements and evaluation recommendation.

  Typical considerations include the geological formation, anticipated well spacing and selection of proppant material, formation temperature, pressure, length of productive interval to be fractured, reservoir depth and formation rock property. Recently developed shale-specific surfcants have improved the recovery and flow back of stimulation water in shale.

- *API HF3, Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing*

  Purpose of guidelines is to mitigate or minimise potential surface environmental impacts associated with fracturing. Operators must comply with all federal, state and local requirements which relate to surface water use, wastewater management, injections activities site construction, discharges and emissions to protect sensitive environments. This practice also calls for active stakeholder engagement and collaboration between industry, regulators and the public.

- *RP 51R, Environmental Protection for Onshore Oil and Gas Production Operation and Leases*

  This guideline addresses the considerations and planning processes that may require approval in the relevant jurisdiction when undertaking onshore oil and gas operations including exploration, production and completion. The guideline provides recommendations for environmentally sound practices. It extends to interactions with landowners and access consideration, road and access infrastructure considerations, design and construction, maintenance and rehabilitation. The focus of the document relates to environmental protection and compliance.

- *PI Std. 65-2, Isolating Potential Flow Zones During Well Construction*

  This guideline is designed to advise proponents of the requirements and potential practices that can be used in creating barriers and sealing different areas of a well conduit to control pressure, prevent unwanted mixing inside the conduit, or assist in regulating well production flow. It is also an important factor in ensuring the there is no loss of well control to protect the surrounding surface and subsurface environment. The guideline includes information on practices employed including management, maintenance and monitoring.

Summary of the regulatory framework for shale gas extraction (using hydraulic fracturing) in Alberta, Canada.

Alberta Canada: Overview

The *Responsible Energy Development Act 2013 (Alberta)* came into force in June 2013. The Act represented a major overhaul of the regulatory regime in Alberta and saw the creation of the independent Alberta Energy Regulator (AER).[80]

The regulatory framework for 'fracking' in Alberta

The Responsible Energy Development Act 2013 (REDA) forms the core of the regulatory framework underpinning Alberta's response to perceived concerns about 'fracking' operations within Alberta. The REDA creates the independent AER, which operates at arms length from the Government, and gives it the mandate to:[81]

- *provide for the efficient, safe, orderly and environmentally responsible development of energy resources in Alberta through the Regulator's regulatory activities; and*

- *in respect of energy resource activities, to regulate*

    - *the disposition and management of public lands*
    - *the protection of the environment; and*
    - *the conservation and management of water, including the wise allocation and use of water.*

The AER is the single regulator of energy development in Alberta, from application and exploration, to construction and development, to abandonment, reclamation and remediation.

The AER was created to "ensure that Alberta's resource policy development, public consultations, and regulation of energy development were efficient and competitive while effectively supporting public safety, environmental management, and resource conservation objectives – all while respecting the rights of landowners".[82]

Section 2(2) of the REDA sets out the powers, duties and functions of the AER which are variously to:

a) consider and decide applications and other matters under the energy resource enactments in respect of pipelines, wells, processing plants, mines and other facilities and operations for the recovery and processing of energy resources;

b) to consider and decide applications and other matters under the *Public Lands Act* for the use of land in respect of energy resource activities, including approving energy resource activities on public land;

c) to consider and decide applications and other matters under the *Environmental Protection and Enhancement Act* and *Water Act* in respect of energy resource activities;

d) to consider and decide applications under Part 8 of the *Mines and Minerals Act* in respect of the exploration for energy resources;

e) to monitor and enforce safe and efficient practices in the exploration for and the recovery, storing and processing and transportation of energy resources;

[80] *Responsible Energy Development Act* (Alberta), s 3(1)
[81] *Responsible Energy Development Act* (Alberta), s 2(1)
[82] www.aer.ca/about-aer/what-we-do

f) to oversee the abandonment and closure of pipelines, wells, processing plants, mines and other facilities and operations in respect of energy resource activities at the end of their life cycle in accordance with energy resource enactments;

g) to regulate the remediation and reclamation of pipelines, wells, processing plants, mines and other facilities and operations in respect of energy resource activities in accordance with the *Environmental Protection and Enhancement Act;*

h) to monitor energy resource activity site conditions and the effects of energy resource activities on the environment;

i) to monitor and enforce compliance with energy resource enactments and specified enactments in respect of energy resource activities.

Issues with the Alberta approach that the NT should not follow – As outlined by EcoJustice Canada:[83]

- The test for standing for appeals under the REDA is those persons "directly and adversely affected".[84] Standing should be given to persons with "relevant information and expertise". There should also be a public interest provision for standing "genuine interest" test. [85]

- Objective factors missing from the REDA which the AER should have regard to are:[86]

    - Considerations relevant to triggering an environmental impact assessment, as listed in section 44(3) of the EPEA;

    - Whether a project will contribute to cumulative impacts where thresholds for those impacts (as set out in the plans, policies and programs) have already been exceeded or can be reasonably be expected to be exceeded by projects under approval.

    - Whether scientific knowledge is missing and where the proposal's environmental impacts cannot be known, are uncertain or unclear.

- The right to seek Judicial Review of AER decisions is excluded under the REDA. This is unacceptable as procedural issues such as whether a party has the right to be heard, or whether a decision maker is biased are not decisions which should be made by the AER in relation to its own decisions. (See section 56).[87]

- Lack of transparency, no requirement to report annually either publically or to the legislature. S16 disclosure to the Minister on his/her request – no duty on Minister to make that information public. [88]

- There should be full disclosure of documentary information, submitted as part of applications and regulator should be required to reasons for decisions, including decision to not hold a hearing. S67 should be removed.[89]

- The REDA doesn't set out in detail how the AER must make its decisions. These details are left for internal processes or regulations. The previous Energy Resources Conservation Board (ERCB) was required to act in the public interest. There is now only

[83] http://www.ecojustice.ca/files/reda-backgrounder-may-2013/at_download/file
[84] See *Responsible Energy Development Act* (Alberta) s 32, s 34 and s 36
[85] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012.
[86] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012.
[87] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012.
[88] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012.
[89] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012.

the broad requirement to provide for the efficient, safe, orderly and environmentally responsible development of energy resources in Alberta.[90]

- The REDA makes allowances for people to submit 'Statements of concerns' (SOC), however, it doesn't state how these SOCs are required to be considered by the AER. The submission of a SOC does not have the effect of triggering the hearing provisions in the REDA.[91]

- EDONT notes the undesirability of having one body responsible for both authorisations and enforcements, as is the case under the REDA. This is similar to the current situation in the Northern Territory. The difference is that the AER, unlike the NT's Department of Mines and Energy, must consider the protection of the environment and its mission statement is not to facilitate the industry; this difference in emphasis is important.

[90] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012
[91] *Legal Backgrounder – Bill 2: Responsible Energy Development Act*, EcoJustice Canada, May 2012

Examples of regulatory frameworks, which utilise independent scientific panels.

Commonwealth

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) was established under the Commonwealth *Environment Protection and Biodiversity Act* 1999. The IESC provides expert, independent, scientific advice to decision makers on the impact coal seam gas projects may have on Australia's water resources.

The IESC was set up following the inclusion of a trigger under the EPBC Act for coal seam gas and large coal mining developments which may impact on water resources. Notably, the IESC does not provide advice on shale gas developments. As CSG actions do not occur in the NT, the Northern Territory is not a party to the *National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development* (**Partnership Agreement**). The Partnership Agreement allows government regulators in signatory states to seek the IESC's advice.[92]

Victorian regulators, for example, can use the IESC to provide information on projects impacts on ecosystems and water and chemicals used in hydraulic fracturing.

New South Wales

The NSW Chief Scientist and Engineer, Professor Mary O'Kane has recently completed an Independent Review of Coal Seam Gas Activities in New South Wales. During the 19 month review of CSG activities, the Chief Scientist publishes a number of documents, documents can be accessed on the Chief Scientists website.[93]

The final report of the Chief Scientist was released on 30 September 2014.[94]

[92] http://www.iesc.environment.gov.au
[93] http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review
[94] NSW Government Chief Scientist and Engineer *"Final Report of the Independent Review of Coal Seam Gas Activities in NSW, September 2014.* http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0005/56912/140930-CSG-Final-Report.pdf

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22 April 2016

Nicole McMaster
Community Engagement Manager
Department of Mines and Energy
Northern Territory Government

[redacted]

Dear Ms McMaster

Discussion Draft – Petroleum (Environment) Regulations
Comments of the Environmental Defenders Office Northern Territory

Thank you for the opportunity to provide our comments on the discussion draft of the *Petroleum (Environment) Regulations* (**Draft regulations**). The EDO is grateful for the extension of time to provide comments. We note that because of our delay in providing this submission, we have had the benefit of reviewing the comments of Dr Tina Hunter.

As you may be aware, the EDO is a non-profit community legal centre specialising in environmental law. We have recognised expertise in environmental law and are the only organisation of this kind in the Northern Territory (**NT**). The EDO carries a great deal of community goodwill. The EDO is a voice trusted by the community to provide well-considered, level-headed advice on matters of public interest environmental law.

Please see attached two documents. The first, a one page document outlining our major comments and recommendations in summary form and, secondly, a more substantial document with our detailed comments.

I wish to emphasise that we do not approach our engagement in this reform process with a closed mind. I look forward to more discussions with members of the Department of Mines and Energy (**the Department**) as the reform process progresses.

If you have any queries, please contact me on [redacted]

Kind regards

Environmental Defenders Office (NT) Inc

David Morris
Principal Lawyer

Cc: Ron Kelly, CEO, Department of Mines and Energy.
Cc: Jop van Hattum, Senior Director Petroleum Technology and Operations

Summary & key comments

There is plenty to commend the Draft regulations. The EDO recognises the significant effort that has gone into the development of the Draft regulations. Particularly we wish to recognise the following aspects of the Draft regulations, which are of great importance and benefit to the establishment of a world-class regulatory regime for oil and gas operations in the Northern Territory (NT):

- The recognition and specific inclusion of ESD principles into the Draft regulations[1]; and
- The increased transparency of process, achieved by:
    - the mandated requirement to publish Environmental Management Plans (**EMP**); and
    - the requirement that decisions be accompanied by a statement of reasons.
- The clear intention to require comprehensive stakeholder engagement.

In terms of constructive criticism, the five major issues the EDO has identified are:

- The Draft regulations do not define what is meant by 'acceptable' or 'as low as reasonably practicable'.
- Our continued scepticism of the merits of an approach, which does not specify in the regulations any minimum requirements that must be met by operators, but instead requires them to achieve environmental outcomes, which are always 'acceptable';
- A continued over-reliance on the Minister to make good decisions;
- The absence of a sufficiently qualified and independent body to assist the Minister in making decisions about the adequacy of EMPs; and
- The absence of third party review rights to challenge the merits of decisions.

Major recommendations

It is clear that there are some drafting errors that need attention, however, these comments have not sought to be too pedantic in terms of those minor issues. Our major recommendations are as follows:

- The introduction of a hybrid regulatory approach which incorporates some prescriptive, enforceable, operational requirements into the regulations, particularly requirements regarding:
    - Well integrity;
    - Requirements for baseline testing;
    - Use and disposal of water;
    - Chemical use; and
    - Limitations on fugitive air emissions and use of flaring
- The introduction of third party merits review of the approval of an EMP.
- The introduction of an expert independent advisory panel.
- Penalties under the regulations should be substantially increased.

[1] We have comments about amendments that need to be made to ensure that ESD principles are observed, however, we support the overarching intention, which is to ensure that decisions comply with principles of ESD.

Detailed assessment of the draft regulations

The merits of an approach that does not establish minimum standards

The solely principle/object-based approach to regulation:

In our report to the Hawke Inquiry, we identified numerous deficiencies in the NT's regulatory regime.[2] Many of those deficiencies related to an absence of identified and enforceable minimum standards. That, combined with the absence of strong environmental protection objectives, sees the currently regulatory regime fall far short of 'best-practice'.

We understand that the Government intends for the approach going forward to be based on operators achieving the required environmental goals by the means they deem appropriate. Put another way, the prevailing view in the Department is that the most effective way to achieve environmental outcomes, which are always 'acceptable', is to make the operator responsible for determining the means of achieving the ends, rather than being specific about the means.

The argument for solely principle or object-based regulation has plenty of merit. In fact, on the face of it, the logic is compelling. We understand that there is a growing trend in taking regulation away from reliance on detailed, prescriptive rules and relying on high-level, broadly stated objects or principles to set standards by which companies must conduct their business. The underlying presumption with this kind of approach to regulation is that companies are better placed to determine what processes and actions need to be implemented to achieve the stated regulatory objective.

We note the comments of Black, Hopper and Band in *Making a success of Principles-based regulation* where they state: *"the potential benefits claimed of using Principles are that they provide flexibility, are more likely to produce behaviour which fulfils the regulatory objectives, and are easier to comply with. Detailed rules, it is often claimed, provide certainty, a clear standard of behaviour and are easier to apply consistently and without retrospectivity. However, they can lead to gaps, inconsistencies, rigidity and are prone to "creative compliance".*[3]

Generally we agree that moving to a combination of Principle based regulation and guideline type documents is sensible. However, there are some problems with a purely Principle based regulatory approach.

It seems to us that the problem with this type of regulatory approach in the context of gas operations is twofold. First, many of the environmental impacts may not be known until some distant point into the future[4] and second, there is an increased reliance on high standard operators. We suggest that a solely object-based approach will allow companies to choose the lowest cost option, without that necessarily being the safest long-term option. In the current environment[5] it is difficult to understand why gas operators would do any more than that.

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[2] Environmental Defenders Office (NT) Inc. (2014) *EDO Northern Territory Report: Best Practice Regulatory Frameworks for Hydraulic Fracturing Operations.*

[3] Black, J. Hopper, M. Band, C. (2007) *Making a success of Principles-based regulation* Law and Financial Markets Review May 2007, p191 – 206 at p193.

[4] "*The benefits nor the harms to health and the environment are not fully known and may not be for many years or even decades",* Quote taken from: Northern Territory Government, (2014) *Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory, p41*

[5] Companies are dealing with very low current prices for oil and gas and they will be aware of the deficiencies of the regulators capacity.

Principle based regulation has been shown to be ineffective when used in the wrong context, this is particularly true when dealing with "recalcitrant or sceptical firms". [6]

In an ideal world perhaps it might be that relying on operators acting in accordance with ESD principles and reducing risk to as low as reasonably practicable (**ALARP**) would be sufficient. However, the NT is not a utopian society, in terms of its ability to regulate this industry. When one considers the realities of the Northern Territory context[7], we believe the community can draw little comfort from an approach, which relies so heavily on an operator's individual approach.

Therefore, the EDO is currently unconvinced of the merits of an approach which doesn't see any enforceable minimum (operational) standards contained in the regulations at all. In our view, a totally object-based regulatory framework lacks certainty and puts the Department (as regulatory) at a disadvantage. An object/principle-based approach makes it more difficult for the community and for operators to know what is required on a day-to-day operational basis. This will be particularly problematic for smaller, less well resourced, petroleum operators.[8]

We do, however, agree that the NT's regulatory regime should not be so prescriptive (in terms of operational requirements) so as to eliminate flexibility to allow innovation and allow companies to 'move with the times'. Using a hybrid type model will recognise the need for flexibility while retaining a minimum acceptable standard of protection.

Having said that, we are open to be convinced of the merits of this approach and we have noted Dr Tina Hunter's comments about the difficulties with a prescriptive approach, particularly that it does not allow flexibility to respond to economic and technological changes in the extraction of gas.[9]

The advantages of a hybrid approach

It is the EDO's view that a hybrid approach to regulation should be implemented[10]. That is, an approach where principles/objects are articulated, but some minimum standards are prescribed. In relation to financial regulation, Black, Hopper and Band state the benefits of detailed rules as follows: [11]

- "detailed rules can thus empower supervisors, and indeed internal compliance officers, in certain circumstances, whereas Principles will not, as debate can always be had about their interpretation"
- "detailed rules are more useful for regulators dealing with ill-intentioned and ill-informed firms than more general rules".
- "detailed rules can be useful for regulators themselves, facilitating quick processing of a large number of cases, and ensuring consistency of interpretation and application by a large number of officials, particularly where they are geographically dispersed.

[6] Ibid 3 at p.195
[7] We refer here particularly to: the lack of operational resources within Government; the inability to retain expertise in a highly transient population; the vast geographic area of the Territory and the difficulty accessing areas during the wet season; this historic failings of the regulator and the perceived conflict that exists within the Department (discussed later).
[8] The Northern Territory currently has a range of petroleum operators from very large (Santos, Origin) to very small (Tom Oates). See Northern Territory Government (2015) *Petroleum Opportunities – Energy Activites for the Northern Territory, Australia.*
[9] Hunter, T. Dr (March 2016) *Review of the Draft Petroleum (Environment) Regulations*, p13.
[10] The Pembina Institute refers to this type of hybrid approach as a *Goal-oriented regulatory system.*
[11] Ibid 3 at p195

All of these statements would seem to lend themselves to application in the Northern Territory context. We should add that the regulations must be drafted bearing in mind the potential for a large gas industry in the Territory, not purely for the relatively small activities of the industry, which are currently occurring. Because of the above, we believe that having some detailed rules in the regulations will derive greater certainty and empower the regulator.

In it's report comparing the regulatory regimes for offshore drilling, the Pembina Institute notes

> "*there is evidence of a general increase in the use of performance based or goal based regulation because of the greater flexibility for innovation and cost effectiveness when compared with traditional prescriptive requirements. Nonetheless, prescription may be the more appropriate approach where compulsory requirements are needed to ensure compliance with standards, provide greater certainty regarding requirements, and facilitate monitoring and enforcement. The National Energy Board has adopted a hybrid approach that combines the use of prescriptive and performance-based requirements depending which one is considered to be most appropriate. Prescription is used when compulsory means of compliance are desired. Goals are used when circumstances can differ greatly among the regulated companies or where superior outcomes are likely to be achieved through innovation or new technology.* [12]

We do see it as desirable that the regulations allow an operator to depart from the minimum standards in certain circumstances, where their proposed approach has identifiable and proven benefits. However, the regulations should also recognise and incorporate more traditional prescriptive rules based regulation in some appropriate areas. For example, the requirement for an operator to obtain baseline data and publish the results.

Some of the recommendations made by Dr Tina Hunter, if implemented, would go a long way to alleviating our concerns about the lack of enforceable minimum standards. Her recommendation that the regulations incorporate a requirement that an operator have an approved well operation management plan (WOMP), and a requirement that all wells be independently certified by a third party inspector, is a good example.

Additionally, placing additional requirements on decision makers to consider the appropriateness of any given operator may alleviate our concerns with a Principle based approach. For example, the regulations could require an operator to include their *environmental history* in a submitted EMP, and for that to be considered by the Minister.[13]

We would add that there should be a specific requirement for a water management plan to be included in the regulations and a corresponding requirement that wastewater disposal methods be signed off by a independently certified third party inspector.

The concept of ESD and its effective integration into the regulatory framework

The centrepiece, and main environmental safeguard, put forward in the Draft Regulations is the requirement for the preparation and approval of EMPs.[14] The Draft Regulations seek to ensure that an EMP will not be approved, unless it demonstrates compliance with ESD principles. To do

[12] Dagg, J et al (2011) *Comparing the Offshore Drilling Regulatory Regimes of the Canadian Arctic, the U.S., the U.K., Greenland and Norway* published The Pembina Institute, Alberta at p20.
[13] *Environmental history* is a defined term in the *Environment Protection and Biodiversity Conservation Act* 1999 and operators are required to outline details of their *environmental history* during the environmental assessment process. This requirement could also (and perhaps preferably) be included at an earlier stage when considering whether an operator should be granted tenure.
[14] Regulation 8, *Draft Discussion – Petroleum (Environment) Regulations*

so, the Draft Regulations rely on the defined concepts of '*environmental objective'* and *'environmental performance standard'*.

In our view, the definitions of those critical terms are so vague as to create real questions about their effectiveness in ensuring that EMP's will achieve 'acceptable' environmental outcomes. Additionally, we query whether these objectives and standards will be enforceable by the regulator.

There is inadequate detail, and there are inadequate safeguards, in the Draft Regulations to ensure that decisions to approve an EMP will ensure that all operations accord with ESD principles.

Specific recommendations to embed the concept of ESD into the Draft Regulations

- The terms '*environmental objective'* and '*environmental performance standard'* must be defined with greater specificity.
- Regulation 10, details the 'approval criteria' the Minister must apply when considering whether to approve an EMP. Regulation 10 should be amended to require that the Minister first:
    - be satisfied that the EMP will ensure an operation is consistent with ESD principles; and
    - believe that an operator will undertake the operation in a manner consistent with ESD principles.

  The requirement that environmental risks and impacts be reduced to ALARP should be an additional and secondary consideration.
- Regulation 12 should be 'beefed up' to require the Minister to consider additional matters before approving an EMP; particularly the Minister should have a positive obligation to consider cumulative impacts of gas operations.
- To assist the Minister with making good decisions under the regulations, we recommend that an independent expert panel be created to assess EMP's for compliance with ESD principles. That independent panel should provide a report the Minister and the Minister should be required to consider that report and provide public reasons if the recommendations of the panel are not followed.[15]

Penalties and infringement notices

Infringement notices

The EDO is in favour of the ability for penalty infringement notices (**PINs**) to be issued. However, the Draft Regulations, at Schedule 3, allows inspectors to issue PINs for offences, which could potentially be serious and are not appropriately dealt with by a PIN.

For example, it seems strange that (without any guidance or context save for that in r 44) an inspector is able to issue an infringement notice for any offence in Schedule 3. That includes the offence under regulation 35(1) for undertaking a *regulated activity* without a current plan. It is worth noting that in our view undertaking any of the activities outlined in r(2) would be a serious offence not amenable to a PIN.

[15] Independent experts are available, in relation to CSG operations, under the *Environment Protection and Biodiversity Conservation Act* 1999.

The broad power to issue PINs could lead to a lazy application of the regulations by overuse of the far less serious infringement penalty offences, rather than the offences proper. The Department's track record as a regulator does not give great confidence that these provisions will be used well in the absence of any other criteria for when a PIN is appropriate.

We note the comments of the NTEPA in their report into Redbank where they noted that, in the context of Redbank Copper Mine "*Regulators do not appear to have been given clear guidance on when enforcement decisions ought to be considered*".[16] We also note there is no publicly available compliance policy at the Department.[17] At the very least a compliance policy must be implemented to give staff guidance on when an infringement notice might be a preferable option.

Inadequacy of penalties

The penalties in the Draft Regulations should be increased. They are markedly lower that similar offences in, for example, New South Wales.[18]

Definitions

We have briefly noted above, the difficulty in defining terms such as 'acceptable' and 'as low as reasonably practicable'.[19] The definition of these terms is, however, critical to the success of the regulations. The difficulties in defining these terms are adequately set out in the report of Dr Tina Hunter.[20]

In our view, it would be difficult to successfully challenge a decision to approve an EMP, or to prosecute an operator for a failure to reduce risk to as low as reasonably practicable in the absence of a very certain definition of ALARP.

In regulation 10(b)(iii) reference is made to the term 'good oil field practice'. This is a term defined in the *Petroleum Act*. In our report to the Hawke inquiry, we raised concerns that the term 'good oilfield practice' is broad, vague and provides no certainty. Those concerns remain.

Engagement with stakeholders

The EDO agrees with the concerns raised by Dr Tina Hunter and her corresponding recommendations.[21]

Cumulative impacts – Schedule 1, Clause 2 (Description of the Environment)

In areas where multiple existing or proposed activities may have an impact on the environment, it is vital that an assessment is made of the cumulative impacts of all of those activities. This is not restricted to gas operations. The current requirements in the Draft Regulations fall short of requiring the operator in providing the EMP, and the Minister on approval, to fully assess the likely

[16] Northern Territory Environment Protection Authority (March 2014) *Redbank Copper Mine – Environmental Quality Report* at p47.
[17] Similar publicly available policies exist in most (possibly all) other Australian jurisdictions. See for example: https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0010/239941/regulatory-enforcement-policy.pdf
[18] See penalties in the *Petroleum (Onshore) Act* 1991 (NSW)
[19] We note that Dr Tina Hunter recommends the removal of the requirement for operations to be acceptable.
[20] Hunter, T. Dr (March 2016) *Review of the Draft Petroleum (Environment) Regulations*, p13.
[21] Hunter, T (2016) *Petroleum (Environment) Regulations – An independent assessment of the Regulations again best practice regulation of environmental aspects arising from petroleum activities involving ground disturbance.*

cumulative impacts of the operation on the environment when considered in context of other current and likely land uses.

