Zero Order Draft

October 12
2015

V3.0

Strategic Environmental Assessment for Shale Gas Development in South Africa

Contents

Strategic Environmental Assessment for Shale Gas Development in South Africa

Zero Order Draft V2.1 7 October 2015

The purpose of a 'Zero Order Draft' is to outline, to the full author team, the Project Executive Committee, and the Project Custodian Group and other stakeholders involved in the process, the scope (coverage), organisation and approximate balance in terms of page-length, of the assessment. It serves as a writing guide to the author teams, and allows them to know where linked or related issues are covered.

Summary for Policymakers

A ~ 5 page summary will accompany the second order draft, built on a synthesis of key messages identified in the first order draft. It will contain traceable pointers to the detailed discussion in the main text, and will use certainty language.

Preface

Purpose of the SEA, the scope, how it was commissioned, governed and performed (including participation mechanisms), map of study area and temporal scope covering exploration, operation and closure [3 pages].

Scenarios and Activities of Shale Gas Development in the Karoo

Integrating Author/s	Mike Burns
Contributing Authors	Oliver Barker, Ian Mclachlan, Doreen Atkinson, Phil Hobbs, Jeff Manuel, Simon Todd, Bob Scholes, Elsona van Huyssteen Nigel Rossouw, Luanita van der Walt
Corresponding Authors	Zainab Mowzer, Selwyn Adams, Tom Murphy? Anton Eberhard?

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What are scenarios and activities? What is included and excluded? Why is it important? Links to other topics. Key assumptions.

Key definitions

Scenario

Activity

Overview of international experience

How did SGD proceed in other countries?

Special features of the Karoo and South African environment

In relation to SGD scenarios, e.g. little existing gas infrastructure, issues of doleritic intrusion into the target area. The broad social, economic and ecological trends currently affecting the region.

Relevant legislation, regulation and practice

Covering mining/petroleum exploration

The potential shale gas resource in the south-central Karoo

Review and assessment of resource quantification estimates (technically recoverable reserve), graphic of the shrinkage down to a risk-adjusted economically viable resource. Assessment of most likely locations for a sweet spot within the study area based on old borehole data, existing seismics and geological information.

Activities associated with shale gas exploration and development

~ 6 pages, with diagrams, photos and map of a conceptual wellfield

Exploration phase

Regional seismic survey, Stratigraphic drilling, Detailed 2D and 3D seismic survey, test drilling with hydraulic fracturing and gas yield measurement.

Development phase

Well pad development; drilling; hydraulic fracturing; transport of materials to and from wellpads and wellfields; roads and pipelines to service wellpads; centralized waste and water processing

facilities per wellfield; modular small-scale Combined-cycle Gas Turbines; moderate scale Gas-to-Liquid plant; storage and pipeline facilities to distribute gas regionally/export.

Closure phase

Well capping, wellpad, wellfield and redundant road restoration; rehabilitation; restoration or repurposing of waste; storage; administration; processing and accommodation facilities; site monitoring.

Four plausible Shale gas futures

The following four scenarios span the range of plausible futures, as best as can be currently judged.

Scenario 1. Baseline: no shale gas development

Narrative on a gradually changing Karoo, due to migration, economic activity shifts and climate change. 0.5 pages

Scenario 2. Exploration only

Narrative where widespread seismic surveys and stratigraphic drilling take place, followed by exploratory drilling and test fracking, with capture and use of any gas produced, but the resource is found to be uneconomic or otherwise undesirable to exploit further, and test wellpads are rehabilitated. 0.5 pages

Scenario 3. Exploration and limited development

A economically viable resource of ~ 5tcf is located, and developed using a single wellfield modular CCGT plus some local use.

Scenario 4. Exploration and extensive development

An economically viable resource> 20tcf is located and developed using ~4 wellfields, CCGT + pipeline out of region + small GTL plant.

Topics on which information is inadequate for decision-making

The critical assumptions which had to be made in developing the scenarios [0.5 pages]

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Table of detailed activities and their timelines

Effects on National Energy Planning and Energy Security

Integrating Author/s	Anton Eberhard
Contributing Authors	Harald Winkler, Tobias Bischof-Niemz
Corresponding Authors	

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? What is included and excluded? Why is it important? Links to other topics. Key assumptions.

Sidebar on key definitions and abbreviations

Overview of international experience

In relation to the contribution of shale gas to national energy budgets.

Special features of South Africa in relation to Energy

High past dependence on coal, desire to diversify, extension of modern energy services to developing population, little current gas infrastructure but gas in neighbouring countries, essentially no oil (but CTL and GTL expertise), good solar potential, little hydro, some wind, some