The EDONT recommends that Schedule 1, clause 2 of the Draft regulations be amended to include a requirement that the operator identify, and the Minister consider, any existing land uses and any likely future land uses. That is, there should be consideration of any existing or confirmed projects and any reasonably foreseeable projects, occurring within the same catchment area.

Conflict within the Department of Mines and Energy

This is perhaps not an issue directly related to the Draft Regulations and we understand it is an issue unlikely to gain much traction with the Department. However, we feel compelled to again raise the issue of perceived conflict where the Department is responsible for both the promotion of the gas industry, approval of gas operations and the regulation of the industry.

That conflict is well articulated in in the Northern Territory Environment Protection Authority's March 2014 report into Redbank Copper Mine, where it was stated that:

> *Government agencies may have been challenged by the tension that can exist between supporting development and ensuring appropriate environmental management, and agencies have operated with little strategic guidance on how best to achieve an appropriate economic and environmental balance.*[22]

Unfortunately, all the leadership in the world cannot, in our opinion, avoid the perception problem created by having the same Department responsible for what is surely an expensive advertising campaign[23] trumpeting the benefits of the gas industry and, at the same time, responsible for overseeing the industry's compliance with the regulatory regime.

This problem is not unique to the Northern Territory. The Pembina Institute, in it's report *Comparing Offshore Drilling Regulations* noted the following:[24]

> *The mandates of departments and agencies with authority in these areas often include the explicit or implicit objectives of promoting or facilitating offshore oil and gas activity and maximizing revenue flows to government. As a result, concerns have sometimes been raised that these departments and agencies may find themselves with competing objectives and potential conflicts of interest if they are also assigned regulatory authority over environmental protection, health and safety and other areas that sometimes result in constraints on drilling activities. The perceived risk is that the emphasis on promoting development and generating revenue may result in pressures within these departments and agencies to relax regulatory requirements. These concerns have led to separation of these functions in some jurisdictions.*
>
> *There is a clear separation of responsibility in Canadian Artic offshore between regulation of drilling and the issuance of oil and gas rights and the collection of royalties. The separation between the regulator and the resource disposition and revenue collecting authority is also found in Norway and the United Kingdom (where these roles were separated after the Piper Alpha disaster in 1988). The U.S. is moving to separate these roles after the Deepwater Horizon blowout.*

[22] Ibid 16
[23] https://onshoregas.nt.gov.au/media/oil-and-gas-its-for-all-of-us
[24] Ibid 12 at p22.

Other matters

The other matters briefly identified below would appear to be drafting inconsistencies that will be weeded out in future versions of the regulations

- Regulation 8 – It would seem simpler to put all of the requirements for the contents of an EMP into Schedule 1.
- Regulation 11 – *environmental reports* are not defined
- Regulation 14(2)(b) removes the Minister's discretion to refuse an EMP if only part of it meets the approval criteria. That is, partial approval is currently drafted as a requirement of the Minister if any part of an EMP meets the approval criteria. This surely is not what is intended?
- Regulation 19 – *significant modification* is not defined and should be or should be amended to provide for any modification. Clearly it should not be for the operator to decide whether they are commencing something, which is a 'significant modification'.
- Regulation 29 – The discretion for the Minister to choose to not publish an EMP should be removed. It is difficult to understand in what circumstances that would be appropriate or desirable from a community perspective. It difficult to see why it would be required from a commercial or regulation perspective. If the discretion is to remain, it should become subject to clearly articulated criteria and a consequence of a decision to withhold publication should require the Minister to publish reasons.
- Transitional provisions will need careful attention, particularly to ensure that the drafting addresses any overlap between requirements under the *Schedule of Onshore Petroleum Exploration and Production Requirements 2012* and the regulations. All existing operations must be required to submit an EMP for approval.

Fracking Inquiry – Anthropologist's Report to the Environment Defenders Office NT

Gareth Lewis, April 2017

I have been requested by Mr David Morris, principal lawyer and chief executive at the Environment Defenders Office (NT) Inc., to prepare a brief report providing my opinion relevant to my area of expertise regarding the terms of reference to the Fracking Inquiry.

I acknowledge that I have read, understood and complied with the NT Supreme Court Practice Direction for Expert Reports and the Expert Witness Code of Conduct. I agree to be bound by the Code of Conduct.

My training and work experience is in the field of anthropology. I have had extensive anthropological field and research experience with Aboriginal people in the Northern Territory since 1998.

This report contains my opinions regarding the nature and extent of the risks posed by the hydraulic fracturing of unconventional reservoirs to Aboriginal people and their culture in the Northern Territory. These opinions are wholly or substantially based on my specialised knowledge of anthropology and my experience of working within the Northern Territory

Introduction

Aboriginal cultures across the Northern Territory present a unique and intricate pattern of relationships between people and the environment. These relationships are maintained and codified by what is generally regarded to be the oldest set of ongoing living cultural traditions in the world.[1]

Anthropological understandings of Aboriginal land tenure systems, refined in the Northern Territory by forty years of land rights and twenty-five years of native title research, provide generalised patterns and applied models where modes of descent, social organisation and religious belief define individual and group connections to, and responsibility for, land and associated sacred sites. Such systems embody people with the landscape and its creative forces derived from the ancestral past (often glossed as 'the Dreaming'), with ceremonial and ritual performance acting to maintain the relationships to these forces and their enduring sentience within and across the landscape.

[1] Australian Human Rights Commission 2013 *Declaration Dialogue Series Paper No.4*, Ensuring the ongoing survival of the oldest living culture in the world – July 2013

Group and individual rights to and responsibilities for land and waters across the Territory are enshrined in principles of descent and kinship. Across most regions, complimentary affiliation to land remains vital and involves the transmission of rights in country along lineages of patrilineal descendants who are considered to be 'owners' of an estate of land and its sacred sites and Dreamings. Complimentary rights are transmitted via matrilineal connections to the same estate with matrifiliates considered to be 'managers' or 'police' whose role it is to ensure that the owners are caring for their country and sites and performing ceremonies appropriately. In central regions of the NT the common terms for these roles are *kirda* for 'owners' and *kurtunggurlu* for 'managers' whilst further north the common corresponding terms are *nimirringgi* and *jungkayi*.

Such social systems produce intimate and overlapping connections between Aboriginal people and their environments that are highly dependent on the internal transmission of knowledge. Knowing country is an educative and existential process taught through lived experience, by being on country and directly accessing through experience the revelatory knowledge and teachings of elders conveyed through everyday practices, narrative, song and ceremony.

The fragility of culture in the face of industrial activity

The intricacy of these connections also constitutes their vulnerability with any introduced activity or form of interference that limits or excludes Aboriginal peoples' access to their traditional lands, or allows entry on or damage to important sites, resource areas or land in general, likely to undermine the social systems which bind people with their land and waters. Inability to access country, or to teach or learn from country, seriously limits an Aboriginal group's ability reproduce itself. These principles were well understood by the Woodward Royal Commission[2] and reflected in the subsequent Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976* ("ALRA") which sought to limit and control impacts of development upon Aboriginal people by granting inalienable rights to their ancestral lands and sites. They are further recognised in Commonwealth native title laws, Indigenous heritage legislation and in the *Northern Territory Aboriginal Sacred Sites Act* ("NTASSA").

Hydraulic fracturing and Aboriginal people and culture

Hydraulic fracturing of onshore unconventional shale reservoirs ("fracking") presents a new layer of risk for Aboriginal people across the Northern Territory to consider and deal with. As the Inquiry Issues Paper notes at 7.5 (p20), Aboriginal people constitute the majority of the population of areas considered to be suitable for fracking. Figure 7 (p10) in the Issues Paper indicates that the known

[2] Aboriginal Land Rights Commission 1973-74

prospective areas are located on a mixture of Aboriginal owned lands and pastoral leases subject to native title.

Previous and current conventional oil and gas exploration in the Northern Territory has produced immediately observable or tangible impacts that been limited to the relatively small footprint of drill sites, wells and associated tracks and infrastructure. Activities of this scale arguably can and have been managed by existing legislation which affords Aboriginal people levels of control to protect country and sites through negotiated agreements with land councils and site protection processes undertaken by land councils or AAPA.

However, it is the unknown and potential impacts of fracking over extended areas and extended timeframes that would in my opinion hold the greatest level of concern for Aboriginal people across the Northern Territory. As a new method of extraction with new technologies there are many aspects of fracking that will be poorly understood by the general public and even less understood by Aboriginal people resident in remote areas due to lack of access of information and their disadvantaged status noted in the Inquiry Paper at 7.5 (p20). Changes to the environment regardless of cause will be noticed, experienced and interpreted by Aboriginal people largely through their own world views. If fracking activity is, or is perceived to be, associated with environmental change, then impacts on Aboriginal peoples' use of country, resources, and land management activities are likely to ensue. If such change is detected or perceived at sacred sites or other places of significance then the impacts experienced by Aboriginal people will be more severe.

Fracking presents the potential to industrialise remote areas on a much broader scale than previous oil and gas production, with a range of direct and indirect possible impacts that would be most keenly experienced by Aboriginal people in such areas. The potential fragmentation of landscapes by networks of roads and pipelines would likely transform how that landscape is perceived and interacted with by Aboriginal people by altering or deterring access to land, transforming or limiting land use practices and activities, and damaging or interfering with the totemic landscape comprised of sacred sites and dreamings, the impacts of which are discussed below.

Across the Northern Territory, sacred sites and other areas of cultural significance for Aboriginal people are places associated with actions and presence of various creative ancestors. Features of the landscape are often instantiations of the bodies, bodily essences or 'shades' of such creative ancestors or the product or an imprint of their actions or movements. Aboriginal sacred sites manifest as almost any feature present in the environment and interconnect with each other in a variety of ways based on their particular cosmologies.

Complementary affiliation as described above results in tensions and accountabilities arising from incidents of damage to country or sacred sites being primarily directed internally within the Aboriginal community. Even where causality is clearly external the 'owners' of country (*kirda* or *nimarrringki*) will still be held to account by their 'managers' (*kurtunggurrlu* or *jungkayi*). Internal processes of punishment in physical and/or compensatory forms will often be meted out by managers on owners who are considered to have failed in their obligations to look after sites even where external processes identity non-Indigenous cause or blame.

At the more serious scale, particularly where sacred sites are damaged, there can be profound and direct impacts on individuals and their communities. At the individual level, damage to country and/or sites is generative of emotional distress and grief and is often associated with physical illness and death, particularly notable amongst senior custodians of sites. Such impacts, being emotive and psychological as well as physiological are difficult to quantify and poorly understood. At the collective level such damage manifests as social rupture and imbalance. They may result in inter and/or intra group disputes, violence, irregular behaviour and even the temporary or permanent cessation of ceremonial activity. In turn, individuals may lose the opportunity to achieve ceremonial maturity and therefore social legitimacy and authority, which ultimately limits their group's ability to culturally reproduce itself. Again such impacts are difficult to quantify and poorly understood.

The importance of the sub-surface and river systems in Aboriginal culture

In my experience, many Aboriginal groups emphasise the importance of the subsurface as a domain beneath the ground where connections between at times distant sites and dreamings can occur - sometimes described as tunnels, roots, or wires, and sometimes seen a zone through which the dreamings themselves travel and communicate[3]. Drilling and fracking works may be considered in some areas as interference or disturbance to this domain and the dreamings associated with it. Environmental change detected even at locations a considerable distance from such works may be considered by Aboriginal people to be caused by the works even if there are other likely causes.

Rivers, watercourses and aquatic systems are similarly considered by many Aboriginal groups as constituting networks of sacred sites, dreamings and resources. It is my experience that Aboriginal people consider many river systems to be associated with the movement of particular dreamings, with permanent billabongs, waterholes or other features often being considered as focal points for or instantiations of the dreamings at sacred sites. In my opinion any impacts on water levels and/or water quality from fracking would be of great concern to Aboriginal people and could act to alter or

[3] I have undertaken extensive work since late the 1990s in the Jawoyn Sickness Country area of southern Kakadu and south west Arnhem land which provides a well-documented example reported on by (amongst others) the Resource Assessment Commission in 1991.

prevent traditional land use activities such as fishing and hunting and possibly constitute damage to sacred sites. My experience has included work related to mining projects such as Ranger, McArthur River Mine, Rum Jungle, Redbank and Coronation Hill and associated mines on the upper South Alligator River where actual and/or perceived impacts from mining activities near river systems have significantly altered Aboriginal peoples' traditional land use activities and in many cases impacted upon sacred sites and areas of cultural significance.

Historical and inter-generational impacts

Aboriginal people have experienced a considerable history of incursions on their lands from explorers to pastoralists and miners. Many have dealt with mineral, oil and gas exploration, mining and oil and gas production for extended periods enduring many negative social and environmental impacts as well as some benefits. Aboriginal people have made and continue to make enormous efforts to remain on their lands and maintain their cultures across the Territory as evidenced by their past and ongoing participation in the buffalo and pastoral industries through to the more recent advent of Aboriginal ranger groups and the increasing land management activities and opportunities.

In my experience of working with Aboriginal people in relation to mining projects at Ranger, Jabiluka and Coronation Hill in Kakadu, Rum Jungle near Batchelor, Frances Creek and Mount Todd near Pine Creek, Bootu Creek near Tennant Creek, and Redbank and McArthur River in the Gulf country, all of these and other abandoned, legacy and ongoing mines in the Northern Territory have been points of conflict and contestation between Aboriginal people and developers[4]. My experience with such projects leads me to conclude that the negative impacts on Aboriginal people are cumulative, regularly extend across generations, erode community confidence and stability, and generate broad social costs.

Sacred Sites Legislation

The NTASSA is a unique legislation which helps Aboriginal people to protect their sacred sites by seeking to balance the need to preserve and enhance Aboriginal cultural tradition with the economic, cultural and social advancement of all Territorians[5]. The offence provisions of the NTASSA make it an offence to enter, work on, or desecrate a sacred site, and it has long been

[4] See further detail in Lewis, G. and Scambary, B. 2016 "Sacred bodies and ore bodies: conflicting commodification of landscape by Indigenous peoples and miners in Australia's Northern Territory." In McGrath, P (ed) *The Right to Protect Sites*. Australian Institute for Aboriginal and Torres Strait Islander Studies, Canberra.

[5] preamble NTASSA

regarded as one of the strongest and most effective legislative frameworks for the protection of cultural heritage nationally. The Act is companion legislation to the *Aboriginal Land Rights (NT) Act 1976.*

Despite the strengths of this legislation, certain issues emerge when considering its application to the potentially broad impacts of fracking.

Authority Certificates as tools for sacred site protection and management are voluntarily sought by developers over areas determined in their applications. In other words, they are sought for areas which applicants are seeking coverage and indemnity over, and typically this will be for a footprint covering known or likely works. In the context of fracking, impacts of works and possible damage to sacred sites could occur outside of areas applied for in an Authority Certificate despite the works being conducted within the subject land and in accordance with the conditions of the Authority Certificate. The ability of the AAPA to identify and attribute damage back to a source in such circumstances could be extremely difficult thereby limiting the NTASSA's ability to act as a deterrent.

The NTASSA does not protect areas of significance to Aboriginal people that are not sacred sites. Areas of resource value, and areas of cultural significance such as dreaming tracks connecting sacred sites are not afforded protection under the NTASSA. Where works are proposed on ALRA Aboriginal lands agreements can be negotiated by Aboriginal people to protect such areas, but this is limited on pastoral lands where indigenous land use agreements derived from the weaker right to negotiate afforded by the *Native Title Act 1994* ('NTA').

Aboriginal Land Rights Land & Native Title Act

Land access agreements and negotiations under ALRA and the right to negotiate under the NTA have provided some Aboriginal groups with benefits particularly from the mining industry. The ability of Aboriginal people to benefit from and manage the impacts of many projects has been a marked improvement from the devastating impacts of projects where consent was not sought. The processes under part IV of ALRA in my experience are now reasonably well understood by many Aboriginal groups, as is the scale of mineral exploration works and most mining operations.

The potential scale of a fracking industry and its difference in scale and scope to mineral exploration and mining would in my view challenge the intent of the provisions of ALRA to effectively ensure that Aboriginal people were able to make free, prior and informed consent on fracking projects. Being required to consent at the exploration phase to unknown scales of production and associated potentially landscape changing impacts would be unconscionable.

Consultation processes, agreements and benefit distributions would be logistically complicated and potentially divisive across different Aboriginal communities and groups. Any broad impacts on land, sites and/or dreamings with shared interests, would be likely extend the impacts described earlier across groups and regions.

Some Recommendations

1. Future oil and gas exploration and production licences should explicitly require Authority Certificates to be in place for the entirety of their licence areas, or for the extent of their potential impacts, not simply surface works and infrastructure or annual work programs;
2. Licencing arrangements should be considered to extend the agreement making processes of ALRA and the NTA to ensure that Aboriginal peoples are not forced to consent to production at the exploration stage;
3. Appropriate scientific and legal advice should be made available to land councils and AAPA to allow for enhancement of their policies and site clearance or Authority Certificate conditions to maximise the protection of sacred sites potentially at risk from future fracking works;
4. Comprehensive, culturally appropriate and fully independent consultation materials should be resourced and developed with appropriate anthropological, technical and cultural expertise to assist Aboriginal communities in understanding and developing their views regarding fracking and the scale and nature of its potential impacts;
5. All baseline environmental and social impact research for fracking should be required to engage with Aboriginal people and their agencies and/or representatives to ensure that they are fully cognisant of Aboriginal cultural and social values - local Aboriginal expertise should be used in designing and undertaking research as well as for ongoing monitoring to ensure Aboriginal concerns and perspectives are part of the impact assessment and monitoring process.

SCIENTIFIC INQUIRY INTO HYDRAULIC FRACTURING IN THE NORTHERN TERRITORY

EXPERT ADVICE

Dr Renata Bali

April 2017

INTRODUCTION

I was briefed by Environmental Defenders Office NT on behalf of Lock the Gate Alliance as a scientific expert to provide independent advice to the Scientific Inquiry into the Hydraulic Fracturing in the Northern Territory (Fracking Inquiry). In particular, I was asked to prepare a report in relation to linear infrastructure impacts associated with the hydraulic fracturing process.

By way of background information, I was asked to review the following documents:

- NT Supreme Court Expert Witness Code of Conduct;
- Fracking Inquiry Terms of Reference; and
- Scientific Inquiry into Hydraulic Fracturing in the Northern Territory: Background and Issues Paper (February 2017).

I was asked to prepare a written report that addresses the Terms of Reference for the Fracking Inquiry that are relevant to my expertise, namely related to assessment of linear impacts, including how this would assist to identify priority no-go zones. I acknowledge that I have read and prepared the following report in accordance with the NT Supreme Court Practice Direction for Expert Reports and the Expert Witness Code of Conduct.

Of relevance to this review is my extensive experience in the area of impact assessment for linear developments –highways, pipelines, Very Fast Train proposals and utility easements. I prepared a comprehensive discussion paper "Compensating for Edge Effects" for the NSW RTA (now RMS) in 2000 and an update in 2005. A copy of my CV is attached to this report (Attachment 1).

LITERATURE REVIEW

Whole books and hundreds of papers have been devoted to the issue of habitat loss and fragmentation. Due to time limitations, much of the information in this report has been summarised from the following reviews:

- Habitat Fragmentation and Landscape Change: An Ecological and Conservation Synthesis (Lindenmayer& Fischer 2006)
- Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation (Bennett 1998)
- Habitat fragmentation and landscape change (Bennett & Saunders 2010)
- Habitat fragmentation and biodiversity conservation: key findings and future challenges (Wilson *et al.* 2016)
- Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities (Trombulak & Frissell 2000)
- Discussion Paper – Compensating for Edge Effects (Bali 2005)

Recent reviews have been undertaken in relation to the potential impacts of shale gas mining operations in Australia. Reports relating to Coal Seam Gas (CSG) mining are also relevant as these two forms of unconventional mining have similar infrastructure impacts:

- Engineering Energy: Unconventional Gas Production – A study of shale gas in Australia Final Report (ACOLA 2013)
- Shale Gas Development in Australia: Potential impacts and risks to ecological systems (Eco Logical 2013)
- Coal Seam Gas Production: Challenges and Opportunities (Williams, undated)
- An analysis of coal seam gas production and natural resource management in Australia: Issues and ways forward (Williams *et al.* 2012)

These references informed my analysis of ecological impacts associated with shale gas development.

Data relating to flora and fauna conservation values of the Northern Territory Bioregions that are subject to shale gas extraction are summarised from:

- Northern Territory Bioregions – assessment of key biodiversity values and threats (Baker *et al.* 2015)

Although Baker *et al.* 2015 is outdated and some flora and fauna listings may have changed,time limitations precluded any updating of information and tabulated data should be considered as indicative only. Current information about NT's threatened flora and fauna is available from:

https://nt.gov.au/environment/native-plants/threatened-plants

https://nt.gov.au/environment/animals/threatened-animals

All other references are cited in the report. A full list of references is found at the end of the report.

HABITAT CLEARING AND FRAGMENTATION AS A KEY THREATENING PROCESS

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) lists 21 key threatening processes. Twelve of the 21 key threatening processes describe declines in native species and/or ecological communities caused by invasive pests.

The key threatening process most relevant to this discussion is 'Land Clearance' which is defined as the "destruction of the above ground biomass of native vegetation and its substantial replacement by non-local species or by human artefacts." It includes clearing native vegetation for crops, improved pasture, plantations, gardens, houses, mines, buildings and roads.

Although the description does not specifically mention habitat fragmentation or degradation, these processes contribute to land clearance. Several other listed threatening processes of relevance to threatened species are caused/ exacerbated by fragmentation, namely:

- Predation by the European Red Fox
- Predation by feral cats
- The biological effects, including lethal toxic ingestion, of the Cane Toad (Bufo marinus)

Other key threatening processes listed such as invasion by 'Gamba grass and other introduced grasses' and by 'invasive garden plants' are also relevant but do not adequately cover the much wider issue of 'weed invasions' in disturbed areas.

Fragmentation associated with linear infrastructure (e.g. roads and tracks, utility easements, rail corridors, pipelines, etc.) not only subdivides contiguous vegetation into habitat fragments but also creates edge habitats. Cleared corridors are utilised by introduced predators for hunting, patrolling and/or dispersing, while human-induced edges provide ideal habitats for weed colonisation. Cane toads were shown to preferentially move along roads and cleared fence lines and to avoid dense vegetation at an invasion front in northern tropical Australia (Brown *et al.* 2006). Weed seeds and pathogens such as Phytophthera are spread by vehicles.

The most recent Australia State of the Environment Report (Cresswell & Murphy 2017, hereafter referred to as SoE 2016) identifies the major threats to Australia's biodiversity based on jurisdictional reports from the states and territories. These include SoE reports (NSW, ACT, SA, VIC) or brief assessments against key pressures and key trends in vegetation, fauna and threatened species and communities (NT, WA, QLD, TAS). It should be noted that the NT has not prepared a SoE report since 2011.

Key pressures related to fragmentation, invasive species and exotic predators are listed below:

- Land clearing and fragmentation were noted as key threats in all jurisdictional reports. Half of all species listed on the EPBC Act are considered to be at risk from habitat fragmentation.
- Pest plants and animals and pathogens were identified as key threats to biodiversity and to threatened species in all jurisdictions. It is estimated that 80% of species listed on the EPBC Act are at potential risk from invasive species.
- Amongst the most frequently cited invasive vertebrates in jurisdictional reports are cats, foxes and cane toads. The Australia SoE (2016) report states that predation by cats and foxes "has contributed most to mammal extinction in Australia and is contributing to the

decline of the highest number of threatened mammals." Cats are known to consume 17 species listed on the EPBC Act. The cane toad is a major threat to at least 4 listed species, including the northern quoll and several reptile species.

The Australia SoE (2016) report also notes that these pressures do not occur in isolation but instead interact in complex ways to compound threats to biodiversity. Examples from northern Australia include:

- The interaction between predation by feral cats and recent burning on mammals;
- The interaction of grazing by introduced herbivores and fire on small mammal decline;
- The interaction of invasive plants, particularly high-biomass pasture grasses, and high intensity fires on ecological communities.

Finally, there are the unknown potential cumulative impacts of climate change and existing identified pressures such as habitat fragmentation, invasive species, grazing and altered fire regimes. This has only recently started to become a detectable impact.

DIRECT AND INDIRECT IMPACTS OF HABITAT LOSS AND FRAGMENTATION

Habitat loss and/or fragmentation is considered to be a primary cause of biodiversity loss and ecosystem degradation. Terminology and definitions used in this report generally consistent with Lindenmayer and Fischer (2006).

Habitat loss and fragmentation at the local level

It is extremely difficult to separate the effects of habitat loss from the effects of habitat fragmentation and degradation as they usually co-occur in modified landscapes. At low levels of remaining suitable habitat, other effects may exacerbate the negative effects of habitat loss (e.g. habitat fragmentation and isolation) and this may further accelerate the decline of populations.

Habitat loss is not synonymous with native vegetation loss. Habitat loss refers to the loss of suitable habitat for a given species such that the particular species no longer occurs in that area.

Habitat fragmentation is the process of subdividing a single large area of habitat into several smaller areas. At a local scale, many different factors can lead to small patches of habitat being less suitable than large ones.

Habitat isolation is species-specific and related to spatial scale, mobility and mode of movement of a particular species. Effective dispersal not only involves movement of an individual but also its successful reproduction in the new location.

Habitat degradation is the slow decline or attrition of habitat suitability that is common in landscapes subject to human modification. This particularly applies to food and shelter resources. This process is slow to occur so that even if species persist, they may not be able to reproduce. The delay in a species' extinction following landscape change is referred to as ***extinction debt***.

Habitat loss, fragmentation, degradation and isolation are ***deterministic*** (i.e. inexorable) threatening processes.

Stochastic threatening processes result from random fluctuations and can be ***exogenous*** (e.g. flood, fire, drought) or ***endogenous*** (e.g. sex ratio, birth rate, death rate, loss of genetic variation).

Interactions between deterministic and stochastic processes are very complex. The negative effects of habitat isolation are sometimes particularly pronounced when the total amount of remaining habitat for a given species is low. Whereas exogenous stochastic processes may lead to an initial decline of a species, the resulting smaller population is more susceptible to endogenous threats.

In general, species most prone to extinction are those that have specialist requirements, low fecundity, are rare or absent in disturbed environments, have poor mobility and/or are rare (i.e. threatened species). On the other hand, species likely to persist are those that have broad habitat requirements, good mobility, can utilise modified habitats and are numerically abundant (i.e. common species). However, this does not fully explain extinction processes due to interaction of threatening processes.

In Australia, it is widely agreed that, based on past extinctions, those species that are most likely to become extinct are non-flying mammals between 35 and 5500 g referred to by Burbidge and McKenzie (1989) as Critical Weight Range (CWR) species. However, this theory has been disputed by Cardillo and Bromham (2001) who argue that it is the smallest mammalian species that are more resistant to extinction, and by Johnson and Isaac (2009) who found that this relationship was not clear-cut and is influence by factors such as habits (ground-dwelling vs arboreal) and rainfall patterns.

Habitat loss and fragmentation at a landscape (multi-species) level

From a practical perspective, it is very difficult to study enough species in sufficient detail to make conservation management decisions. At the landscape scale, clearing of native vegetation often leads to the loss of habitat for many individual species (related to overall vegetation loss and smaller patch size) at the same time.

Numerous studies have demonstrated how landscape change affects biodiversity. In modified landscapes, the following general principles apply:

- Larger patches of remnant vegetation generally support more species than smaller ones (contain core habitat or refugia, interior zones, habitat diversity, random placement, lower emigration, higher immigration). Small patches are subject to more disturbance.
- Loss of structural complexity (grazing, forestry, firewood collection) results in a loss of species richness. Usually this co-occurs with loss of vegetation and connectivity.
- An increase in edges (i.e. perimeter to area ratio) and edge effects (abiotic and biotic) can significantly affect the distribution and abundance of species assemblages that inhabit vegetation remnants. In general, edge-exploiting species tend to be generalist species that thrive in highly fragmented habitats. Specialist species tend to prefer unfragmented habitats as would be typical of a forest interior.
- Modified landscapes that retain more connectivity between patches are assumed to be more likely to maintain populations of various species that inhabited the original landscape. A lack of connectivity can lead to vegetation patches being unoccupied by suites of species, extinction, altered ecological processes and/or cascading effects.

Cascading effects (or **regime change**) occur when interrelationships between key variables an ecosystem change fundamentally. Cascading effects can be brought on by excessive loss of vegetation and associated disturbance (e.g. where populations and/or species diversity is lost faster than expected), by a reduction in structural complexity (e.g. the loss of keystone features such as hollow-bearing trees) or the loss of species themselves (i.e. affecting predation, pollination, seed dispersal).

Species-rich systems are more likely to be **resilient** and less likely to experience cascades of ecosystem shifts as a result of landscape modification (i.e. some remaining species may be able to compensate for loss of others).

The conservation of **keystone species**, or those species that fulfil a disproportionate effect on ecosystem functioning relative to their abundance, is particularly important.

AUSTRALIAN CONDITIONS AND SHALE GAS EXTRACTION

In Australia, shale gas extraction would potentially be undertaken in remote parts of WA, Queensland, SA and the NT. Eco Logical (2013) noted that these arid and semi-arid rangelands comprise large areas with reasonable cover of contiguous sparse native vegetation. The authors claim that it is that high level of intactness and vast size that have imparted these landscapes with "a level of resilience resulting in the survival of native inland species populations."

These rangelands are also described by Eco Logical (2013, p. 10) as having the following characteristics:

- Coincide with vast and remote parts of Australia's inland that support contiguous and extensive areas of arid to semi-arid vegetation.
- Located in dry to very dry regions that experience highly variable rainfall and sporadic flood events. Most rivers and channels are ephemeral, and permanent water is scarce.
- The main land use is cattle grazing (and to a lesser extent sheep grazing), which is practiced across most semi-arid and temperate regions. Domestic grazing in combination with grazing pressure imposed by macropods and feral herbivores, results in a total grazing pressure that is often detrimental to grazing sensitive native flora, including perennial grasses, particular during dry periods, and in association with over-frequent burning.
- Significant populations of feral/invasive animals and infestations of exotic weeds have adversely impacted (and continue to impact) native flora and fauna in many parts of the shale gas region.
- A rich biota of native plants and animals occurs in the shale gas region, including many endemics and threatened species, and various threatened ecological communities.
- Tourism is growing in some regions, particularly those associated with scenically spectacular and beautiful landscapes (e.g. MacDonnell Ranges).
- Biodiversity and ecosystem values in shale gas regions are not well represented in formal conservation reserves (e.g. National Parks).

Within the NT, the bioregions most likely to be affected include: Arnhem Central, Channel Country, Davenport Murchison Ranges, Finke, Great Sandy Desert, Gulf Fall and Uplands, MacDonnell Ranges, Mitchell Grass Downs, Ord Victoria Plain, Sturt Plateau and Tanami. These overlie the Amadeus, Georgina and McArthur Basins and the Beetaloo Sub-basin and cover part of the Cooper and Canning Basins that are shared with adjoining states.

A number of tables have been compiled to compare relevant features for each bioregion potentially affected by shale gas extraction:

- Table 1 compares relevant management issues for each of the affected bioregions (adapted from Baker *et al.* 2005);
- Tables 2& 3 describe habitats and threats for threatened flora and fauna species recorded from bioregions of concern (adapted from Baker *et al.* 2005, NT government websites);
- Tables 4 & 5 summarise numbers of significant and threatened flora and fauna species found in bioregions of concern (Baker *et al.* 2005, Woinarski *et al.* 2014);

- Table 6 lists the reservation status of broad vegetation communities in bioregions of concern (adapted from Baker *et al.* 2005).

POTENTIAL IMPACTS OF LINEAR INFRASTRUCTURE ON NT BIODIVERSITY

In reviewing the ecological impacts of shale gas extraction, Eco Logical (2013) concludes that the two main issues associated with habitat loss/fragmentation are:

- Loss of vegetation, habitat, landscape function; and
- Ongoing impacts including road mortality, noise and light.

The authors assessed the risk (i.e. the likelihood of the event occurring and the consequences of that event) for these impacts and recommended mitigation measures based on US environments while acknowledging that these may need to be modified for Australian conditions.

The authors report that vegetation removal may result in the potential loss of flora and fauna species of national significance (MNES) but do not consider other threatened (i.e. listed under state legislation) or otherwise significant (i.e. endemic, range-restricted) species. They conclude that, because the location of wells and infrastructure is flexible, loss of threatened species can be minimised at a 'project level' and that therefore the risk of losing habitat is 'Moderate'. In my opinion, this does not address habitat loss, fragmentation and degradation at a landscape level.

Nonetheless, Eco Logical (2013) concluded that habitat fragmentation due to shale gas extraction was 'unavoidable' and assessed the risk of fragmentation and consequent loss of landscape function as 'High'.

The authors describe ongoing impacts associated with shale gas extraction as road mortality, noise and light. While they recognize that associated fragmentation, edge effects and invasive species are likely to place additional pressure on native flora and fauna species and communities, they do not consider these in any detail nor do they attempt to assess the highly complex interactions between deterministic and stochastic processes. Mitigation measures recommended are standardised and are not likely to ameliorate the negative impacts of road construction on biodiversity (see below).

In my opinion, the impacts of linear infrastructure associated with shale gas development that are likely to be significant are:

- Vegetation clearing, fragmentation and degradation
- New road, tracks and pipelines
    - Road mortality
    - Edge effects
        - Weeds
        - Predators
        - Human activity
- Aquatic impacts
- Cumulative impacts

These issues are discussed further below with respect to arid and semi-arid Australian rangelands and to the NT bioregions most likely to be subject to shale gas extraction.

Vegetation clearing, fragmentation and degradation

As discussed above, the effects of habitat clearing are intricately linked with habitat fragmentation, isolation and degradation and cannot be conveniently separated for the purposes of analysis. They are therefore discussed together.

While clearing associated with shale gas exploitation is obviously less than that due to agriculture or forestry practices, shale gas extraction would be associated with linear infrastructure connecting industrial sites over thousands of square kilometres. This would involve constructing a new network of roads, pipelines and access tracks and upgrading some existing roads.

The NT bioregions overlying basins that may be subject to shale gas extraction have generally experienced less than 1% clearing (see Table 1). Thus the existing vegetative cover maintains a high level of connectivity. Eco Logical (2013) reports that intactness is a reasonable (but not absolute) measure of landscape function and argue that GIS data and modelling can be used to generate an intactness index. They estimate that the establishment of a fully operational gas field in a relatively contiguous landscape would reduce intactness from 1 to less than 0.7 and conclude that fragmentation and associated disturbances (noise, light, traffic) is likely to "compromise the long term viability of extant populations of various species."

Despite the high level of intactness, rangelands have had a long exposure to disturbances related to pastoral activities, especially grazing (Table 1). Grazing occurs over 60% of Australia's land surface and is associated with loss of herbaceous cover, soil compaction, trampling, weed invasions and soil erosion. Together with altered fire regimes, this has resulted in a loss of vegetative structural complexity or a 'homogenisation' of habitats with consequent loss of species richness (see Table 5). Habitat degradation can be described as a slow decline in habitat quality and even though some native species may persist in altered habitats for some time, they may eventually become extinct.

While vegetation clearing may result in range contraction or habitat fragmentation and isolation, threatening processes that act to degrade remnant habitat quality may eventually lead to species' extinction. Although the specific reasons for a species' decline are often unknown, altered fire regimes, weed invasion, predation by or competition with exotic pests have been implicated in the decline of most of the threatened flora and fauna species listed in Tables 2 and 3.

Amongst the plant species, fragmentation is a threat to *Austrobryonia argillicola*; the remnant population of *Eleocharis papillose* is also highly fragmented.

Of particular concern is the Northern Crested Shrike-tit that is particularly susceptible to fragmentation. Furthermore, the populations of Carpentarian Grasswren and Common Brushtail Possum are severely fragmented as is the cane grass habitat for the Purple-crowned Fairy-wren. These species are likely to now be at risk of endogenous stochastic threatening processes (i.e. genetic drift, changes to sex ratios, etc).

New roads, tracks and pipelines

Linear infrastructure associated with shale gas extraction would predominantly comprise a network of access tracks, roads (access and service) and pipeline easements. It may also require upgrading existing roads subject to heavy truck traffic.

The impacts of roads on landscapes are well documented and can have profound negative ecological impacts. For the purposes of this report, these can be divided into two main categories: road mortality and edge effects. Roads contribute to fragmentation of populations through increased mortality and road avoidance behaviour. Furthermore, roads are often recognised as indicators of loss of environmental health (Trombulak & Frissell 2000).

Road mortality

Over the life of a gas field, the level of vehicular access can be considerable. While there is some scope to lessen road impacts (i.e. through multi-well pads, co-location of services, reduced road length) and to reclaim temporary access tracks, Eco Logical (2013) concluded that road kills will be an unavoidable consequence of road construction. Few species are immune from road mortality, including: mammals of all sizes, raptors, owls, granivorous and scavenging birds, snakes and other reptiles, toads and migrating frogs and insects (Trombulak & Frissell 2000). Roads also pose a threat for bats (Medinas *et al.* 2013, Fensome & Mathews 2016).

The impacts of road mortality on Australian biodiversity are already significant. Eco Logical (2013) summarises numerous Australian road kill studies on p. 13 of their report. Road mortality affects a wide diversity of species, can cause local extinctions and varies with season, time of day, fauna density, distribution of resources such as food and cover, traffic speed and other factors. Mitigation measures aimed at reducing road kills have had mixed success and cannot be relied upon with any confidence to significantly reduce road kills (Trombulak & Frissell 2006, Ramp undated, Rytwinski *et al.* 2016).

Some species modify their behaviour in the vicinity of roads through home range shifts or through altered movement patterns, reproduction, escape responses or physiological states. While some species will avoid roads or crossing roads, others are attracted to roadside habitats and will be at higher risk of road mortality (e.g. macropods).

Common species (i.e. abundant and widespread) are also impacted by road mortality. Roger *et al*. (2011) quantified the impacts of road mortality at a landscape level for the Common Wombat in NSW. They estimated the total annual count of wombat road-kills in optimal habitat to be as high as 13.6% of the total NSW population. Gaston and Fuller (2007) stress that there is growing evidence that large numbers of presently common species are undergoing massive declines.

Shale gas extraction not only involves road construction but would result in increased traffic on local roads and in increases in both volume and speed on upgraded roads. As road mortality tends to increase with increased traffic speed (Trombulak & Frissell 2000, Forman & Alexander 1998, Jones 2000), road upgrades associated with shale gas extraction are therefore expected to result in a higher incidence of road kills.

In the case of threatened fauna species, roads not only act as population sinks but also as barriers to fauna movement, thus fragmenting and isolating small populations, separating individuals from important resources or possibly halting gene flow (e.g. frogs). Road mortality has been directly linked to extinctions of local populations of eastern quolls, Tasmanian devils and bandicoots (Ramp undated, Jones 2000).

Amongst the NT's threatened species, the endangered (or possibly extinct) kowari and northern quoll may be particularly susceptible to road mortality. The Southern Marsupial Mole is sensitive to soil compaction by vehicles; road construction increases soil compaction up to 200 times relative to undisturbed sites.

Edge effects

Edge effects associated with roads can be described as: changes to microclimate, hydrology, floristics, pattern and frequency of fire; invasion by exotic plants and animals; increase in sedimentation, tree death, rubbish and water pollution; and improved access for predators.

While road mortality generally only applies to roads or other transport corridors, edge effects apply to tracks, easements or any interface between native vegetation and cleared areas. Edge effects are not confined to edges but extend much further; there is no generic edge width. It is generally agreed that the road edge effect extends about 200 m (Trombulak & Frissell 2000, Ramp undated). Bali (2005) found that edge width varied from <50 m (e.g. abiotic effects) to 500-1000 m (e.g. behavioural responses) to 2+ kilometres (e.g. seed dispersal). Edge width varies with vegetation structure, vegetation community, geographic and local context and sampling techniques.

Forman *et al*. (2013) found that road effects typically penetrated further into grassland than forest. Grassland birds were more sensitive to noise generated by varying levels of traffic; population densities decreased within 1200 m of road with high traffic volumes and within 400 m of roads with moderate traffic volumes. Hansen and Clevenger (2005) found grassland to be particularly susceptible to weed invasion. Of particular relevance to arid and semi-arid rangelands, the authors found that communities characterised by low soil moisture, shallow soil depth and/or low nutrient levels may exhibit fewer edge effects.

While it is accepted that road construction causes habitat fragmentation, it may be less obvious that road improvements (i.e. upgrades) can also exacerbate edge effects. Gerbard and Belnap (2003) compared weed and native species cover and species richness along roadside verges in semi-arid country adjacent to ungraded four-wheel drive tracks, graded unpaved roads, improved surface roads and paved roads. Although they found that road verges directly adjacent (<50 m from edge) to improved/paved roads contained a higher species richness of both exotic and native species than ungraded/unpaved roads, interior habitats (>50 m from edge) next to improved/paved roads supported 50% greater exotic species richness and 30% less native species richness. Parendes and Jones (2000) found that exotic species were more frequent along high-use and low-use roads compared to abandoned roads; weed cover was correlated with light levels and disturbance history.

We can therefore expect that construction of new roads, tracks and easement as well as upgrading existing roads will increase fragmentation and consequent edge effects in NT rangelands. The edge

effects of most significance to NT flora and fauna are weed invasion and increased access to introduced predators.

Weeds

Gelbard and Belnap (2003) summarise the reasons that roads act as conduits for exotic plant species:

- Vehicles and road-fill operations transport exotic plant seeds into uninfested areas.
- Road construction and maintenance activities provide safe sites for seed germination and seedling establishment.
- Vegetation clearing, addition of road-fill and grading of unpaved roads creates areas of bare and deeper soils that allow exotic seeds to become established.
- Mowing roadside verges and herbicide treatment may favour exotic plant species over native species.
- Compaction by vehicles creates areas of competition-free space that is open to invasion.

Also, vehicle traffic aids the dispersal of exotic species into adjoining habitat by causing air turbulence and by transporting seeds and other plant parts (Hansen& Clevenger, 2005).

Weeds are able to displace native species as they have a high tolerance to disturbance, drought and high light levels (Hansen & Clevenger 2005, Trombulak & Frissell 2000). As discussed above, road improvements (such as widening) creates more disturbed habitat likely to support weeds.

Despite the application of weed control measures as standard mitigation protocols accompanying every major road and construction project (outside of urban environments), it is apparent that weeds are proving difficult or impossible to control Australia wide. Almost all states and territories reported (SoE 2016) that data on the distribution and abundance of pest plants and animals is lacking and that management effectiveness for these pests are poor. Clearly, our weed control strategies are not working.

The SoE (2016) notes that the Northern Territory floodplain systems, including areas of high conservation significance, are under threat from weeds, especially exotic pasture grasses.

The Finke and MacDonnell Ranges bioregions have the highest proportion of exotic weeds at 12-15% (Table 1). Within all NT bioregions potentially affected by shale gas extraction, the following significant exotic plant species are found along roads: Buffel Grass, Gambia Pea, Paddy's Lucerne, Coffee Bush, African Boxthorn, Castor Oil Plant, Mexican Poppy, Devil's Claw, Lion's Tail, Noogoora Burr and Rubber Bush. This is by no means a comprehensive list as there are many hundreds of other non-significant weed species that prefer disturbed edge habitats.

Although weed invasion is implicated in habitat degradation affecting many of the flora and fauna species listed in Tables 2 and 3, the spread of Buffel Grass is identified as a particular issue for *Acacia latzi*, *Acacia undoolyana*, *Sporobous latzii*, Slater's Egernia and the Long-Tailed Dunnart.

Exotic Pests

It is a well-recognised fact that predation by exotic predators is the major threatening process for small-medium mammals, ground-nesting birds and a variety of reptiles. Predation by cats and foxes

has contributed most to mammal extinctions in Australia and is contributing to the decline of threatened mammals (Woinarski *et al.* 2014). Moreover, the SoE (2016) report claims that many invasive species appear to be increasing in abundance and distribution. Even though threat abatement plans under the EPBC Act are in place, these are apparently failing to control feral pests.

Furthermore, there are many studies to show that roads and cleared easements act as conduits for introduced predators (May & Norton 1996, Robertshaw & Harden 1989, Graham *et al.* 2012). Graham *et al.* (2012) detected more exotic predators in spatially heterogeneous landscapes and in edge-affected habitat than in intact native woodland. It is therefore inevitable that a new road network extending over thousands of square kilometres in currently remote areas will have a significant impact on threatened fauna. Cats alone reportedly consume 17 of the threatened species listed under the EPBC Act (SoE 2016).

McGregor *et al*. (2014) hypothesised that the impact of feral cats on small mammals may have increased in northern Australia due to the interaction between cat predation, grazing and fire. They found that cats selected for areas with open grass cover and strongly selected for recently burnt areas presumably because these factors increase hunting success. Although time since fire did not appear to affect the distribution of foxes in the arid zone (Payne *et al.* 2014), prey species may be more at risk of fox predation in recently burnt areas.

Given that data on the density distribution of cats is poor in the Northern Territory (SoE 2016), the following information is indicative only. Cats are found in all of the NT bioregions under consideration and foxes are present in most (see Table 1). The bioregions where cats and foxes are considered to be serious pest include Finke, Great Sandy Desert and Tanami; these bioregions have also experienced some of the highest fauna extinction rates at 25, 22 and 13 respectively. The MacDonnell Ranges also has a high extinction rate at 19 with foxes only considered a serious pest.

Whether CWR species are more prone to extinction or not, it is clear that this group is most at risk of predation by introduced predators, especially cats and foxes. There is a long list of mammals in this size range which are now extinct in the NT including: Burrowing Bettong, Crescent Nailtail Wallaby, Western Quoll, Dusky Hopping Mouse, Mala, Pig-footed Bandicoot, Red-tailed Phascogale, Lesser Bilby, Lesser Sticknest Rat, Long-tailed Hopping Mouse, Shark Bay Mouse, Central Hare-wallaby, Numbat and Desert Bandicoot.

In the bioregions potentially affected by shale gas extraction, the following mammals are of conservation concern (see Table 3): Greater Bilby, Brush-tailed Mulgara, Black-footed Rock Wallaby, Central Rock-rat, *Fawn-hopping Mouse,*Kowari, Southern Marsupial Mole, Long-tailed Dunnart, *Sandhill Dunnart, Brush-tailed Rabbit-rat, Carpentarian Rock-rat and *Northern Quoll. It is notable that several of these species (marked with an *) were listed in Baker *et al.* (2005) although they may already be extinct in the NT.

The Central Rock-rat is listed as Endangered under both national and state legislation. According to the SoE (2016), the Action Plan for Australian Mammals (2012) recommends that it be upgraded to Critically Endangered under the EPBC Act 1999, given its ongoing decline in population size and its small area of occupancy. It is already listed as Critically Endangered by the IUCN. Since its discovery in the 1890s, this species has disappeared and reappeared on several occasions. Most recently (2009-10) it was rediscovered near the summit of Mt Sonder and now appears to be restricted to

high elevation quartzite ridges and mountain peaks. Pavey *et al.* (2015, in SoE 2016) considers that this species is persisting in core refuge areas but recommend that predation pressure by cats in particular, be the focus of management efforts.

Other non-mammalian species that are threatened by predation include the Partridge Pigeon, Great Desert Skink, *Night Parrot and the Purple-crowned Fairy-wren (Table 3). It should be noted that the Night Parrot may be extinct in NT, but it has recently been rediscovered in WA (https://phys.org/news/2017-03-night-parrot-rediscovery-wa.html) and in Queensland (https://www.theguardian.com/environment/2016/oct/25/night-parrot-population-discovered-in-queensland-national-park).

Another exotic pest species that prefers moving along roads and cleared corridors during migrations is the cane toad (Seabrook & Dettmann 1996). Poisoning by this species is a major threat to 4 species including the Northern Quoll and has been implicated in marked declines of "iconic, and culturally and ecologically significant" reptile species (SoE 2016, Jolly *et al.* 2015).

In the NT, cane toads have recently established in Central Arnhem, Gulf Fall and Uplands and Sturt Plateau bioregions (Table 1). They are likely to soon be established in Ord Victoria Plain. Although the Northern Quoll may be extinct in the NT, with a >80% decline in the population estimated during the past 10 years, historical records come from the Gulf Fall and Uplands bioregion. If quolls persist, they would be under renewed threat from cane toads.

Human access

Roads and tracks also act to facilitate human access to otherwise remote areas, thus opening up these areas to legal and/or illegal purposes (e.g. hunting, fishing, collecting, camping, 4-wheel driving, trail bike riding) resulting in fauna mortality, habitat destruction or degradation, pollution, erosion and sedimentation, etc. Noise, light spill and general disturbance associated with these activities may result in passive or active harassment of wildlife. This may also lead to an increased incidence of accidently and/or deliberately lit fires.

Eco Logical (2013) assessed the risk of an increased incidence of bushfires as a result of shale gas extraction. They found that, while there is likely to be an increase in the incidence of arson or accidental fires due to increased human activity, there would be a 'Low' risk of destructive wildfires due to the industry's self-interest in controlling and preventing fires, the established network of roads and access tracks and because many areas in northern Australia are regularly burnt.

In most NT terrestrial environments, the key pressure identified is "altered fire regimes, particularly more frequent, intense and/or extensive fires" (SoE 2016). Proportion of NT bioregions burnt over a 7-year period are highest for Central Arnhem (28.9-40.4%) but also substantial for Gulf Fall and Uplands, Sturt Plateau, Ord Victoria Plain and Tanami (see Table 1).

Changing fire regimes is considered a threat to 60% of listed species (SoE 2016). Fire is identified as a threatening process for most of most of the threatened plant species occurring in bioregions of concern (see Table 2). The interaction between fire and other threatening processes (grazing, exotic grass invasion) may be implicated in the decline of *Actinotus schwarzii*, *Livistona mariae mariae*, *Olearia macdonnellensis*, *Minuria tridens* and *Cycas armstrongii*.

It should be noted that there is only one endangered ecological community (EEC) in the NT that is listed under the EPBC Act and *Territory Parks and Wildlife Conservation* ACT (TPWC Act) – Arnhem Plateau Sandstone Shrubland Complex (http://www.environment.gov.au/biodiversity/threatened/communities/pubs/111-listing-advice.pdf). It is confined to the Top End within the Arnhem Plateau Bioregion but may extend to sandstone outcrops in Central Arnhem and Gulf Fall and Uplands. Fire is a key threat for this community.
Altered fire regimes, in combination with invasive species and grazing, have contributed to significant population declines in NT's threatened fauna species including: Partridge Pigeon, Bilby, Mulgara, Great Desert Skink, Princess Parrots, Night Parrot, Long-tailed Dunnart, Sandhill Dunnart, Gouldian Finch, Northern Crested Shrike-tit, Purple-crowned Fairy-wren, Brush-tailed Rabbit-rat, and Common Brushtail Possum (see Table 3).The interaction between feral cat predation and fire regimes is recognised as being particularly important in driving negative impacts on small mammal populations.

Any increase in the frequency or intensity of fires associated with shale gas extraction is likely to have a significant impact on threatened flora and fauna, especially in combination with other threatening processes.

Aquatic impacts

While shale gas extraction and particularly hydraulic fracturing has potential impacts on groundwater and surface water, this discussion is limited to the impacts of linear infrastructure, namely roads, on surface water. At the landscape level, roads result in the ecological fragmentation of aquatic ecosystems; numerous studies have demonstrated that there is a decline in stream health associated with roads (Tombulak & Frissell 2006).

Roads and bridges can alter the development of shorelines, stream channels, floodplains and wetlands through alterations to hydrodynamics and sediment deposition (Trombulak & Frissell 2006). Roads can:

- Redirect water, sediment and nutrients between streams and wetlands and their riparian systems;
- Act as barriers to fish and aquatic animals;
- Change the hydrology of slopes and stream channels, resulting in alteration to surface water habitats;
- Intercept shallow groundwater flow paths, diverting water along the roadway;
- Create or destroy wetlands habitats by altering surface and subsurface flows;
- Create high concentrations of run-off and consequent erosion by changing the route of shallow groundwater or surface flow;
- Send fine sediments to streams, lakes, wetlands, increasing turbidity (unpaved roads); and/or
- Contaminate adjacent aquatic environments with heavy metals, salt, organic molecules, ozone and nutrients.

Although standardised mitigation measures are applied to all road construction projects in order to minimise aquatic impacts, it is apparent that these are not always effective in the long-term. Findlay & Bourdages (2006) documented lags in wetland biodiversity loss in response to road construction. They found that the full impacts of road construction on some taxa may be undetectable for decades. Importantly, they reported that:

- Short-term environmental assessments of road construction impacts are inadequate;
- Accurate estimates of road construction impacts on wetlands require that current and historical effects be integrated as part of a cumulative impact assessment;
- The negative effects of historical road densities are detectable 1-2 kms away from a wetland; and
- Designated buffer zones extending at most several hundred metres from a wetland's edge, are considered to be inadequate.

This final point is of particular relevance when determining buffer zones between road and RAMSAR and other important wetlands.

Of particular concern in arid and semi-arid areas is the reliance of many vegetation communities on sheet flow for adequate moisture. Issues surrounding sheet flow are discussed in ACOLA (2013, p. 116-7 and Table 8.3) and summarised here. Sheet flow occurs as a broad, sheet-like flow typically over a gentle downhill slope and does not concentrate into channels larger than rills. It is a low volume water movement that has low potential for erosion.

Linear infrastructure associated with shale gas extraction has the potential to intercept or divert sheet flow through raised embankments, sections of cut and fill and water diversion works. This may result in:

- Water ponding upslope of infrastructure;
- Reduced sheet flow downslope of infrastructure;
- Concentrated water flow through diversion infrastructure causing erosion;
- Channel formation.

A sheet flow dependent ecological community is Mulga, a significant component of vegetation in arid and semi-arid regions; 'true' Mulga (*Acacia aneura*) and its close relatives occupy approximately 20% of Australia (Miller *et al.* 2002). It is slow-growing and long-lived and is an important ecosystem component because it captures nutrients and slows down surface water. Within the NT bioregions of concern, the Long-tailed Dunnart prefers Mulga shrubland.

<u>Cumulative impacts</u>

It is my understanding that up to 85% of the NT is under application for shale gas exploration permits or has already had exploration permits granted (see Attachment 2). This includes areas immediately surrounding Kakadu NP and Uluru-Kata Tjuta NP.ACOLA (2013) reports that in excess of 10,000 wells are 'feasible' in Australia. Thus, the cumulative impacts of shale gas extraction are potentially enormous.

In its assessment of unconventional gas production in Australia, ACOLA (2013) notes that:

"In most prospective shale gas basins, gas production will be an additional land use, adding to any or all of the other uses including urban development; extensive, irrigated or intensive production of food and fibre; energy production; water storage; roads, railways and pipelines; tourism; mining; manufacturing industry; production forestry; as well as conservation."

The SoE (2016) reports that the "greatest potential for negative impacts on biodiversity is not usually from individual mines but from cumulative impacts of extensive development in highly prospective regions or where diffuse exploration and development take place across large regions." As part of a priority threat management project across a CSG development area in Queensland, it was noted that the cumulative impact of vegetation loss, land degradation, development, invasive species and climate change is having a significant impact on the biodiversity of the Queensland Brigalow Belt.

In order to mitigate cumulative impacts ACOLA (2013) recommends that good bioregional planning and cumulative risk assessment are "absolutely fundamental matters that require priority attention." They also warn that, even though there is some flexibility with regard to the exact location of infrastructure that might lessen local impacts on threatened species, cumulative impacts may be more 'intractable'.

Climate change

One of the key findings of the SoE (2016) is that the cumulative impact of multiple pressures – changed fire regimes, invasive species, changed land use – have contributed to significant declines in Australian flora and fauna. These pressures are historical and ongoing. The global impacts of another key pressure, climate change, are increasing. Climate change generally exacerbates existing pressures and may ultimately alter ecosystem structure and composition, phenology, fire regimes and hydrology (SoE 2016). The future challenge will be to better understand the cumulative impacts of climate change and to mitigate them.

Lee *et al.* (2015) assessed the vulnerability to climate change of a sample of EPBC Act–listed species, including 44 species of birds, 43 species of mammals, 19 species of amphibians, 14 species of reptiles and 112 species of plants, for which there were known population trends. The authors found that nearly half of Australia's threatened species were ranked as moderately to highly vulnerable to climate change, with amphibians unsurprisingly being the most vulnerable. As is typical of extinction-prone species, those most susceptible to climate change those that are reliant on particular abiotic features, moisture or disturbance regimes or habitats (i.e. specialists) and/or have poor dispersal ability or low genetic variation. Furthermore, climate change vulnerability was shown to increase strongly with geographic range declines. While these characteristics would describe many of the threatened species in the NT, only a handful were actually analysed. Of these, only the Southern Marsupial Mole was considered to be highly vulnerable to climate change while the Purple-crowned Fairy-wren, Night Parrot, Mulgara, Red Goshawk and Partridge Pigeon were considered to have only a low vulnerability.

All jurisdictions reported adverse effects of climate change on biodiversity including extreme weather, bushfire, drought, cyclones and flood (SoE 2016). In the NT, it has been linked to severe pressures in coastal regions, especially floodplains, and to extensive dieback of mangroves.

Cumulative risk assessment

Eco Logical (2013) provides a framework for cumulative risk assessment methodology based on its experience working in the Namoi Catchment Management Area (Eco Logical 2011, 2012). The authors recommend that a modelling tool be developed in the early stages of shale gas development to assess cumulative impacts associated with new project approvals in the context of prior shale gas exploration and production impacts. The tool would require compilation of key environmental layers: MNES distribution/ models; vegetation type maps; landscape intactness and corridor layers; median surface flow of major rivers/channels; and groundwater aquifer data.

The risk associated with cumulative impacts could then be assessed according to critical thresholds which may lead to major and potentially irreversible impacts to affected ecosystems. Examples of thresholds that could be used included: IUCN threat categories; vegetation cover thresholds; critical habitat areas; contribution by shale gas development to surface water flow to nationally important wetlands; and contribution of shale gas development to groundwater extraction rates.

Eco Logical (2013) argues that this type of modelling would enable users to forecast the impact of future shale gas developments, may be useful in guiding approvals or in 'adjusting' the position or orientation of future proposals. In my opinion, modelling as described appears to be more concerned with 'shoehorning' more and more mines (and other land uses) into a given area and less about ensuring the protection and maintenance of ecosystem structure and function.

In my opinion, while this type of modelling may provide a reasonable approximation of reality within restricted and well-studied areas and or where the activity generates reliable and consistent data (e.g. erosion, water extraction), accurate data relating to distribution/abundance and to triggers/thresholds is sadly lacking for species, communities and ecosystems over most of Australia. I would argue that it would be very irresponsible and potentially catastrophic (in terms of extinction risk) to rely on modelling that uses incomplete, false and/or misleading data sets.

Eco Logical (2013) recommends that it would be 'prudent' for approval authorities to identify trigger and threshold values for the relevant bioregions and then to set commensurate triggers and threshold values for individual project assessments. ACOLA (2013) recognises that there is a paucity of baseline data available to assess cumulative impacts on biodiversity. The wider ecological community lists "lack of understanding of ecological processes, threatening processes and potential ecological thresholds or tipping points" as a major knowledge gap hindering effective management of biodiversity (SoE 2016). For NT threatened species, we do not know what the historical threatening processes were and, in many cases, are only guessing what threats or interactions between threats may be operating currently.

In NSW, where approximately 1500 vegetation communities are relatively well-understood and have been extensively mapped historically, the recent introduction of vegetation mapping based on modelling using a combination of satellite imagery, aerial and locally derived data has been shown to have little relation to the communities verified by ground-truthing. Hunter (2016) found that it was only 17% accurate for the Upper Hunter Region and therefore was "inherently unusable". If this type of data were used in cumulative impact modelling, it could have tragic and irreversible consequences for ecosystems.

It is my opinion that restricting cumulative impact assessment to MNES species only is overly restrictive and ignores the large number of significant species (and common species that could

become threatened in the future) that comprise biodiversity (Gaston & Fuller 2007, Gaston 2008). The topic of 'conservation triage' (i.e. abandoning some species to extinction) is hotly debated amongst scientists (Possingham *et al.* 2002, Parr *et al.* 2009, Jechowski & Kesler 2008, Gerber 2005, Bottrill *et al.* in press). However, from a conservation perspective, it may not be as useful to expend all conservation efforts in saving a few highly threatened species, as it would be to invest more effort into protecting iconic species that still occur over relatively large areas, and whose continued survival and/or range expansion could be measured as an indicator of ecosystem health (i.e. keystone species). The Bilby is one example of such a species; although it is threatened in NT, it is wide-ranging, undergoes large population fluctuations, is vulnerable to predation and does not occur in any reserves. Because bilby diggings are important in the restoration of soil and regrowth of vegetation, any increase in the population would have positive feed-back on NT arid lands. As a well-loved symbol of Easter for many Australians, success in restoring populations would be widely celebrated.

In the Northern Territory, the paucity of ecological data is of concern. The NT has not produced a SoE report since 2011. In addition the SoE (2016) report confirms that there is:

- No systematic remote monitoring of vegetation clearing currently exists (clearing has not been monitored since 2004);
- Very poor data for the density distribution of feral cats;
- No systematic remote monitoring of land-cover change in the Northern Territory;
- No standard methodology for assessing vegetation condition in the Northern Territory, and very limited systematic assessment and monitoring of vegetation condition; and
- Little or no information on conservation status of most invertebrate groups.

In my opinion, the critical thresholds against which cumulative risks would be compared are extreme. Apart from not having the appropriate data to derive these thresholds, I would suggest that there would have to be a cut-off point well before a 'tipping point' or critical threshold is reached in order to avert irreversible cascading effects. Once the tipping point is reached, it would be impossible to turn back. How far in advance of ecosystem collapse would such a decision to reject a development be made?

Given the paucity of available data, I would advise a more precautionary approach in terms of ecological conservation and bioregional planning, that is, the conservation of significant areas of contiguous habitat that support large assemblages of species and a wide variety of communities and ecosystems, rather than to prepare for ecosystem collapse with each project approval. Cumulative impact modelling may have a useful role to play if and when accurate ecological data becomes available and when applied to more localised areas outside an extensive, robust and resilient reserve system.

NO GO PRIORITY AREAS, MITIGATION AND OFFSETS

As part of their assessment of the ecological impacts of shale gas extraction in Australia, Eco Logical (2013) cautioned that there likely to be 'areas of extreme risk' (i.e. no go areas) due to the presence of key threatened species populations, places of scenic beauty or cultural significance or iconic wetlands. ACOLA (2013) also noted that, while current approaches may allow shale gas developments to co-exist with other land uses, 'no go' zones may need to be included. The authors also recommend that the shale gas industry should strive to achieve 'no net loss' of biodiversity.

Eco Logical (2013) recommended a framework be developed at the bioregional level to avoid, mitigate and offset impacts associated with shale gas extraction. The authors recommended the following mitigation measures to reduce the risk of habitat loss and fragmentation, loss of landscape function and increased incidence of wildfire:

- Avoidance of sensitive areas;
- Establishment of offsets (both ecosystem and threatened species);
- Land site rehabilitation (including top soil management);
- Inclusion of strategic buffers around rivers, streams, wetlands and other sensitive areas;
- Timing stipulations for construction activities;
- Co-location of pipelines;
- Full utilisation of established roads and tracks;
- Design of gas well network that minimises road length (and edge effects);
- Reclamation of temporary service tracks;
- Control feral animals and noxious weeds;
- Enforce speed limits and dawn/dusk driving curfews;
- Construct strategic underpasses and overpasses to facilitate fauna movement;
- Habitat augmentation (e.g. nest boxes);
- Establishment of fire breaks around the periphery of the production area.

I would argue that these mitigation measures are of a typical standard that we would expect to accompany any large development. While they may help to ameliorate impacts at a local scale, they will do very little to mitigate habitat fragmentation at the landscape scale.

In my opinion, the impacts and mitigation approaches have been oversimplified. Whereas habitat loss has been measured simply as cleared vegetation, in reality it extends into those areas that may still be vegetated but can no longer be utilised by particular species (i.e. due to microclimate, noise, disturbance, competition, predation, light spill, etc.). It is estimated that up to 20% of land in the US is affected by roads (Forman 2000). Road edge effects alone are usually assumed to extend 200 m but behavioural effects may be detected at even greater distances. Furthermore, the authors only appear to consider MNES or flora and fauna species of national significance in their assessments. In order to maintain ecosystem function and resilience, it is important to protect a wide diversity of species.

Furthermore, Trombulak & Frissell (2006) concluded that "it is unlikely that the consequences of roads will ever be completely mitigated or remedied". They recommend instead that it is critical to retain remaining roadless or near-roadless portions of the landscape in their natural state.

The SoE (2016) report provides the most recent evidence that our attempts to control invasive weeds and exotic pests are not working because there is no evidence that major pressures on biodiversity have decreased since 1996 and subsequently, the number of threatened species and ecological communities continues to rise. Not only is our knowledge about invasive species incomplete, we are not able to assess the long-term effectiveness of management actions on them.

In their review of Australian offset schemes, Hawdon *et al.* (2015) recommended that 'no go areas' and mitigation measures be established first, before considering offsets. The authors caution that offsets are the final step in the mitigation hierarchy (i.e. they apply to residual impacts only) and may not always be appropriate. It is generally recognised that offset schemes have not achieved the aim of 'no net loss' of biodiversity for various reasons including failure to consider 'like for like' or 'like for better' compensation, acceptance of payment in lieu of offsets or by approval of offsets that are not under threat (principle of additionality) or not conserved in perpetuity (double-dipping).

It should be noted that the Northern Territory does not have an offset scheme. It is unclear if Eco Logical (2013) is suggesting that offsets in relation to shale gas extraction be applied according to the EPBC offsets scheme (DSEWPAC 2012a). If so, then presumably only those impacts relating to nationally listed species would be offset. As the residual impacts of shale gas development are likely to be huge and to include the fragmentation and degradation of habitat utilised by assemblages of species at the landscape level, it is questionable whether or not an appropriate offsets package could be calculated using the EPBC offset scheme considering that it stipulates that "suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter" (DSEWPAC 2012a).

There is also a concern that, because offset assessments are undertaken on a case-by-case basis, this piecemeal approach would not result in a good conservation outcome for the many species potentially impacted. From a bioregional planning perspective, it would be much more proactive and precautionary to nominate priority no go areas prior to the development of shale gas fields; these would form the core conservation areas to which future additions, including offsets, can be made.

NO GO PRIORITY AREAS AND THE NATIONAL RESERVE SYSTEM

It is reasonable to assume that existing parks and reserves should form the cornerstone of any proposal for priority no go areas. In general, the infrastructure associated with large scale shale gas development is not compatible in areas where conservation management is a priority or in those areas containing significant scenic and/or cultural values. At an international scale, this would include World Heritage sites, global biodiversity hotspots and RAMSAR wetlands (see Attachment 3). Only two of these, Kakadu NP and Uluru-Kata Tjuta NP, fall in the Northern Territory.

Baker *et al.* (2015) have compared the level of protection for threatened flora and fauna species in reserves within NT bioregions (Tables 4-6). While these are predominantly government-managed reserves, they also include one Indigenous Protected Area (Dhimmuru) and one private reserve (Newhaven). Attachment 4 shows that NT reserves are restricted in their size and coverage and are unlikely to adequately protect biodiversity in the regions subject to shale gas mining. In fact:

- Central Arnhem, Channel Country and Tanami Bioregions have no reserves whereas Finke, Mitchell Grass Downs and Sturt Plateau Bioregions have <1% of their areas reserved (Tables 4 & 5).
- Most bioregions have significant flora species that are not protected in reserves; Finke Bioregion has 26 significant flora species (2 threatened) and 4 significant fauna species (1 threatened) that are not protected in any reserves (Table 4).
- None of the broad vegetation types are reserved in Central Arnhem, Channel Country and Tanami Bioregions (Table 6).
- The following significant species are not found in (or not known to occur in) any reserves: *Minuria tridens, Austrobryonia argillicola, Eleocharis papillose, Schoenus centralis, Acacia latzi, Endiandra limnophila* and *Sporobolus latzii* (see Table 2).
- Only 0.9% of hummock grassland is reserved in NT. This habitat type is utilised by many threatened species including: Bilby, Mulgara, Great Desert Skink, Central Rock-rat, Night Parrot, Long-tailed Dunnart, Sandhill Dunnart, Carpentarian Grasswren and Gouldian Finch (Table 6).
- Although the Bilby occurs in numerous bioregions, it is not known to occur in reserves in the Great Sandy Desert, Mitchell Grass Downs, Ord Victoria Plain, Sturt Plateau or Tanami (Table 5).

Woinarski *et al.* (1992, 2010; in 2014) claim that even the largest conservation reserves are inadequate for the maintenance of some ecological and evolutionary processes, and for highly dispersive species. There has also been a marked decline in the native mammal fauna of 20,000 km^2 Kakadu NP (Woinarski 2001, 2010; in 2014). By surrounding existing reserves in a matrix of shale gas infrastructure, we can expect a continuation and even an acceleration of extinctions (i.e. cascading effects).

Large reserves are increasingly being recognised to be a cornerstone for biodiversity conservation, especially in the era of climate change (Woinarski *et al.* 2014). We can expect larger reserves to support more species, to contain more interior habitat and to be more resilient. This approach is in keeping with the Australian Government's initiatives, the National Reserve System (NRS) and National Wildlife Corridors Plan (2012). The NRS is Australia's network of protected areas; it aims to protect 17% of bioregions in Australia by 2020.

The National Wildlife Corridors Plan represents a shift away from protecting large representative ecosystems through formal reservation and management, to retaining, restoring and facilitating active management of corridors and other landscape features through public and private lands (DSEWPAC 2012b). It demonstrates the Australian government's focus on improving ecosystem resilience and connecting fragmented landscapes. According to DSEWPAC (2012b), wildlife corridors are "the most effective tools available for conserving biodiversity and preparing landscapes for climate change" because they can:

- Insure against climatic uncertainty by conserving a diversity of species;
- Provide alternative pathways for species' movement and adaptation; and
- Create and protect natural stores of carbon in the environment.

Corridor management involves not only improving landscape and habitat connectivity in the short- to medium-term but also ensuring ecological and evolutionary connectivity in the long-term.

This type of management is also consistent with the guiding principles for mitigating the decline of species and species assemblages in modified landscapes (Lindenmayer & Fischer 2006):

- Maintain and/or restore large and structurally complex patches of native vegetation;
- Maintain and/or restore a matrix that is structurally similar to native vegetation;
- Maintain and/or restore buffers around sensitive areas;
- Maintain and/or restore corridors and stepping stones; and
- Maintain and/or restore landscape heterogeneity and capture environmental gradients.

Ecologist John Woinarski, author of the Outback Papers, believes that the Australian outback should be classified and protected as one landscape (http://www.smh.com.au/technology/sci-tech/think-of-outback-as-one-huge-landscape-says-top-ecologist-john-woinarski-20141014-115qd5.html). Woinarski *et al.* (2014) point out that corridor networks across extensive landscapes provide an opportunity to maintain significant conservation values on lands that are not formally part of the reserve system. Towards this end, South Australia and Northern Territory have collaborated towards the Trans-Australia Eco-Link (Attachment 5), a wildlife corridor extending 3500 kms from Port Augusta to Arnhem Land. This conservation initiative will benefit many of the NT's threatened flora and fauna species and will incidentally protect a greater proportion of NT's broad community types that are poorly represented in existing reserves.

TOWARDS A NO GO PRIORITY ZONE IN NT

In adopting a landscape approach to conservation, the NT has vastly increased the number and extent of non-government reserves and IPAs. Indigenous Protection Areas are sites on Aboriginal-owned land subject to a non-binding agreement between traditional owners and the Commonwealth relating to meeting management and conservation objectives (http://155.187.2.69/biodiversity/wildlife-corridors/publications/pubs/national-wildlife-corridors-plan.pdf). There are currently 75 dedicated IPAs; most of these are shown in relation to other protected areas Australia-wide as at 2015 in Attachment 6.

The integration of IPAs and land acquired by the Australian Wildlife Conservancy (23 sanctuaries comprising ~3 million ha) and Bush Heritage Australia (35 sanctuaries totalling ~1 million ha) has augmented the percentage of each bioregion that is currently reserved (see Tables 4 and 5): Tanami Bioregion increased from 0 to 25-50%; Great Sandy Desert increased from 3.97% to 10-25%; and both Central Arnhem and Channel Country increased from 0 to 5-10%.

The total number of hectares covered by all conservation reserves and IPAs in the NT during 2014 is shown in Table 7. Whereas the total area of terrestrial reserves (excluding IPAs) is more than 25 million ha, the total area including IPAs comes to almost 135 million ha. Applying a precautionary approach, in light of the paucity of ecological data and the unknown threat of climate change, existing reserves together with declared IPAs should form the basis of a priority no go zone for the shale gas industry in NT, subject to appropriate consultation with, and agreement from, traditional owners and in accordance with any existing statutory requirements.

Because management of IPAs promotes a balance between conservation and other sustainable uses to deliver social and economic benefits for local Indigenous communities it would appear to be compatible with management of existing reserves for conservation, heritage and coastal protection. It would not appear to be compatible with construction of an ever-expanding network of roads and pipelines and the installation of industrial sites and associated disturbance.

The dedication of the existing reserves and dedicated IPAs is a first step in creating an extensive, robust and resilient reserve. It is in keeping with government initiatives at the Federal (the NRS and National Wildlife Corridors Plan) and state (Trans-Australia Eco-link) to manage extensive corridors to protect a wide diversity of species, to ensure ecosystem function and to improve resilience from the threat of climate change.

In my opinion, the infrastructure associated with shale gas infrastructure is not consistent with the conservation results expected from the Trans-Australia Eco-Link, namely:

- To incorporate local conservation priorities into land management and decision-making;
- To increase opportunities for indigenous and pastoral community involvement in natural resource management;
- To develop innovative conservation tools and incentives for private landholders; and
- To increase protected areas.

The priority no go zone should act as a core conservation area which will be augmented in future in line with the broad aims of the NRS and Trans-Australia Eco-Link. Woinarski *et al.* (2014) suggest that this can be achieved through various options, including:

- Excision of part of existing leasehold lands;
- Buy-out of non-viable pastoral properties; and
- Volunteer land-for-wildlife or other conservation schemes.

The acquisition and/or transfer of land to form part of the NRS corridor should be considered as part of the suite of mitigation measures and 'offsets' aimed at ameliorating residual impacts associated with individuals shale gas extraction projects. It may be more practical for the shale gas industry to address this issue directly through land acquisition and/or negotiation with landholders, rather than through the EPBC offsets scheme, which is overly restrictive in considering only nationally significant species. A future aim should be to augment the NRS with productive lands that are underrepresented in the reserve system.

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Outback Papers:
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NT threatened fauna:
https://nt.gov.au/environment/animals/threatened-animals

NT threatened fauna:
https://nt.gov.au/environment/native-plants/threatened-plants

Declared Indigenous Protected Areas:
http://environment.gov.au/indigenous/ipa/declared/index.html

Map of Indigenous Protected Areas:
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NT Terrestrial Protected Areas:
http://www.environment.gov.au/land/nrs/science/capad/2014

Trans-Australia Eco-Link:
http://www.environment.sa.gov.au/files/dac142cc-2f26-4a40-8863-a0e300f3b5ce/Trans-Australia_Eco-link_Brochure.pdf

Table 1: Comparison of management issues across NT bioregions in arid to semi-arid rangelands that are most likely to be affected by shale gas extraction (from Baker et al. 2005).

Bioregion	Basin	Proportion cleared	Proportion burnt over 7 yrs	% Exotic weeds	# mammal spp extinct	Fauna pests
Central Arnhem	McArthur	<1%	28.9-40.4	6-9	1	9; cats widespread but low densities; dogs widespread but uncommon; cane toads recently established
Channel Country	Cooper	<1%	5.3-13.2	3-6	5	6; cats widespread but low densities; dogs widespread but uncommon; foxes serious pest
Davenport Murchison Ranges	Georgina Basin	<1%	5.3-13.2	6-9	12	8; cats widespread but low densities; dogs widespread but low densities; foxes widespread but low densities
Finke	Amadeus	<1%	1.4-5.3	12-15	25	8; cats widespread and common; dogs widespread and uncommon; fox serious pest
Great Sandy Desert	Canning	<1%	5.3-13.2	3-6	22	8; cats widespread and common; dogs widespread and uncommon; fox serious pest
Gulf Fall and Uplands	McArthur	<1%	17.8-28.9	3-6	4	7; cats widespread but low densities; dogs widespread but uncommon; cane toads recently established
MacDonnell Ranges	Amadeus	<1%	1.4-5.3	12-15	19	16; cats widespread but low densities; dogs widespread but uncommon; foxes serious pest
Mitchell Grass Downs	Georgina	<1%	0.1-1.4	3-6	5	6; cats widespread and common; dogs widespread and uncommon; fox roadkills recorded
Ord Victoria Plain	Canning	<1%	13.2-17.8	6-9	3	9; cats widespread but low densities; dogs widespread and uncommon; cane toads likely to soon establish
Sturt Plateau	Beetaloo & McArthur	<1%	17.8-28.9	6-9	4	8; cats widespread but low densities; dogs widespread and uncommon; foxes gradually increasing; cane toads recently established
Tanami	Canning & Georgina	<1%	13.2-17.8	3-6	13	8; cats serious pest; dogs widespread and uncommon; foxes serious pest

Table 2: Threatened flora species recorded in NT Bioregions containing arid to semi-arid rangelands most likely to be affected by shale gas extraction.

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
Apiaceae	Desert Flannel Flower *Actinotus schwarzii*	MacDonnell Ranges Occurs only in this bioregion, restricted to <20km²	V (TPWC), V(EPBC)	Exotic perennial grass invasion, inappropriate fire regimes, disrupted gene flow, climate change and natural enemies (predators and pathogens); flower picking and seed collection are a threat.	Occurs in soil pockets in sheltered gorges on steep south facing precipitous cliffs	West Macdonnell NP
Arecaceae	Central Australian Cabbage Palm *Livistona mariae mariae*	MacDonnell Ranges restricted to an area of <60km²	V (TPWC), V(EPBC)	Exotic grass invasion; fire; tourism and stock impacts; ground water depletion; and climate change.	Restricted to Finke River and tributaries. Dependent on perennial groundwater seepages	Finke Gorge NP
Asteraceae	*Olearia macdonnellensis*	MacDonnell Ranges	V (TPWC), V(EPBC)	Exotic grass invasion; fire; tourism and stock impacts; ground water depletion; and climate change.	Occurs in only one valley in the Heavitree ranges, in gullies and drainage lines and at the base of slopes. Requires fire protected habitat and likely requires light for germination.	West Macdonnell NP
Asteraceae	Minnie Daisy *Minuria tridens*	MacDonnell Ranges	V(TPWC) V(EPBC)	Exotic grass invasion; fire; tourism and stock impacts; ground water depletion; and climate change.	Several scattered populations on south-facing slopes of dolomite, limestone and calcrete impregnated	None

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
					sandstone hills and ranges.	
Cucurbitaceae	*Austrobryonia argillicola* (formerly Mukia A90788 Tobermorey Station)	Mitchell Grass Downs	V(TPWC)	Preferred habitat of this species is favoured by stock and feral animals; pastoral and infrastructure (e.g. road and seismic lines)	Occurs along creeks and in poorly drained areas on cracking clay plains. It has been recorded from Bluebush swamps Gidgee shrubland and riparian woodlands dominated by *Eucalyptus camaldulensis*.	None
Cycadaceae	*Cycas armstrongii*	Sturt Plateau *	V(TPWC)	Species habitat is also preferred horticultural and agricultural land subject to development pressure; introduced competition from exotic grasses; changed fire regimes	It occurs mainly in open grassy woodland on yellow and red earths, limited in the area by drainage.	Berry Springs Nature Park; Blackmore River CR; Casuarina Coastal Reserve; Djukbinj NP, Garig Gunak Barlu NP; Holmes Jungle Nature Park; Howard Springs Nature Park; Howard Springs Hunting Reserve; Kakadu NP; Litchfield NP; Manton Dam Recreation Area
Cyperaceae	*Baumea arthrophylla*	MacDonnell Ranges Known from a single population	Endangered (TPWC)	Vulnerable to stochastic events including fire, groundwater depletion, climate change	Occurs in a seepage area amongst rocks in a sandstone gorge.	Watarrka National Park.

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
Cyperaceae	*Bolboschoenus caldwellii*	Channel Country * MacDonnell Ranges >50 known mature plants	Endangered (TPWC)	Competition from couch grass is an identified threat. Habitat degradation by stock may also be a threat.	Occurs in damp soils adjacent to permanent or semi-permanent water.	Finke Gorge National Park but may now be extinct there
Cyperaceae	*Carex fascicularis*	MacDonnell Ranges In the NT known only from a single population, consisting of only a few plants in	V(TPWC) Listed 2012	Highly vulnerable to the effects of stochastic processes, Invasion by exotic grasses, increased fire occurrence.	Swampy areas - permanent water around a permanent spring in the Chewings Ranges	West MacDonnell Ranges National Park
Cyperaceae	Dwarf Desert Spike Rush *Eleocharis papillose*	Finke Great Sandy Desert MacDonnell Ranges Tanami Known from just eight locations across the NT, highly fragmented.	V(EPBC), V(TPWC)	Invasion by couch grass is the main threat and may have already eliminated the species at two locations. Changed hydrological conditions may affect some subpopulations. Degradation of habitat by cattle	All records are from temporary wetlands; predominantly freshwater and semi-saline swamps. One record is from the edge of a temporary riverine waterhole.	None
Cyperaceae	*Schoenus centralis*	Great Sandy Desert MacDonnell Ranges	V(TPWC) Listed after 2005 report	Invasive exotic grasses, grazing and trampling by livestock	Occurs around sheltered seepage areas or springs associated with range systems.	Not known
Euphorbiacea e	*Amperea spicata*	MacDonnell Ranges Recorded from two places 10 kms apart	V(TPWC)	Stochastic events such as disease, an extended drought due to climate change or catastrophic fire; Invasive exotic grasses	In rock crevices on sheltered sandstone cliffs along gorges.	Watarrka National Park

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
Euphorbiaceae	Glory of the Centre *Ricinocarpos gloria-medii*	MacDonnell Ranges	V(EPBC), NT(TPWC)	None known	Occurs in deep gullies and well-shaded areas on south facing slopes of quartzite or sandstone hills.	N'Dhala Gorge Nature Park; Trephina Gorge Nature Park; West MacDonnell National Park.
Fabaceae	Latz Wattle, Tjilpi Acacia latzi	Finke Restricted to 2 areas 200 km apart	V(EPBC), V(TPWC)	Stochastic events, competition and Increased fire exposure from Buffel grass invasion.	Silcrete-capped mesas and low stony hills derived from mainly shale and siltstone.	None
Fabaceae	Sickle Leaf Wattle, Undoolya Wattle *Acacia undoolyana*	MacDonnell Ranges	V(EPBC), V(TPWC)	Buffel grass invasion, climate change leading to increased fire frequency, more C4 grass competition	Confined to sandstone and quartzite ranges where it is closely associated with steep, south facing outcropping slopes and gullies	N'Dhala Gorge Nature Park.
Goodeniaceae	*Goodenia quadrifida*	Gulf Fall and Uplands	V(EPBC)	Data Deficient	Data Deficient	Data Deficient but may occur in Mary National Park
Lamiaceae	*Prostanthera schultzii* (formerly *Wrixonia schultzii*)	MacDonnell Ranges	V(TPWC) V(EPBC)	No known extant threats. May be vulnerable to stochastic events	Occurs on shady, upper slopes and tops of quartzite mountains and ranges, particularly on southerly aspects. It grows in shallow soils.	West MacDonnell National Park
Lauraceae	*Endiandra limnophila*	Gulf Fall and Uplands *	V(TPWC)	A small population and restricted distribution makes this species susceptible to stochastic	Grows in well-developed rainforest. It is normally found on swampy or wet	None

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
				events; feral pigs may affect recruitment	situations along creek margins.	
Myoporaceae	Rainbow Valley Fushia Bush *Eremophila prostrata*	Finke MacDonnell Ranges	V(EPBC), NT(TPWC)	None known	Occurs on sandplains and lower dune slopes that characteristically support hummock grasses, Hakea Grevillea, Acacia, and Desert Oaks. Populations are concentrated near the base of rocky ranges.	Rainbow Valley Conservation Reserve
Myrtaceae	Palm Valley Myrtle *Thryptomene hexandra*	MacDonnell Ranges	V(EPBC)	Data Deficient	Occurs in deep slot gorges and sheltered south facing aspects of steep sandstone ranges.	Finke Gorge NP
Poaceae	*Sporobolus latzii*	Davenport Murchison Ranges	V(TPWC) *	Buffel Grass invasion; possible impacts from nearby phosphate mine	Known only from the type locality in the Wakaya Desert. Discovered in 1993. Occurs in clay soil on the edge of a Coolabah-fringed seasonal swamp.	None
Poaceae	*Triodia fitzgeraldii* (formerly *Triodia* sp. Matt Wilson.)	Ord Victoria Plain	V(TPWC)	Susceptible to stochastic events. Possibly a poor competitor with other Poa species.	Occupies the rocky cliff top at the edge of a laterite plateau and the upper 20 metres or so of scree slope.	Gregory NP

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
Pteridaceae	Venus Hair Fern *Adiantum capillus-veneris*	MacDonnell Ranges Ord Victoria Plain Known from two very disjunct sites in the NT	V(TPWC)	Climate change	Grows on limestone or sandstone rock, or on alkaline soils. In the Chewings Range the species grows in quartzite rock crevices in deep sheltered gorges where the root zone is fed by permanent streams or seepage	Gregory NP; West MacDonnell NP
Santalaceae	Desert Quandong *Santalum acuminatum*	MacDonnell Ranges	V(TPWC)	Wildfires; introduced herbivores, particularly camels may kill adult plants, resprouts and seedlings; timber is sought after for carving.	Occurs in southern NT but most populations have few plants, with likely high clonality. Watarrka NP has the largest population. It occurs in dune swales, along creeks, on plains and low rises, and rarely on hills. It typically occurs in areas where the soils are sandy or loamy, sometimes with limestone or sandstone shallowly below the soil surface.	Watarrka NP; Uluru-Kata Tjuta NP.
Zamiaceae	MacDonnell Ranges Cycad *Macrozamia macdonnellii*	MacDonnell Ranges	V(EPBC) NT(TPWC)	Illegal collection of seed for the horticultural industry is a known threat to accessible populations. An	It occurs on rocky sites, predominantly in gorges and on steep sheltered slopes but	Alice Springs Telegraph Station Historic Reserve; Arltunga Historic

Threatened flora family	Threatened flora species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	Habitat requirements	Reported in protected areas?
				increasingly arid climate may be a threat.	occasionally on exposed hills or mountain tops.	Reserve; Finke Gorge NP, Ruby Gap Nature Park; Watarrka NP; West MacDonnell NP.

Notes*:

Arenga australasica — Central Arnhem
Appears as V(EPBC) in 2005 report however delisted from EPBC in 2013

Bolboschoenus caldwellii - Channel Country
2005 report lists species in Channel Country however the species location in Channel Country is not shown in https://nt.gov.au/environment/native-plants/threatened-plants accessed Apr2017

Sporobolus latzii - Davenport Murchison Ranges
Listed as Vulnerable in NT after 2005 report

Endiandra limnophila - Gulf Fall and Uplands
Baker et al. (2005) lists species in Gulf Fall and Uplands however the species location in Gulf Fall and Uplands is not shown in https://nt.gov.au/environment/native-plants/threatened-plants accessed Apr2017

Solanum carduiforme- Gulf Fall and Uplands
Appears as V(EPBC) in 2005 report Delisted from EPBC in 2013

Thryptomene hexandra - MacDonnell Ranges
V(EPBC), NT(TPWC)
Info on listing fromhttp://eflora.nt.gov.au/factsheet?id=22429

Cycas armstrongii -Sturt Plateau *
2005 report lists species in Sturt Plateau however the species location in Sturt Plateau is not shown in https://nt.gov.au/environment/native-plants/threatened-plants accessed Apr2017

Table 3: Threatened terrestrial fauna species recorded in NT Bioregions containing arid to semi-arid rangelands most likely to be affected by shale gas extraction.

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Partridge Pigeon	Arnhem Central	V(EPBC), NT(TPWC) Unknown population size	Predation by feral cats; drought (requires water daily); changes in grass composition and fire regimes; invasion by exotic grasses; fewer but more extensive fires with exotic grasses adding to fuel load; change in vegetation composition due to grazing	n/a	Lowland eucapyt open forests and woodlands with grassy understoreys; feeds on seeds of grass, Acacia and other woody plants; nests in dense grass; nests and feeds on the ground	Blackmore River CR; Butterfly Gorge Nature Park; Garig Gunak Barlu NP; Gregory NP; Kakadu NP; Litchfield NP; Mary River NP; Nitmiluk NP; Territory Wildlife Park/Berry Springs Nature Park; Tjuwaliyn (Douglas) Hot Springs Park; Umbrawara Gorge Nature Park
Emu	Arnhem Central Channel Country Davenport Murchison Ranges Finke Great Sandy Desert Gulf Fall & Uplands MacDonnell Ranges Mitchell Grass Downs Ord Victoria Plain Sturt Plateau Tanami	V (TPWC)	No data available at https://nt.gov.au/environment/animals/threatened-animals	n/a		
Bilby	Channel Country Great Sandy Desert[NR] Mitchell Grass	V (TPWC), V(EPBC) Declining	Predation by fox, cat, dingo; competition with rabbits; grazing by cattle; unsuitable	Yes	Sandy soils dominated by hummock grasslands covered mainly by 3 spp	None; used to occur in Uluru Kata-Tjuta NP; Watarrka NP and West MacDonnell NP;

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
	Downs[NR] Ord Victoria Plain[NR] Sturt Plateau[NR] Tanami[NR]	population <10,000	fire regimes		of Spinifex and low shrub cover; prefer laterite and drainage line land systems	declining population estimated at <10,000
Mulgara	Channel Country Davenport Murchison Ranges Finke Great Sandy Desert MacDonnell Ranges Tanami	V (TPWC), V(EPBC) Declining population <10,000	Unknown; possibly habitat degradation and homogenisation; change in fire regimes; grazing; predation	Yes	Mature hummock grasslands of Spinifex; better watered areas such as paleodrainage systems or drainage lines in sandplains or sand dunes	Uluru-Kata Tjuta NP; declining population estimated at <10,000
Australian Bustard	Arnhem Central Davenport Murchison Ranges Finke Great Sandy Desert Gulf Fall & Uplands MacDonnell Ranges Mitchell Grass Downs Ord Victoria Plain Sturt Plateau Tanami	V(TPWC) Considered NT(TPWC) at http://www.ala.org.au/	No data available at https://nt.gov.au/environment/animals/threatened-animals	n/a		

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Black-footed Rock Wallaby	Davenport Murchison Ranges Finke Great Sandy Desert MacDonnell Ranges Tanami	V (EPBC), NT(TPWC) No population estimate	Predation by fox and cat; habitat degradation caused by grazing; foxes have played major role in decline	Yes	Rocky outcrops and associated steep rocky slopes; grassy areas	Alice Springs Telegraph Station Historical Reserve; Arltunga Historical Reserve; Davenport Range NP; Emily and Jessie Gap Nature Park; Finke Gorge NP; Kuyunba CR; Ruby Gap Nature Park; Trephina Gorge Nature Park; Watarrka NP; West MacDonnell NP
Great Desert Skink	Finke* Great Sandy Desert Tanami	V(EPBC), V(TPWC) Declining <10,000	No single factor identified; habitat homogenisation; intense wildfires; predation by cats and foxes; rabbits may dig up burrows	n/a	Sand plains and adjacent swales that support hummock grassland and scattered shrubs; paleodrainage lines on lateritic soils supporting Melaleuca	Uluru-Kata Tjuta NP, Watarrka NP and Newhaven Reserve (managed for conservation)
Slater's Egernia	Finke Great Sandy Desert MacDonnell Ranges	E(EPBC), E(TPWC) No estimate	None identified; degradation of alluvial habitat due to invasion by Buffel Grass	n/a	Little known; shrubland and open shrubland on alluvial soils close to drainage lines; minor drainages in stony hills	Finke Gorge NP; Owen Springs Reserve; West MacDonnell NP; Henbury Station and Illamurta Springs CR
Australian Painted Snipe	Finke Gulf Fall & Uplands MacDonnell Ranges Mitchell Grass Downs Sturt Plateau Tanami	V(EPBC), V(TPWC) Declining <10,000	Wetland drainage; degradation of habitat by cattle	n/a	Shallow, vegetated freshwater swamps, claypans or inundated grasslands; feeds on mudflats; no known resident populations	Kakadu NP

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Princess Parrot	Finke Great Sandy Desert MacDonnell Ranges Tanami	V(EPBC), V(TPWC) *Breeding population <5000*	None identified; possibly habitat degradation and homogenisation; grazing by rabbits and introduced herbivores; changed fire regimes; camels; raiding of nests	n/a	Swales between sand dunes with shrubs such as *Eremophila*, *Grevillea* and *Hakea*; riverine forest, woodland or shrubland; hollows in large eucalypts especially River Red Gums and desert oaks; diet mainly seeds	Uluru Kata Tjuta NP; West Macdonnell NP (1 record)
Central Rock-rat	Finke* MacDonnell Ranges	E(EPBC), E(TPWC) *>70% decline in last 10 yrs*	None identified; likely to be predation by dingoes and cats; inappropriate fire regimes	Yes	Tussock and hummock grasslands and low open woodland on ridge tops, cliffs, scree slopes, hills and valley floors; high altitude rugged quartzite peaks; granivorous	West MacDonnell NP; formerly occurred in Uluru-Kata Tjuta NP
Fawn Hopping Mouse	Finke* Great Sandy Desert*	E(TPWC) *Possibly extinct in NT*	Unknown; habitat degradation; predation by introduced carnivores; competition with introduced herbivores	Yes	Gibber-dwelling; granivorous;	Uluru Kata Tjuta NP (unconfirmed)
Kowari	Finke[NR]	V(EPBC), DD(TPWC) *Possibly extinct in NT*	Unknown; introduced herbivores reduce cover and food; predation by cats and foxes; roads and tracks; road mortality	Yes	Gibber patches among grasslands, sand dunes and river channels; feed on invertebrates and small vertebrates	None

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Southern Marsupial Mole	Finke Great Sandy Desert MacDonnell Ranges Tanami	E(EPBC), V(TPWC) *Declining <10,000*	Very little known; predation by cats, foxes and dingoes; soil compaction by stock or vehicles; altered fire regimes and grazing	Yes	Sandy deserts in dunes, sandy plains and river flats; require soft sand; feed on invertebrates and small vertebrates	Uluru Kata Tjuta NP; Watarrka NP
Night Parrot	Great Sandy Desert* Tanami	E(EPBC), CR(TPWC) *Possibly extinct in NT*	Habitat alteration due to altered fire regimes, grazing and predation by introduced predators	n/a	Nocturnal ground forager; Spinifex grasslands in stony or sandy areas and samphire and chenopod associations in floodplains salt lakes and claypans; nests in Spinifex hummocks; may prefer mature Spinifex that is long unburnt; granivorous	None; may be extinct in NT
Long-tailed Dunnart	Great Sandy Desert MacDonnell Ranges	V(TPWC) *Population <1000*	Unknown; possibly inappropriate fire regimes, alteration of habitat due to introduced herbivores or invasion by Buffel Grass; predation by introduced predators	No	Specialist rock-dwelling species; rugged rocky landscape supporting low open woodland or shrubland of Acacia (especially Mulga) and an understorey of Spinifex hummocks; feeds on invertebrates	West MacDonnell NP
Sandhill Dunnart	Great Sandy Desert	E(EPBC), DD(TPWC) *Possibly*	Inappropriate fire regimes and clearing for agriculture; predation by cats and foxes	Yes	Sand ridges covered in hummock grassland with groves of desert oaks; prefers large mature	None

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
		extinct in NT			Spinifex clumps for nesting; insectivorous	
Carpentarian Grasswren	Gulf Fall & Uplands	E(TPWC) *Declining; severely fragmented population*	Inappropriate fire regimes affecting food availability (seeds) and nest sites;	n/a	Restricted to sandstone outcrops within the Carpentarian and Adelaidean Systems of the Gulf of Carpentaria; utilize mature stands of Spinifex; nest within Spinifex clumps	Caranbirini CR
Gouldian Finch	Gulf Fall & Uplands Ord Victoria Plain Sturt Plateau	E(EPBC), E(TPWC) *>1000; sex ratio strongly biased; high degree of instability*	Parasitic mite; trapping; pastoral grazing; alteration of food availability due to understorey vegetation being altered by pastoral activities, fire regimes	n/a	In dry season occupy wooded hills containing snappy or salmon gums and forage for seeds on the ground; in wet season found in lowland drainages where they feed on seeds of soft Spinifex, cockatoo grass and golden beard grass;	Caranbarini CR; Judbarra/Gregory NP; Kakadu NP; Limmen NP; Nitmiluk NP
Northern Crested Shrike-tit	Arnhem Central Gulf Fall & Uplands Ord Victoria Plain Sturt Plateau	V(EPBC), DD(TPWC) *Paucity of records; <2500*	Unclear; habitat quality affected by fire or grazing (density of large trees, prey densities); patchy distribution makes this sp particularly susceptible to fragmentation in areas of extensive land clearing	n/a	Eucalypt and Melaleuca woodlands from relatively wet areas to semi-arid woodlands; insectivorous; forage in foliage, under bark, in dead wood	Elsey NP; Kakadu NP; Nitmiluk NP

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Purple-crowed Fairy-wren	Gulf Fall & Uplands Ord Victoria Plain Sturt Plateau	V(EPBC), NT(TPWC) *<5000; cane grass habitat highly fragmented*	Degradation or loss of habitat; livestock trampling riparian veg; more frequent or more intense fires; trampling in combination with predation by cats; flood in combination with habitat degradation; heavy weed infestation; nest predation by rats	n/a	Thick riparian vegetation, particularly of cane grass and/or pandanus or patchy shrubs up to 3 m; breed in crown of pandanus or thick clumps of cane grass	Judbarra/Gregory NP
Red Goshawk	Gulf Fall & Uplands Sturt Plateau Tanami	V(EPBC), V(TPWC) *~330 (1/3 of total population)*	Tall open eucalypt forest and riparian areas, including paperbark and gallery forests; nests in large trees near water	n/a	Habitat clearing for agriculture and forestry; egg collection, shooting and fire;	Garig Gunak Barlu NP; Kakadu NP; Litchfield NP; Nitmiluk NP
Brush-tailed Rabbit-rat	Gulf Fall & Uplands	V(TPWC) *No estimate; >50% decline during last 10 years*	No one factor; predation by feral cats; habitat alteration due to fire, grazing, weeds and feral animals may have affected food availability; hot fires may have limited availability of hollows, hollow logs, tall fruit-bearing understorey shrubs or grass species	Yes	Eucalypt tall open forest to coastal grasslands with scattered Casuarinas; shelters in tree hollows, in hollow logs or in crowns of pandanus or sand-palms; forages for seeds, fruits and invertebrates on ground or arboreally	Garig Gunak Barlu NP; Kakadu NP

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Carpentarian Rock-rat	Gulf Fall & Uplands[NR]	E(EPBC), CR(TPWC) *<2000; all records within a radius of 35 kms*	Extremely limited range; dependence on core monsoon rainforest; fire and grazing that degrades rainforest habitat; impact of cats unknown	Yes	Sandstone gorges and escarpments containing a wet or dry core of rainforest, mixed with broadleaf woodland, scree slopes and permanent water, surrounded by savanna woodland; feeds on large fleshy fruits and seeds	None
Northern Quoll	Gulf Fall & Uplands	V(TPWC) *Possibly extinct; >80% decline in 10 years*	Declining for decades possibly due to feral cats, disease or changed fire regimes; cane toads pose a catastrophic threat (quolls are particularly susceptible to their poison)	Yes	Rocky areas, open eucalypt forest; dens in hollow logs, rock crevices, caves and tree hollow; generalist predator foraging mainly on ground;	Berry Springs NP; Black Jungle CR; Charles Darwin NP; Fogg Dam CR, Garig Gunak Barlu NP; Howard Springs Nature Park; Kakadu NP; Leaning Tree Lagoon, Limmen NP, Litchfield NP; Manton Dam Recreation Area; Mary River NP; Nitmiluk NP; Tjuwaliyn (Douglas) Hot Springs Park; Umbrawara Gorge Nature Park
Common Brushtail Possum	MacDonnell Ranges Mitchell Grass Downs Tanami	E(EPBC) *Unknown; declining; severely fragmented*	Interaction between severe drought and homogenisation of habitat by herbivores, hunting near aboriginal settlements (and historically), altered fire regimes and predation	Yes	Riverine habitat close to rocky outcrops and moist gullies within ranges or rocky slopes; diverse associations of fire-sensitive plant species	West MacDonnell NP; Ruby Gap Nature Park; Uluru-Kata Tjuta NP

Threatened fauna species	Extant in bioregion (reserved?)	Conservation significance	Threatening processes	CWR?	Habitat requirements	Reported in protected areas?
Masked Owl	Mitchell Grass Downs Tanami	V(EPBC), NT(TPWC) *Declining; <10,000*	No reliable data; possible decline in abundance of small-medium prey species due to changed fire regimes; increased cover and height of exotic grasses may hinder hunting efficiency; intense and frequent fire may reduce availability of large trees and hollows	n/a	Eucalypt tall forests especially those dominated by Darwin woollybutt and Darwin stringybark; roosts in monsoon rainforest; forages in open habitat types including grassland; roosts and nests in tree hollows; feeds on mammals	Garig Gunak Barlu NP, Judbarra / Gregory NP, Kakadu NP, Keep River NP;Nitmiluk NP; declining population less than 10,000

Table 4: Comparison of flora conservation values across NT bioregions containing arid to semi-arid rangelands most likely to be affected by shale gas extraction (from Baker *et al*. 2005).

Bioregion	Basin	% reserved* (# reserves)	% reserved[#] (Woinarski *et al*. 2014)	# significant spp[1]	# significant spp not reserved	# threatened spp	# threatened spp not reserved
Central Arnhem	McArthur	0% (0)	5-10%	11	10	1 (1N)	0
Channel Country	Cooper	0% (0)	5-10%	3	2	2 (2S)	1
Davenport Murchison Ranges	Georgina Basin	2% (5)	1-5%	1	0	0	N/A
Finke	Amadeus	0.04% (6)	5-10%	28	26	3 (2N, 3S)	2
Great Sandy Desert	Canning	3.97% (2)	10-25%	16	9	1 (1S)	1
Gulf Fall and Uplands	McArthur	8.44% (3)	5-10%	26	16	3 (2N, 1S)	0
MacDonnell Ranges	Amadeus	13.7% (21)	10-25%	86	14	14 (9N, 14S)	0
Mitchell Grass Downs	Georgina	0.60% (3)	1-5%	14	11	1 (1S)	1
Ord Victoria Plain	Canning	7.99% (1)	10-25%	29	21	2 (2S)	0
Sturt Plateau	Beetaloo & McArthur	0.21% (3)	<1%	5	3	1 (1S)	0
Tanami	Canning & Georgina	0% (0)	25-50%	20	19	1 (1S)	0

[1] threatened, endemic, area restricted

* National Parks, Conservation Reserves, Historical Reserves, 2 parks managed by Parks Australia, 1 proposed NP (Limmen), 1 proposed extension to a NP (Keep River), 1 Indigenous Protected Area (Dhimmuru) & 1 private reserve (Newhaven)

[#]Government and non-government protected areas including IPAs

Table 5: Comparison of fauna conservation values across bioregions in arid to semi-arid rangelands that are most likely to be affected by shale gas extraction (from Baker *et al*. 2005).

Bioregion	Basin	% reserved* (# reserves)	% reserved[#] (Woinarski *et al*. 2014)	# significant spp[1]	# significant spp not reserved	# threatened spp	# threatened spp not reserved	# spp extinct in bioregion[2]	# threatened invertebrates
Central Arnhem	McArthur	0% (0)	5-10%	7	0	7 (4N, 7S)	0	1	None listed
Channel Country	Cooper	0% (0)	5-10%	3	1	3 (2N, 3S)	1	5	None listed
Davenport Murchison Ranges	Georgina Basin	2% (5)	1-5%	4	0	4(2N, 4S)	0	12	None listed
Finke	Amadeus	0.04% (6)	5-10%	15	4	12 (9N, 12S)	1	25	None listed
Great Sandy Desert	Canning	3.97% (2)	10-25%	13	1	12 (9N, 13S)	1	22	None listed
Gulf Fall and Uplands	McArthur	8.44% (3)	5-10%	13	1	12 (7N, 11S)	1	4	None listed
MacDonnell Ranges	Amadeus	13.7% (21)	10-25%	15	0	12 (7N, 12S)	0	19	21
Mitchell Grass Downs	Georgina	0.60% (3)	1-5%	8	2	6 (3N, 6S)	1	5	None listed
Ord Victoria Plain	Canning	7.99% (1)	10-25%	13	6	7 (4N, 7S)	1	3	2
Sturt Plateau	Beetaloo & McArthur	0.21% (3)	<1%	9	2	8 (6N, 8S)	1	4	1
Tanami	Canning & Georgina	0%	25-50%	13	1	13 (10N, 13S)	1	13	None listed

* National Parks, Conservation Reserves, Historical Reserves, 2 parks managed by Parks Australia, 1 proposed NP (Limmen), 1 proposed extension to a NP (Keep River), 1 Indigenous Protected Area (Dhimmuru) & 1 private reserve (Newhaven)

[#]Government and non-government protected areas including IPAs

[1] threatened, endemic and area restricted

[2] may be extant in other parts of NT

Table 6: Percentage of broad vegetation communities reserved in bioregions most likely to be affected by shale gas extraction.

	Percentage Reserved* in Bioregion (%)											
Broad Vegetation Communities	CA	CHC	DMR	FIN	GSD	GFU	MAC	MGD	OVP	STU	TAN	Total NT
Eucalyptus Forest and Woodlands with Tussock Grass Understorey	0					17.8			45.4	0.09		14.1
Eucalyptus low Woodland with Tussock Grass Understorey	0	0	0	0	0	1.7	0	0.54	0.22	0.02	0	2.4
Eucalyptus Woodland with Hummock Grass Understorey	0	0	2.5	0	0	5.6	0	0	11	0	0	8.7
Mixed Species low open Woodland			0			0		0	13.9	0		9.9
Melaleuca Forest and Woodlands	0				0	17.1				33.1	0	8.5
Acacia Woodland (including Mulga)	0	0	0.41	0.3	6.3	5.0	7.8	0	0	0.48	0	1.2
Hummock Grassland		0	0	0.05	3.9		19.7	2.8	0	0	0	0.9
Tussock Grassland		0	0			0	0	0.73	1.6	0	0	1.5
Chenopod Shrublands			0	0.07	5.6			0	0	0	0	1.4
Floodplain	0											24.9
Littoral	0					10.1						8.4

CA=Central Arnhem; CHC=Channel Country; DMR=Davenport Murchison Ranges; FIN=Finke; GSD=Great Sandy Desert; GFU=Gulf Fall & Uplands; MAC=MacDonnell Ranges; MGD=Mitchell Grass Downs; OVP=Ord Victoria Plain; STU=Sturt Plateau; TAN=Tanami

* National Parks, Conservation Reserves, Historical Reserves, 2 parks managed by Parks Australia, 1 proposed NP (Limmen), 1 proposed extension to a NP (Keep River), 1 Indigenous Protected Area (Dhimmuru) & 1 private reserve (Newhaven)

Table 7: Terrestrial protected areas by reserve type in the Northern Territory in 2014 (from http://www.environment.gov.au/land/nrs/science/capad/2014).

Terrestrial Protected Areas by Reserve Type in Northern Territory (2014)					
TYPE	**Type Code**	**Number**	**Area***	**% of PA**	**% of NT**
Biodiversity Hotspot	HPOT	1	194,845	0.78	0.14
Coastal Reserve	COR	1	1,366	0.01	0.00
Conservation Area	CA	3	7,044	0.03	0.01
Conservation Covenant	ACCP	3	140,071	0.56	0.10
Conservation Reserve	CR	18	154,566	0.61	0.11
Historical Reserve	HIR	4	7,781	0.03	0.01
Hunting Reserve	HTR	1	1,605	0.01	0.00
Indigenous Protected Area	IPA	11		71.04	13.25
National Park	NP	18		15.49	2.89
National Park (Commonwealth)	NPC	2		8.11	1.52
Nature Park	NAP	10	23,659	0.09	0.02
NRS Addition - Gazettal in Progress	NRS	3	632,797	2.52	0.47
Other Conservation Area	OCA	5	176,708	0.70	0.13
Other Conservation Area / Nature Park	OCA/NAP	1	807	0.00	0.00
Total		**81**	**25,129,386**	**100.00**	**18.65**

Total (including types below)		**85**	**25,230,266**		
Additional reserves WITHIN the protected areas above		Completely within	Overlapping Area		
Indigenous Protected Area	IPA	4	100,880	0.40	0.07
Total		**4**	**100,880**	**0.40**	**0.07**
Area of Northern Territory			134,778,762		

RENATA V BALI (NEE JAREMOVIC) CURRICULUM VITAE

POSITION:

Director, Ecosense Consulting Pty. Ltd.

QUALIFICATIONS:

Bachelor of Science (Hons Zoology), University of British Columbia
Doctor of Philosophy (Zoology), University of New South Wales

EMPLOYMENT PROFILE:

2017-	Community Member, Strathfield IHAP
1999-	Director, Ecosense Consulting Pty. Ltd.
1995-98	Associate, Biosis Research Pty. Ltd.
1992-94	Research Fellow, UNSW
1988-92	Senior Research Biologist, Biosis Research Pty. Ltd.

FIELDS OF COMPETENCE:

- ✓ environmental impact assessment – natural environment
- ✓ conservation significance assessment
- ✓ native and feral pest management
- ✓ regional environmental planning
- ✓ environmental design guidelines
- ✓ scientific review
- ✓ peer review
- ✓ policy development

PROFESSIONAL EXPERIENCE:

Renata has over 30 years experience in applied conservation biology and consulting. A sample of key professional experience is presented below.

Expert Reviewer, critically reviewing the adequacy of various EISs and REFs to identify any outstanding environmental issues (2014- for the NSW EDO).

Expert Witness, preparing submissions and presenting evidence regarding the ecological values of land proposed for a sand mine at Gerroa (2008 for the Gerroa Environmental Protection Society).

Independent Reviewer, undertaking a scientific review of Concept Plans and environmental studies relating to urban subdivisions at Gwandalan and Catherine Hill Bay (2007 for the Gwandalan Summerland Point Action Group).

Environmental Consultant, assessing and ranking candidate compensatory habitat sites for the Oxley Highway Upgrade (2006 for the NSW Roads & Traffic Authority Grafton).

Workshop Participant, providing expert scientific input into DEC workshops held to investigate the survey methodology to be used as part of the NSW Biobanking Scheme (2006 for Environmental Defender's Office Sydney).

Reviewer, undertaking a confidential review of the *NSW Threatened Species Survey and Assessment Guidelines: For Environmental Impact Assessment of Developments and Activities* (2006 for DEC Sydney).

Environmental Consultant, updating discussion paper regarding compensation of edge effects associated with highway development (2005 for the NSW RTA Sydney).

Independent Reviewer, assessing the adequacy of the Port Botany Expansion EIS and preparing a submission for the Commission of Inquiry (2005 for Botany Bay Catchment Alliance Inc.).

Compensatory Habitat Advisory Committee Member, reviewing and providing advice on the compensatory habitat package proposed for the Tugun Bypass (2003-5 for Parsons Brinckerhoff Brisbane).

Environmental Consultant, assessing and ranking potential candidate sites as part of the final compensatory habitat package for the F3 to Branxton, on the Central Coast (2003 for Biosis Research Pty Ltd).

Reviewer, undertaking a scientific and practical review of NPWS Threatened Species Survey and Assessment Guidelines and Regional Biodiversity Survey and Assessment Guidelines (2001 and 2004 for RTA Sydney).

Environmental Consultant, undertaking a preliminary assessment of the compensatory habitat package for the Tugun Bypass (2001 for PPK Environment & Infrastructure Brisbane).

Expert Witness, preparing a submission and presenting evidence regarding the potential impacts of the adaptive re-use and conservation of the Quarantine Station on the North Head population of Long-nosed Bandicoots (2001-2, for NPWS).

Independent Reviewer, assessing the effectiveness and practicality of amelioration measures aimed at protecting endangered bandicoot and penguin populations during the proposed conservation and adaptive re-use of the Quarantine Station, Sydney Harbour National Park, North Head (*2000 for NSW NPWS*).

Senior Ecologist, preparing a discussion paper aimed at providing an ecological basis for the compensation of edge effects associated with highway development for input into the RTA compensatory habitat policy. (2000 for RTA Sydney).

Senior Ecologist, identifying, assessing and ranking suitable compensatory habitat for the Bonville Deviation (2000 for RTA Grafton).

Independent Reviewer, reviewing environmental reports and making recommendations relating to the endangered Eastern Suburbs Banksia Scrub community found in the York Road Bushland, Queens Park (*1999, for Colin Ging & Partners*).

Senior Ecologist, preparing a discussion paper to determine the appropriate type and quantity of compensatory habitat for areas impacted by the Bonville Deviation, Coffs Harbour (1998 for RTA Grafton).

Project Manager, co-ordinating flora and fauna study team in the preparation of a Species Impact Statement and liaising with NPWS Northern Region and RTA about Koala mitigation measures and possible compensatory habitat packages for the proposed Pacific Highway upgrade at Bonville *(*1997-8 for PPK Environment and Infrastructure Brisbane).

Project Manager, assessing ESD principles of the three winning entrants into the Competition of Ideas for the redevelopment of the Kingston Foreshore, Canberra. (*1997 for the Interim Kingston Foreshore Development Authority*).

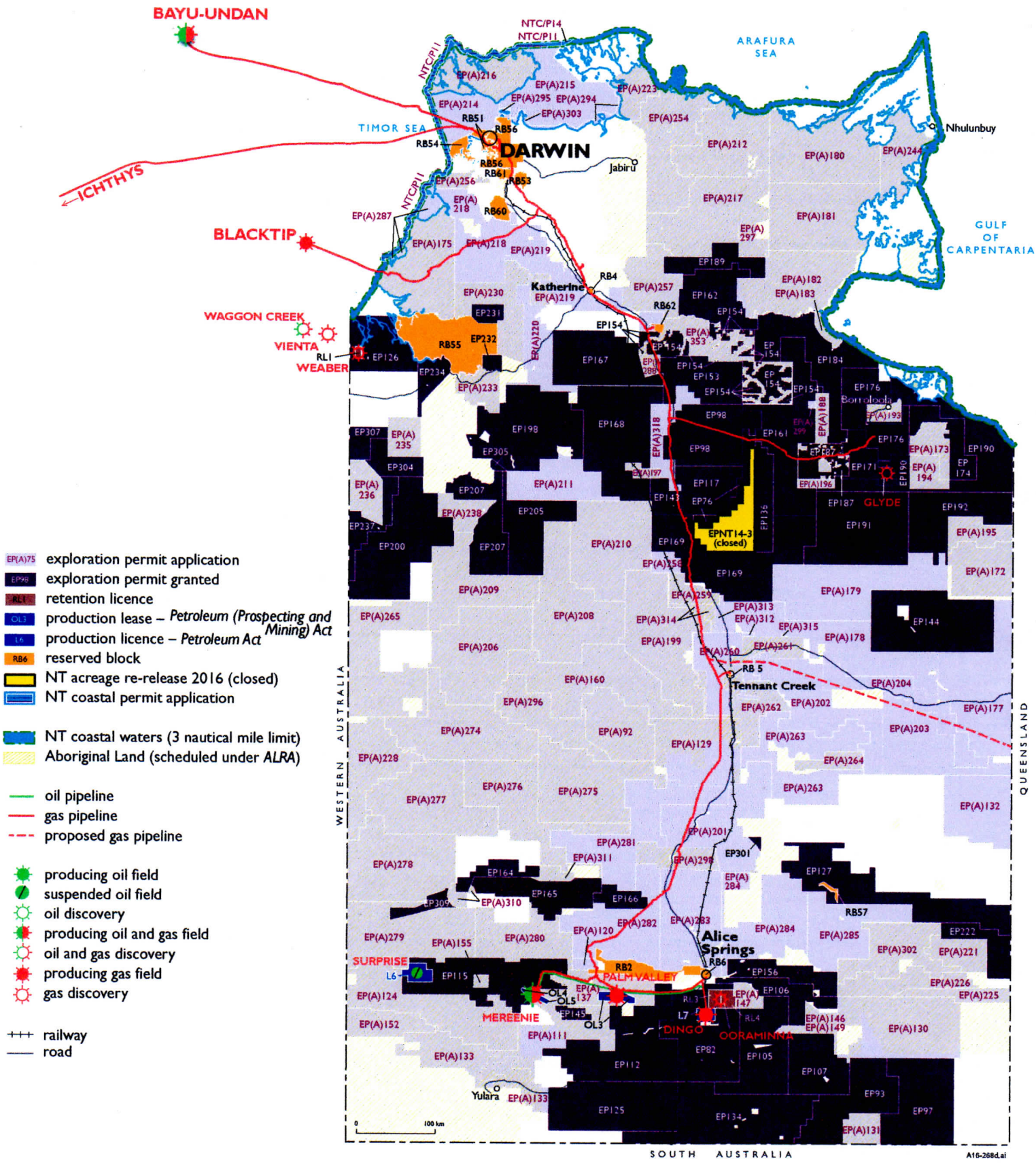
PUBLICATIONS:

Dr Bali has written over 100 consultant's reports and published a number of journal papers.

Onshore petroleum titles and developments

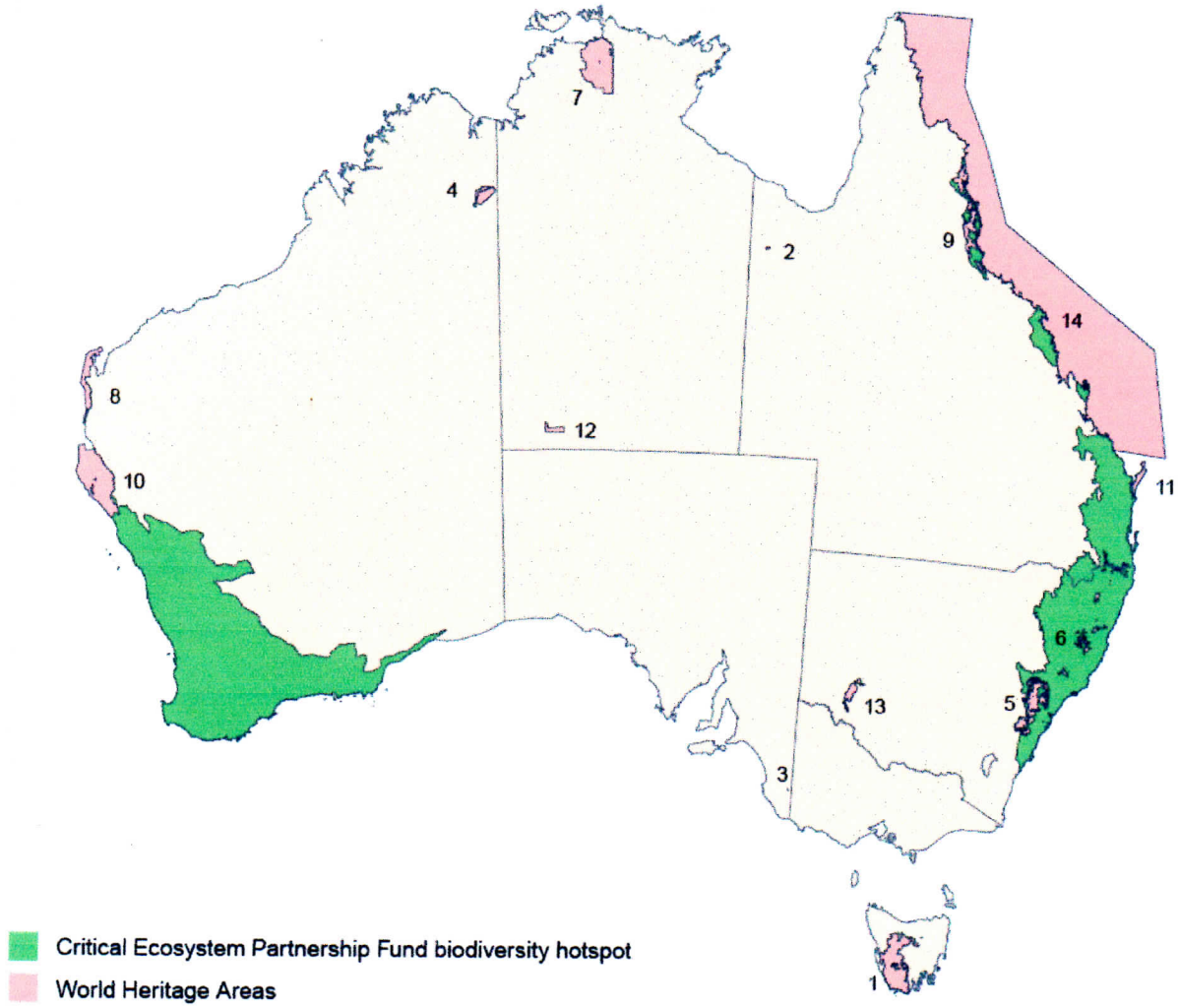
Creating Opportunities for Resource Exploration

CORE



- exploration permit application
- exploration permit granted
- retention licence
- production lease – *Petroleum (Prospecting and Mining) Act*
- production licence – *Petroleum Act*
- reserved block
- NT acreage re-release 2016 (closed)
- NT coastal permit application
- NT coastal waters (3 nautical mile limit)
- Aboriginal Land (scheduled under *ALRA*)
- oil pipeline
- gas pipeline
- proposed gas pipeline
- producing oil field
- suspended oil field
- oil discovery
- producing oil and gas field
- oil and gas discovery
- producing gas field
- gas discovery
- railway
- road

October 2016

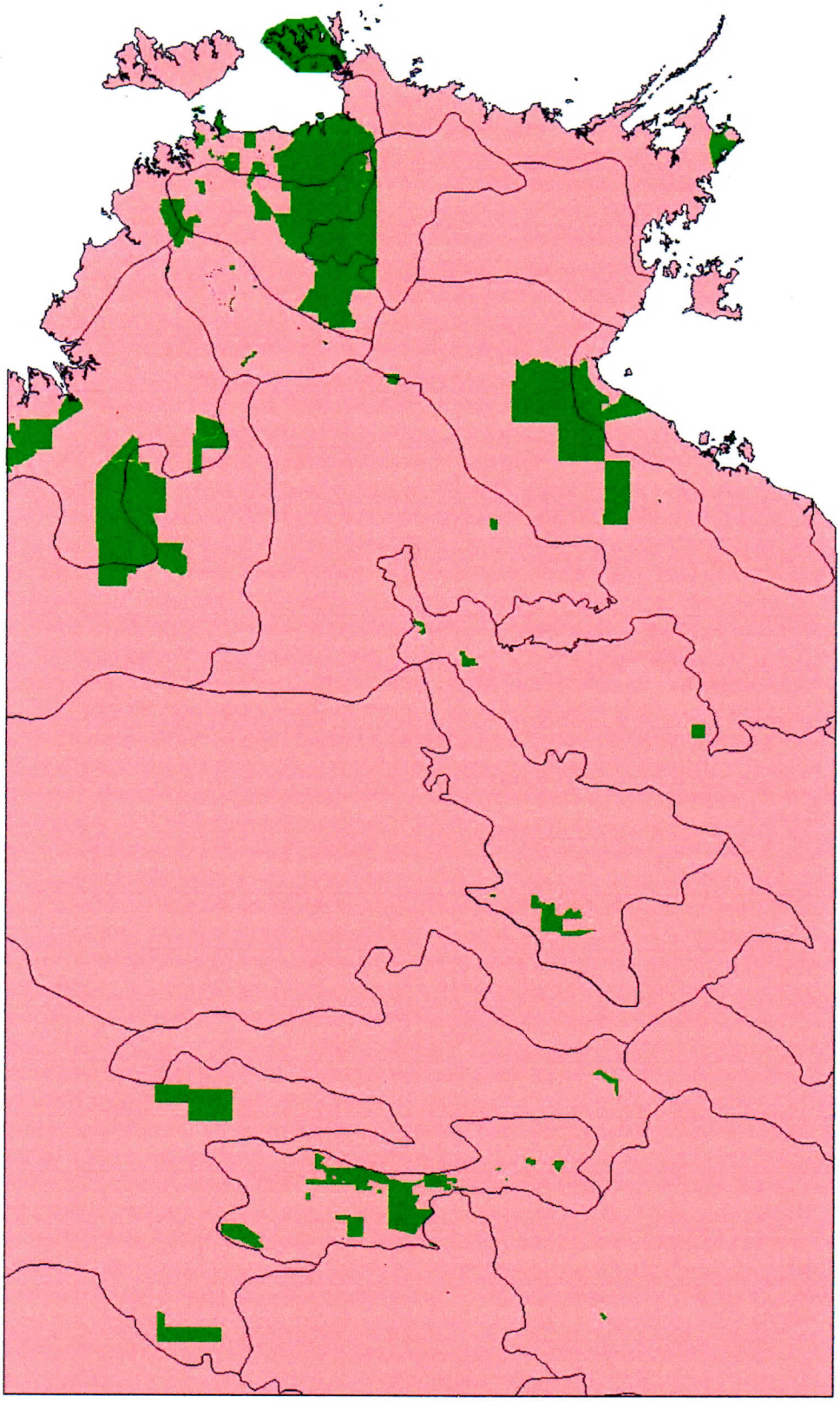


1 Tasmanian Wilderness
2 Australian Fossil Mammal Sites (Riversleigh)
3 Australian Fossil Mammal Sites (Naracoorte)
4 Purnululu National Park
5 The Greater Blue Mountains Area
6 Gondwana Rainforests of Australia
7 Kakadu National Park
8 The Ningaloo Coast
9 Wet Tropics of Queensland
10 Shark Bay, Western Australia
11 Fraser Island
12 Uluṟu–Kata Tjuṯa National Park
13 Willandra Lakes Region
14 Great Barrier Reef

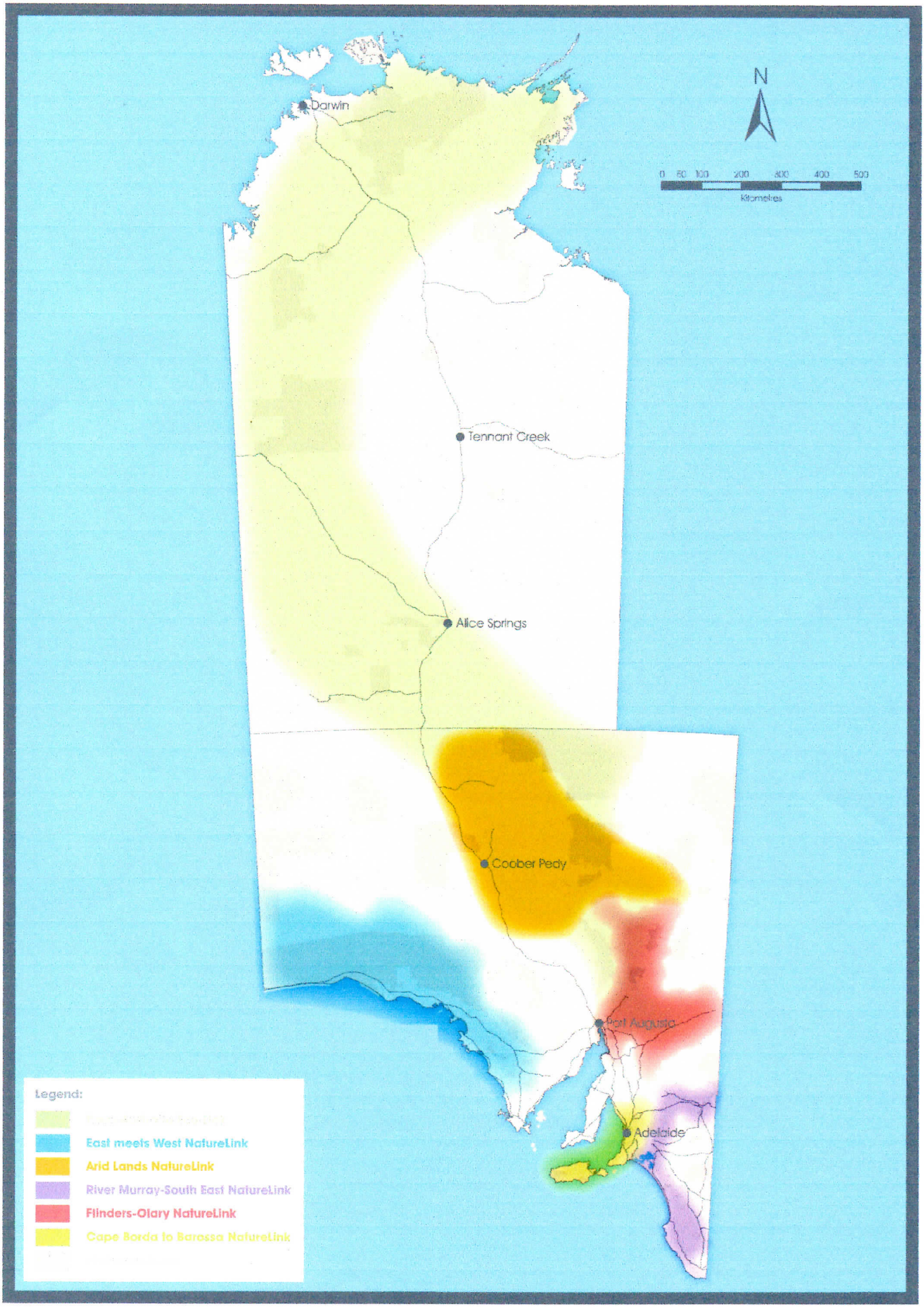
Note: Lord Howe Island Group; Macquarie Island; and Heard Island and McDonald Islands are not shown.
Source: Critical Ecosystem Partnership Fund, used under CC BY 3.0; World Heritage List database, Australian Government Department of the Environment and Energy

Figure BIO1 **Global biodiversity hotspots and natural value World Heritage Areas in Australia**

2. Reserves of the Northern Territory

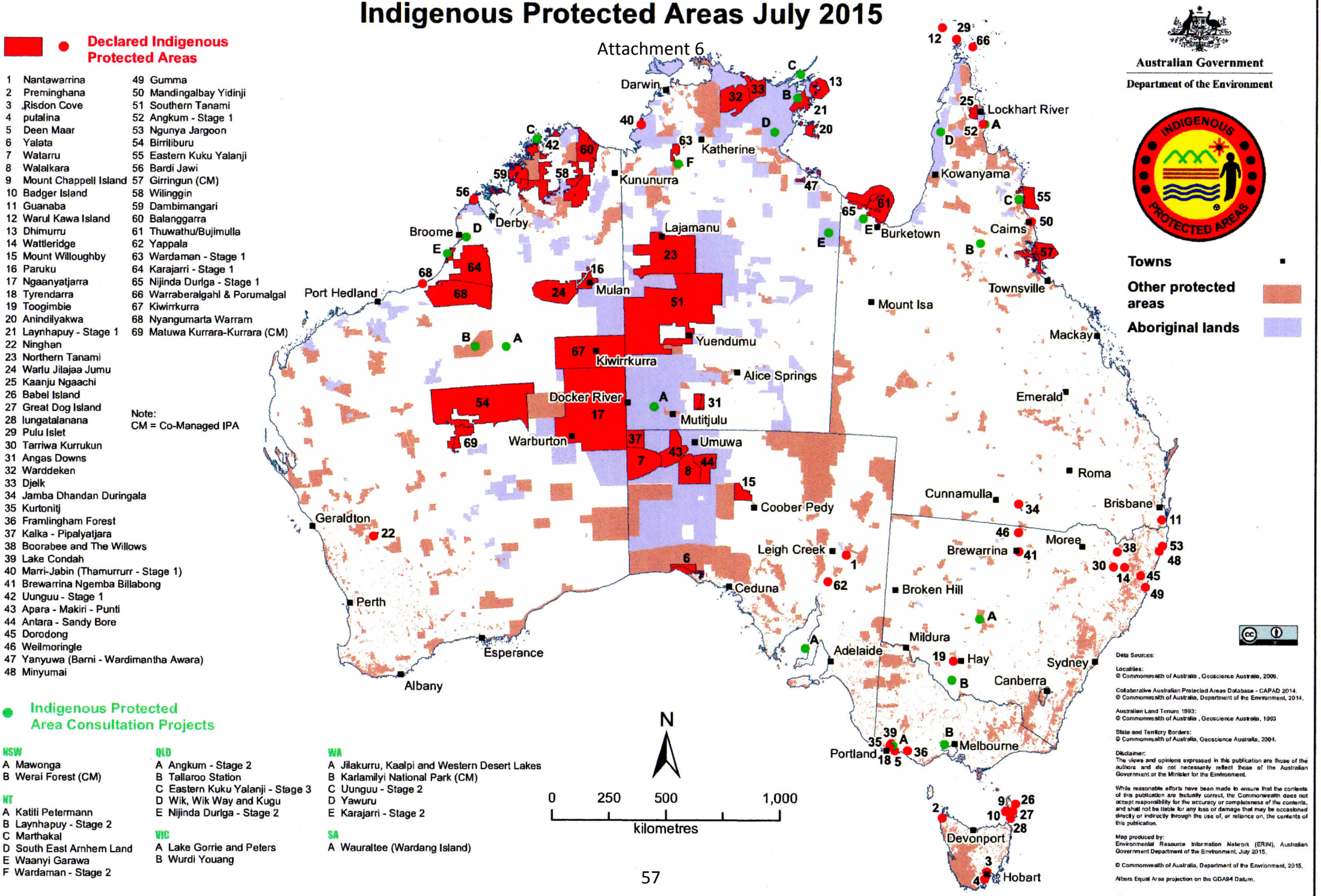


Trans-Australia Eco-Link



Indigenous Protected Areas July 2015

Attachment 6



Submission to the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory

Matthew J. Colloff

Biographical details

I am Dr Matthew Colloff, Visiting Fellow at the Fenner School for Environment and Society, Australian National University. Previously I was employed as a Principal Research Scientist at CSIRO Land and Water, where I worked for 22 years. My areas of expertise relevant to this enquiry, and based on my record of published research, include ecosystem function; ecology of rivers, wetlands and groundwater-dependent ecosystems; soil and vegetation ecology; water resources development and use; climate change and adaptation of social-ecological systems; environmental science, policy and governance.

Introduction

This submission, prepared in response to an expert brief from Environmental Defenders Office NT on behalf of Lock the Gate Alliance, contains an overview of published evidence on environmental impacts of hydraulic fracturing for shale gas in the Northern Territory, particularly related to risks to wetlands, rivers, floodplains and other groundwater-dependent ecosystems and on biodiversity, including consideration of the ecological function of groundwater. I acknowledge that I have read and prepared the following report in accordance with the NT Supreme Court Practice Direction for Expert Reports and the Expert Witness Code of Conduct.

Because development of shale gas in the Northern Territory is still in its exploratory phase, with few commercial wells, there is a lack of empirical evidence on the environmental impacts of hydraulic fracturing. The evidence base I draw on includes what little information there is from the Northern Territory, and from other regions with shale gas development. Shale gas extraction from a hydraulically fractured horizontal well has similar environmental characteristics regardless of region (Mauter et al., 2014, p. 8298).

The contextualisation of general, potential impacts within a set of region-specific social-ecological drivers and stressors forms the basis of this submission. First, I consider the distribution of shale gas resources in the Northern Territory in relation to significant wetlands, rivers, and related ecological assets. Secondly, I detail risks of hydraulic fracturing and associated activities, including water-related risks to ecosystem function and biodiversity from gas operations. Thirdly, I consider synergised risks from interactions between hydraulic fracturing and current and future changes in biophysical drivers of

ecosystems, including climate change, fire and flood regimes and groundwater recharge. Finally, I consider risks and interactions within the context of a Whole-of-Landscape Assessment and Planning framework for sustainable land and water use.

Distribution of shale gas resources in relation to significant ecological assets

Distribution of potential shale gas resources has very significant overlap with areas of Aboriginal freehold and Native Title, pastoral leasehold and important ecological assets (Fig. 1). Particular overlap occurs in the MacDonnell Ranges and the Lake Amadeus and Karinga Creek System which together form one of the most important regions for environmental tourism in the Northern Territory and which contain major refugia for biological diversity.

Distribution of wetlands and refugia

Refugia are places where water, food and habitat resources for biodiversity are present that are not available in the broader landscape. Extensive river networks that connect with aquifers and springs occur in the Lake Eyre Basin, as well as rock holes, riverine waterholes, claypans and temporary lakes (Fensham et al., 2012). Wetlands in the arid zone of the Northern Territory are ephemeral, often isolated amongst large areas of dry and inhospitable habitat (Morton et al., 1995; Davis et al., 2013). The ecological importance and environmental values of such freshwater refugia for biodiversity is disproportionate to their relative extent (Fig. 1). Duiguid et al. (2015) stated:

> There is a common perception that [arid Northern Territory] has very few wetlands. This is far from the truth. A diverse array of wetland types are described…The vast majority of arid NT wetlands are episodic, filling occasionally and with water derived from rainfall within the region. Isolated in vast dry surrounding landscapes, these wetlands have a significant biological, economic and visual impact when inundated.

The survey by Duguid et al. (2015) covered the area of the Northern Territory from 20°S (just south of Tennant Creek) to the South Australian border. Other important wetlands in the Northern Territory are detailed by Aquatic Ecosystems Task Group (2012) for the NT section of the Lake Eyre Basin, the *Directory of Important Wetlands in Australia* (Environment Australia, 2001; Department of Environment and Energy, n.d.) which lists 33 wetlands, and Northern Territory Government (2017).

Environmental values of wetlands & conservation sites in regions with shale gas resources

Beetaloo Sub-basin

Lake Woods receives variable inflow from the Newcastle Creek catchment to the north and east and, when filled, is a major stop-over area for migratory shorebirds, including painted snipe, listed as vulnerable under NT legislation and nationally. The lake is listed as "an outstanding example of a temporary freshwater lake…one of the largest such lakes in the NT and one of the few permanent waterholes in the NT part of the [Mitchell Grass Downs] bioregion. The lake includes the largest area of lignum swamp in the NT and one of the largest in tropical Australia. It is a globally important wetland for waterbird migration, breeding and populations." (Department of Environment and Energy, n.d.). Northern Territory Government (2017) provide details of Lake Woods as a wetland of international significance (though not Ramsar listed) and four threatened species.

To the north of Newcastle Creek is an extensive, but poorly-documented, series of waterhole refugia extending to the Carpentaria Highway in the north and the Tablelands Highway to the east. Environmental values of these refugia are not known because they have not been surveyed. Bullwaddy Conservation Reserve, 100 km east of Daly Waters, contains the endemic plant, bullwaddy (*Macropteranthes kekwickii*) restricted to the NT and contains near-threatened bush stone curlew, spectacled hare wallaby and northern nailtail wallaby (Parks & Wildlife Commission, 2005).

Western McDonnell Ranges, Lake Amadeus and Karinga Creek System

The region contains an extensive series of significant refugia for biological diversity in semi-arid Australia including brine lakes such as Lake Amadeus and Lake Neale that provide important habitat for waterbirds and groundwater discharge lakes of the the Karinga Creek Palaeodrainage System (Department of Environment and Energy, n.d.).

The river gorges of the MacDonnell Ranges, including Finke River Gorge and West MacDonnell National Park, are major drought refugia for fishes, frogs, birds, mammals and reptiles, including the Finke River hardyhead, endemic to the Finke River system. The MacDonnell and George Gill Ranges are botanically the most important area in Central Australia (Morton et al., 1995). In concert with its high value for biodiversity conservation, the region is of considerable cultural and educational value (Department of Environment and Energy, n.d.). Morton et al. (1995) provided an extensive list of rare, endangered and regionally endemic species found in refugia, as well as relict populations of species.

Impacts on ecosystem function and biodiversity

Hawke (2014) stated: "There have been no demonstrated environmental impacts associated with hydraulic fracturing operations in the NT" (p. 73). However, there is no publicly-accountable, transparent procedure for the monitoring, assessment and reporting of such impacts (Hawke, 2014, pp. 81-82). Absence of evidence of environmental impact does not constitute evidence of absence of environmental impact.

Impacts on wetlands and other ecosystems

Because there are currently few commercial shale gas wells in the Northern Territory there is a lack of empirical evidence on impacts on wetlands. Also, documentation of wetlands is lacking for several regions; surveys in the arid zone began only in 2000 (Duiguid et al., 2005). It is likely that unsurveyed wetland systems exist in some shale gas regions such as the Beetaloo Sub-basin. Although there is no empirical data on impacts, some inferences can be drawn based on risk assessment (cf. Souther et al., 2014, Table 1 therein).

Use of water for fracking

Shale gas is found in strata typically at least a kilometre below the surface, requiring water to be pumped into the well to fracture shales and release gas. In arid and semi-arid regions, access to sufficient water for fracking could add to existing competition for current and future water resources from environmental, urban, pastoral and agricultural uses. Accessing water for fracking from surface sources may have significant negative ecological impacts, even where such sources are available, because abstraction is likely to reduce the volumes and frequency of what are already highly sporadic, variable of flow regimes characteristic of rivers in arid Australia (Davis et al., 2013). A reduction in streamflow volume may increase secondary risks, particularly increased concentrations of contaminants that are accidentally or deliberately discharged into surface waters and reduced downstream water quality because less water for dilution is available (Entrekin et al., 2011, p. 508).

Extraction of groundwater for fracking may draw down aquifers so that springs that feed freshwater refugia no longer flow. Springs are sites at which water from underground aquifers is discharged. Typically, springs occur where porous rock overlies an impermeable one, for example at a series of discharge sites along the base of the western MacDonnell Ranges. Such springs may dry temporarily during dry periods when the aquifer is not being recharged by rainwater infiltration. The volume of water extracted from an aquifer that will cause a spring to dry may be relatively small, depending on the volume of the aquifer, its recharge characteristics and the location of the spring in relation to the aquifer. Given that

recharge and discharge rates from such systems are very poorly known, there is a risk that extraction of groundwater for fracking could cause groundwater-dependent aquatic refugia to dry permanently or for periods considerably longer than hitherto.

Produced water

Surface water bodies cannot be used as receiving zones for water that has been pumped out of the well because such 'produced water' is often highly saline and contaminated with metals, radionucleotides and fracking fluid constituents (Andrew et al., 2005; Barbot et al., 2014; Kim et al., 2016). Such components may be toxic to plants, native animals, stock and humans. Contaminated produced water requires careful storage and treatment. If such treatment is on-site there is further risk of contamination via the subsequent mobilisation of concentrated salts and toxins extracted from the produced water. Even after treatment, its disposal to natural drainage systems may still have potential negative ecological effects if not matched to natural temperature and flow regimes.

Evaporation ponds and waste pits for produced water are used extensively in the USA for temporary storage and have overflowed during heavy rainfall or leaked as liners degraded (Entrekin et al., 2011). Souter et al. (2014) detected many examples where containment facilities failed to prevent release of contaminants and management of waste products was inappropriate. These authors concluded (p. 333) "There is virtually no empirical information about the biotic risks associated with disposal of produced water…Given this paucity of data, the unquantified spatial and temporal extent of contamination, and few mitigation options, the pathways and consequences of environmental contamination from waste storage and disposal represent high research priorities."

The footprint of shale gas development

The footprint of shale gas development on the land surface, by its scale and nature cuts across landscapes, ecosystems and habitats. The areas occupied by the wells (well pads), together with connecting roads and pipelines for gas and water, as well as firebreaks require vegetation clearing, potential for introduction of invasive plants on vehicular traffic, and the fragmentation of habitat patches with negative effects on biodiversity (Ries et al. 2004). Severe effects are possible, including increased risk of erosion: "the cumulative impact of extensive well development over a gas play may be significant" (Hawke, 2014, p. 84). Fragmentation and clearing of native vegetation "needs to be managed in a way that balances the needs of and permissions available to landholders, gas and mining companies and other developers, without threatening biodiversity" (Williams et al., 2017, p. 429).

Potential impacts of spills and erosion on ecosystem functions

Accidental spills or illegal discharge of produced water carries the risk that salts and toxic contaminants will infiltrate soil and groundwater causing adverse effects on soil and plant communities. Experimental release of 303,000 L of fracturing fluids on 0.2 ha of forest in West Virginia resulted in death of ground layer vegetation and premature leaf drop from trees within 10 days and 50% tree mortality within two years, associated with a 50-fold increase in concentrations of sodium and chloride in the soil (Adams, 2011).

Flow of water containing toxins, high concentration of salts or sediments to creeks or other aquatic ecosystems carries a high risk of damage to these ecosystems. Such risks have been reviewed for shale gas in the USA (Vengosh et al., 2014). Aquatic organisms can be highly sensitive to increases in salinity: "direct adverse biological effects are likely to occur in Australian river, stream and wetland ecosystems if salinity is increased to ca. 1000 mg L^{-1} [one gram of salt per liter of water]" (Hart et al., 1991). Produced water may be hypersaline (up to 120,000 mg L^{-1} of total dissolved salts; Vengosh et al., 2014, p. 8340), so even small inputs risk negative impacts on freshwater ecosystems.

Sediment pollution from produced waters and erosion associated with well development is likely to be a risk if received by creeks and wetlands with low sediment input from other sources. Sediment deposition disrupts freshwater food webs by impairing photosynthesis by large aquatic plants and planktonic algae by reducing light penetration and by smothering; it reduces habitat availability for feeding and reproduction of invertebrates and fishes and can reduce dissolved oxygen concentrations in water to levels lethal to fishes (Wood & Armitage, 1997). Shale gas well density was positively correlated with increased turbidity of stream water due to sediment in the Fayetteville Basin, Arkansas (Olmstead et al., 2013).

Souter et al. (2014) examined 523 spill events, representing 5% of wells in Pennsylvania, relating to "failure to properly store, transport, process, or dispose of residual waste; failure to adopt required or prescribed pollution prevention measures and failure to plug a well upon abandonment." Spills ranged from 4–43 000 L: "poor data quality and lack of consistent reporting represent a major obstacle to understanding the impacts of chemical contamination."

Synergised risks from interactions between fracking and biophysical drivers of ecosystems

Groundwater

The CSIRO Northern Australia Sustainable Yields Project summarised the knowledge of groundwater resources as follows: ‘‘Groundwater data are very sparse for most aquifers across the project area [north of the arid zone] and there are large uncertainties regarding the volumes that might be safely extracted. This uncertainty is greater than the variability inherent in any possible changes expected due to climate change. Increased extraction will have impacts downstream that currently cannot be fully evaluated” (CSIRO, 2009, p. 9).

It should be a major concern that mining activities in the Northern Territory are not subject to the Water Act (Hawke, 2014, p. 37).

Lack of knowledge on the extent and magnitude of groundwater reserves in the Northern Territory, or likely changes in recharge rates caused by altered rainfall and evaporation rates under climate change prevent effective *conjunctive water management*, i.e. the integrated management of groundwater, surface water and recycled or harvested water via water allocation plans to achieve public policy outcomes and management objectives (Ross, 2017).

Climate change, fire and flood regimes

Estimates of water requirements for fracking activities vary, but figures of 10-20 megalitres per well are commonly quoted (Mauter et al., p. 8299; Vengosh et al., 2014, p. 8342). A shale gas field of 500 wells would require 7.5 gigalitres of water. There has been no assessment of water requirements of projected shale gas production in the Northern Territory or the environmental effects of such water use. Under climate change, evaporation is projected to increase and winter rainfall decline in the arid zone (Watterson et al., 2015, p. 23), with subsequent reductions in soil moisture and groundwater recharge. There is a risk that rates of groundwater use for fracking will exceed rates of recharge, with negative effects on wetlands, groundwater-dependent ecosystems and other water users.

Fire regimes in the arid zone have changed, in part due to the introduction of invasive buffel grass (Bastin, 2014, p. 11). With climate change, more frequent, intense fires are predicted (Bastin, 2014, p. 8; Watterson et al., 2015, p. 33). Floods are likely to be rarer but of greater intensity. Existing flood regimes are driven by short periods of heavy rainfall (e.g. 240 mm in two hours fell at Kintore in January, 2017). Such intense flood events have closed mines and access roads (Chandla, 2017a) and caused major erosion (Mooney et al., 2014, p. 27).

Synergised risks of fracking and climate change include increased risks of accidents caused by extreme weather events, including spillage of waste water, damage to the well head and associated infrastructure, increased risk of gas escape and enhanced risk of fire. The details, nature and magnitude of synergised risks of fracking and climate change were not considered as part of the Hawke Report.

Risks in the context of Whole-of-Landscape Assessment and Planning

Production of shale gas can be considered just another land use imposed on the landscape, with attendant risks to land, air and water. A basic proposition of sustainable development is that activities permissible in a region are those that allow the landscape to maintain its functions indefinitely: "It would be folly to secure one natural resource while putting at risk renewable long-term resource use" (Williams et al., 2017, p. 427).

Williams et al. (2017) propose a "knowledge-based long-term regional strategic land-use planning approach" for the regulation of shale gas, ideally involving assessment of all developments for their use of resources and impacts on social-ecological systems. A Whole-of-Landscape Assessment and Planning approach is used in bioregional assessment of landscape development (Australian Government, 2015), and differs fundamentally from species-, habitat- and project-based assessments (including environmental impact statements); the most common forms of assessment of environmental impacts. Whole-of-Landscape Assessment and Cumulative Risk Assessment (Williams et al., 2012) can be linked to existing land and water use planning, using principles of integrated catchment management to model appropriate and sustainable land and water uses and the capacity of landscapes and ecosystems to support particular desired sets of values and benefits. Such assessments, including the Australian Government bioregional assessment program, include development of 'multi-layered records of the natural environment in specific bioregions' with significant coal, oil and gas deposits, including ecology, hydrology, geology and hydrogeology (Australian Government, 2015). Such assessments do not extend to shale gas.

Land surface impacts on food and fibre production

Food and fibre production is at risk from cumulative fragmentation involved in the development of gas fields. Risks include loss or contamination of grazing land and its water resources. On pastoral leases these risks include stock watering points that use groundwater and surface water sources. Soil contamination and its effects on pasture plants is another source of concern. Shale gas production may compromise the landscape for pastoral use. Co-existence of gas production with pastoralism, including various forms of vegetation

management for carbon sequestration, would require careful management as well as a rigorous framework of integrated catchment management within a robust regional environmental governance framework, as has been attempted recently in New South Wales (Natural Resources Commission, 2010).

Impacts on communities

Assessment of impacts of fracking on landscapes and ecosystems would be incomplete without consideration of the communities that depend upon and benefit from those landscapes and ecosystems for their physical and spiritual wellbeing. Livelihood benefits may be impacted by perceived discounting of the quality and value of land owned or leased where sub-surface resources are committed by state governments to mining and energy companies via Crown ownership. Issues of environmental justice and equity arise in relation to the legal standing of landholders. Trust and engagement with all other land users becomes a prerequisite for those companies to achieve social licence to operate. Loss of property values or water resources for groundwater-dependent enterprises close to shale gas developments remains a highly contested issue.

As with land surface impacts on food and fibre production, achieving and maintaining trust and engagement to mitigate impacts on communities requires a rigorous overarching framework of regional environmental governance that is flexible and adaptable to ongoing negotiations over the principles and practice of sustainable land and water use. Such governance arrangements require engagement and commitment of all stakeholders and are unlikely to be successful if authority and power is concentrated within an organisation that also has authority over the granting of resources and licence to operate to a particular sector at the potential expense of others. Many prospective areas are either Designated Aboriginal Land or are subject to Native Title, thus traditional owners not only have to be made aware of the impacts and scale of shale gas developments from the outset (Hawke, 2014), but also engaged in ongoing dialogue and negotiations over land and water use.

Well closure and legacy implications

This issue is about integrity of wells no longer in use, including separation of the well from the strata and aquifers it intersects. Multiple cycles of fracturing along the horizontal well bore, often ten or twenty times, can increase the stresses on steel and cement well casings. Failures in casings can lead to contamination of aquifers with methane and other chemical components within the shales and fracture spaces. While such events may be rare, they cannot be excluded, and the wells will be in the landscape for ever. If decommissioned wells

do not retain their integrity there is a future risk of connections between strata which may contain confined, connected aquifers and water-bearing materials with very different chemical composition could lead to unforeseen impacts. The long-term integrity of decommissioned wells is poorly understood (Hawke, 2014, p. xvi).

Concluding remarks

Empirical evidence that shows cause-and-effect relationships between shale gas production and environmental impacts is still scarce. In part this situation is because this logistically difficult, contentious and challenging area of research requires access to sites and data owned by shale gas companies who may perceive they have little to gain from co-operation. (State and Federal agencies with statutory responsibilities for environmental monitoring may be best placed to conduct such research, but they may lack resources for anything more than basic monitoring.) However, an assessment of risk of environmental impacts from shale gas production has been made based on the relative extent, difficulty of mitigation and current understanding of potential impacts of contamination of surface water and groundwater, wastewater disposal, habitat loss and fragmentation, reduced streamflow, air-, noise-and light pollution (Souther et al., 2014).

The need to plan for the risks and possible impacts of multiple developments is recognised within State, Territory and Federal governments and the gas industry. The Federal government protects water resources from the impacts of coal and coal seam gas development through the 'water trigger' provisions of the Environment Protection and Biodiversity Conservation Act 1999 (Department of Environment and Energy, n.d.). However, these regulations do not apply to shale gas development. The legislation, frameworks and governance arrangements are inadequate to support policy development and implementation across all sectors and interest groups in whole-of landscape assessment frameworks. For example, area-wide reverse osmosis plants to remove salt for re-use of produced water are likely to be deployed in some shale gas production regions, but standards and regulations remain to be developed (Cronshaw & Grafton, 2017, p. 102).

In remote regions there is a risk that however well-designed such frameworks may be, capacity to monitor such compliance, as well as any environmental impacts, will be under-resourced and inadequate. Environmental monitoring and assessment relating to adverse industry impacts on the environment, particularly inland aquatic environments, has a very poor track record in Australia (SoE, 2011). Regulation and governance are likely to be most effective when they follow, and are informed by, a detailed knowledge of (and access to

information on) landscape functional processes and an adequately-resourced commitment to long-term maintenance of landscape functionality and sustainability.

Land users and governments need to be accountable to each other so that one group is not given advantage at the expense of others; or where agencies with regulatory powers apply different rules to different groups; or have actual or perceived conflicts of interest, such as in licencing, purchasing and regulatory agreements, like the purchase of shale gas by the NT government-owned Power and Water Corporation (Hawke, 2014, p. 66). The exemption of the mining and petroleum sectors from water allocation regulations is another example. As a common pool resource, water in the Northern Territory remains the property of the Crown, managed in accordance with the Water Act for all other users except the mining industry. Yet knowledge regarding current water availability and use remains fragmentary and incomplete in the Northern Territory, particularly the magnitude, extent and connectivity of groundwater reserves (CSIRO, 2009).

Fracking in the Northern Territory is a justice and governance issue as well as an environmental one. A major recommendation of the Hawke enquiry was that "the environmental risks associated with hydraulic fracturing can be managed effectively subject to the creation of a robust regulatory regime" (Hawke, 2014, p. x). Governance arrangements, regulations and monitoring to ensure accountability, justice and management of environmental risks remain to be established.

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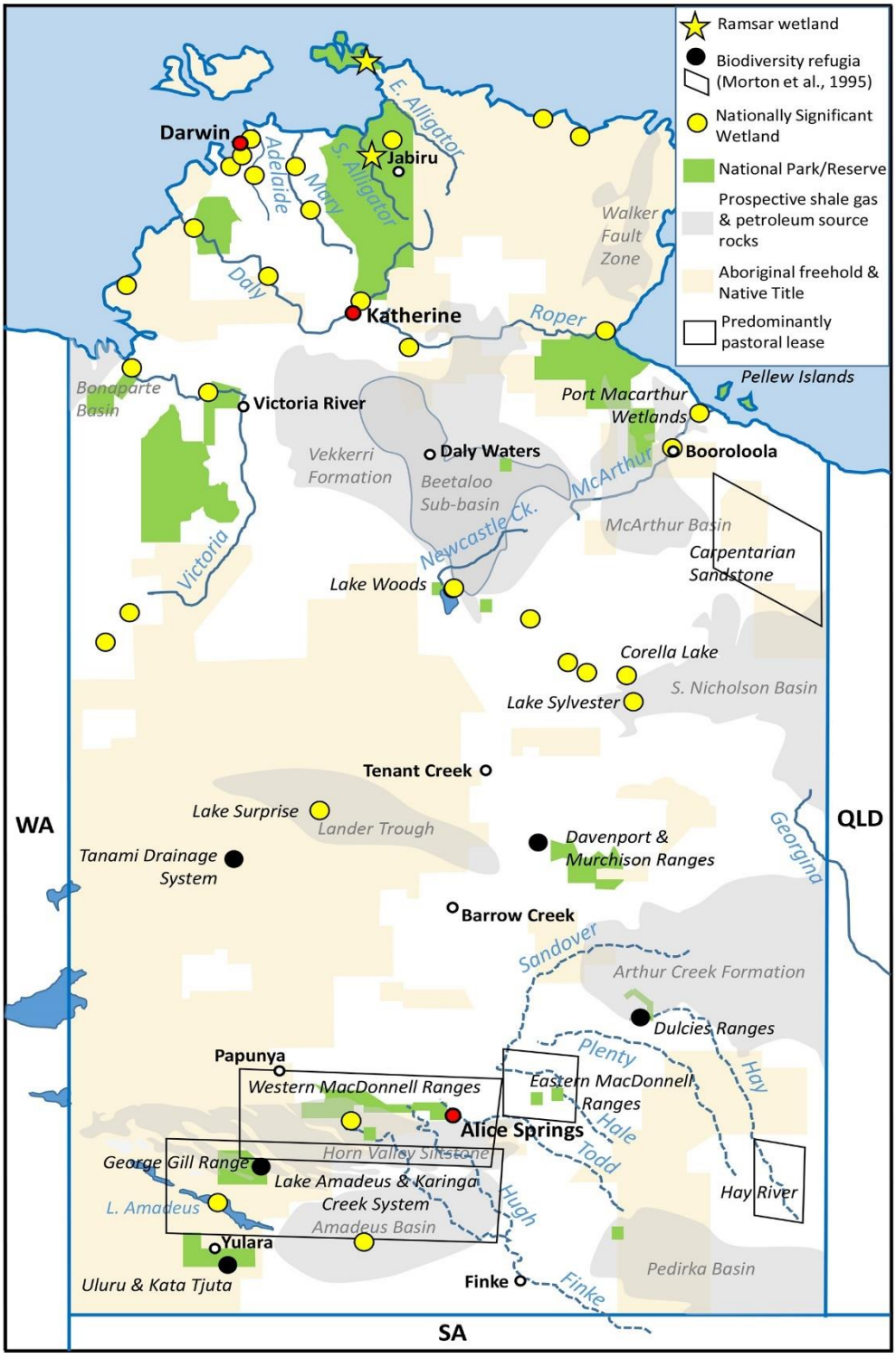
Figure 1. Map of the Northern Territory showing multiple land uses and values, including native title, potential production of shale gas, pastoral production and biodiversity conservation. Areas of overlap between Aboriginal freehold and Native Title and pastoral leases are not shown, nor are areas of current oil and petroleum licences and those under application, which cover ca. 85 percent of the area of the Territory (Chandla, 2017b). Biodiversity refugia based on Morton et al. (1995), Nationally Significant Wetlands from Environment Australia (2001) and Department of Environment and Energy (n.d.).



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EXPERT ADVICE

SCIENTIFIC INQUIRY INTO HYDRAULIC FRACTURING IN THE NORTHERN TERRITORY

REVIEW OF TERMS OF REFERENCE AND BACKGROUND AND ISSUES PAPER

DR SCOTT WILSON

MACQUARIE
University

PREAMBLE

1. This report was requested by Environmental Defenders Office NT, on behalf of Lock the Gate Alliance, to comment on issues identified in the Terms of Reference and Background and Issues Paper for the Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Shale Reservoirs and its Associated Activities.

2. I, Dr Scott Paton Wilson, am an expert in the field of ecotoxicology with over 20 years' experience, specialising in impacts of inorganic and organic contaminants to aquatic species and their ecosystems.

3. The context of this report specialises in points relevant to the groundwater and surface water quality, alterations to these and potential biological and ecological effects. I do not provide comment on whether or not hydraulic fracturing (fracking) in the NT should proceed, but discuss issues that should be considered in any consideration of fracking in the NT.

4. I acknowledge that I have read and prepared the following report in accordance with the NT Supreme Court Practice Direction for Expert Reports and the Expert Witness Code of Conduct.

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TERMS OF REFERENCE

5. The Terms of Reference (TOR) for the Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Shale Reservoirs and its Associated Activities are for the most part sufficiently described to provide guidance to the inquiry for a detailed assessment of the nature and extent of the environmental impacts and risks, and strategies to mitigate these. There are however a few points, outlined below, that the inquiry should particularly consider.

6. Under Point 2 of the TOR, the knowledge gaps, additional work or research that may be required to address Point 1 of the TOR are presented and four areas are specifically raised. Issues that are not explicitly listed but should be considered key features include:

    a. subsection 2d. baseline health impact assessment should be further defined as to pertaining to human and/or environmental health aspects;

    b. baseline biological surveys of surface water and groundwater, with particular reference to stygofauna should be specified; and

    c. ecotoxicological data using locally relevant and condition specific species should be included.

7. The definitions section of the TOR should have included the meaning of 'cumulative impacts' in the terms of this inquiry. This should include but not be limited to, direct and indirect effects of the past, present and future.

8. Points (6 and 7) are discussed further in the section below. I note that my expertise is in environmental rather than human health aspects so this report focusses on those issues.

9. Section 7.1 of the Background and Issues Paper lists and describes the possible risks that hydraulic fracturing of onshore unconventional shale reservoirs and its associated activities may have on surface and groundwater. My comments provide further details on the aspects of fracking that require additional emphasis, as mentioned above, and are explained in the following points.

10. To understand and mitigate the risk associated with fracking and associated activities, collecting baseline data is imperative. This should be conducted ideally over several seasons to account for natural weather, climatic and lifecycle fluctuations/perturbations.

11. To assist in evaluating potential impacts a broad scale monitoring design that includes both multiple reference and potential impact sites should be included. The Before, After, Control, Impact (BACI) approach (Underwood 1994) where control (reference sites) data are used to assess the potential effects at 'impact' sites both before and during or after an activity or event, is one such design. This form of monitoring should not only pertain to relevant surface and groundwater, but also potentially affected soil and sediment and include relevant biological communities.

12. A long-term site management plan and a groundwater and surface water monitoring plan should consider and refer to the *National Environment Protection (Assessment of Site Contamination) Measure (1999)* to enable ongoing site assessment.

<u>Groundwater Ecosystems</u>

13. Attention should be given to groundwater ecosystems which are both physically and ecologically unique. There is presently limited knowledge on the biodiversity of groundwater fauna or stygofauna locally, and even less known on the impacts contaminants have on them (Boulton et al. 2003; Humphreys 2006). This group of organisms have been suggested to be highly vulnerable to disturbances from fracking operations (Eco Logical Australia 2012).

14. Any groundwater fauna assessment should consider the approach undertaken in Western Australia, where the Environmental Protection Authority have an *Environmental Factor Guideline* (WA EPA 2016a) addressing how subterranean fauna are to be considered in environmental impact assessment (EIA) and provides a technical advice document (WA EPA 2016b) to proponents on the level of information and survey required. A diagram showing the process of undertaking subterranean fauna surveys is presented as an example below in Figure 1.

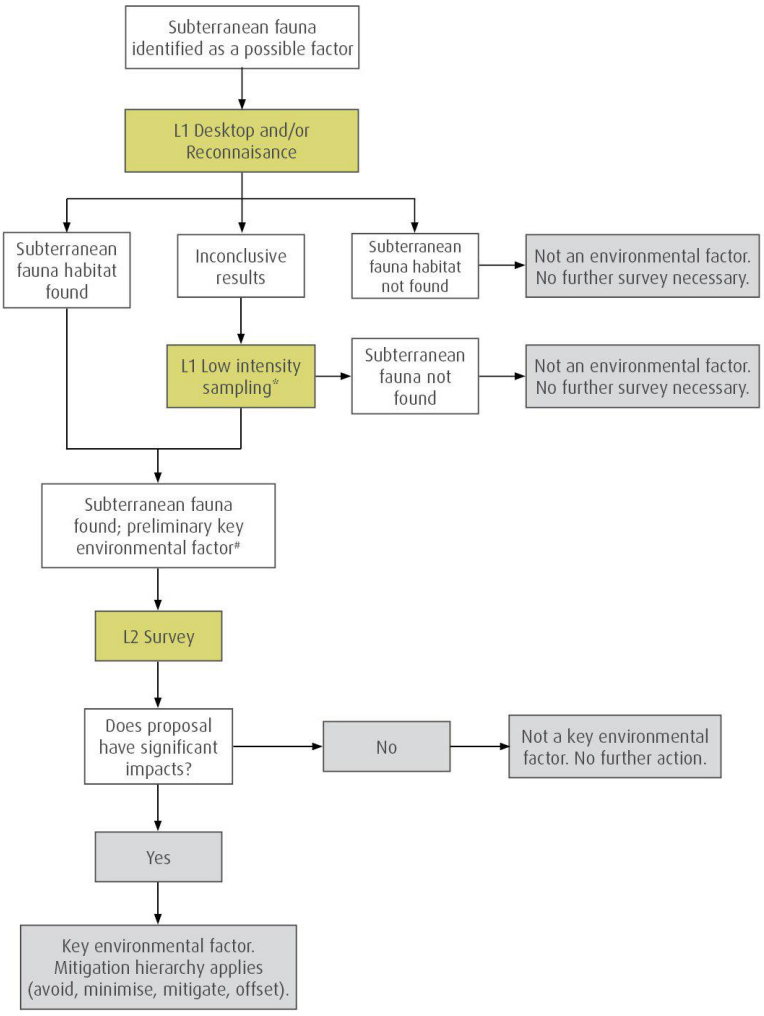

Figure 1: Flow diagram of process for assessing potential impacts to subterranean fauna (WA EPA 2016b)

15. The difficulty of biological sampling of groundwater ecosystems is constrained by access thus limiting the degree of monitoring. However, standard techniques and processes are available for assessment where access is possible (Hose and Lategan 2012).

Surface Water Ecosystems

16. The ephemeral nature of surface waters in the region means that these habitats can have specifically adapted and locally endemic fauna species. Monitoring and sampling accordingly needs to account for the timing and life history strategies of these species (Smith et al. 2004). Monitoring should consider both biodiversity and functionality of the targeted communities.

17. The relatively high volumes of water required for the fracking process requires large treatment or storage ponds per well to deal with the high flowback water recovery (up 80%). This water can contain a range of contaminants including the fracking chemicals, metals, hydrocarbons and is normally highly saline (Hawke 2014).

18. In terms of reducing risk of potential movement of contaminated water any ponding or storage for flowback water should be sufficiently sealed or contain an aquitard to avoid contaminant transport offsite into the underlying aquifer. Clay sealant or aquitard depth needs to fully consider the climatic condition of the site/region, where an 85% saturation rate needs to be maintained to preserve the integrity of the boundary layer (NT Minerals Council 2004).

19. Similarly, to reduce potential escape of these contaminants across the surrounding surface, storage and drainage facilities should be designed to account for a minimum of a 1 in 100 year event for a 72 hour duration rainfall as per the NT Government's *Template for the preparation of a mining management plan* (NT Department of Primary Industries and Resources 2017). This document does highlight the need for localised assessment to determine the most appropriate level of protection.

Ecotoxicological Considerations

20. To understand the potential risks and biological impacts these contaminants might have in the surrounding environment toxicological assessments should be performed. These should be conducted on each of the relevant ecosystem types present and account for seasonal variations.

21. Currently, there are no standard toxicity tests for assessing stygofauna under Australian conditions and limited tests for species adapted to ephemeral streams or temporary water bodies.

22. At present, surrogate species from perennial streams or permanent water bodies are used in toxicity testing for most surface and subsurface freshwaters, due in part to the ease of culture and testing and the knowledge of their life history. However, the sensitivity of these species may potentially over or underestimate the likely risk to fauna from habitats that are under different stressors or conditions (Smith et al. 2004) such as in subterranean or temporary water bodies.

23. The most appropriate tool for assessing the toxicity of a mixture of contaminants such as flowback water is through a Direct Toxicity Assessment (DTA). This whole effluent style approach is described in the *Australian and New Zealand Guide for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000). The precautionary approach is recommended for assessment of post-baseline data through trend analysis or feedback triggers.

24. While DTA is useful to determine risk, it cannot identify individual toxic components of the mixture/effluent. Other techniques such as toxicity identification evaluation are required should this be needed. It is important to note that DTA is only one part in the overall assessment of the potential risk of contaminants (van Dam and Chapman 2001).

25. With a distinct gap in the appropriate test methods and suitable species the ability to adequately assess the toxic risk of contaminants from these fracking operations is limited. Therefore, appropriate species, relevant to the ecosystem being assessed (e.g. ground water habitat) and derived where possible from the local region should be used. New methods also need to be developed to account for the potential differences in the physical, chemical and biological environments these species are accustomed to.

26. The cumulative impacts associated with the past, present and potential future contaminants at each site, including direct and indirect effects need to be considered in any assessment.

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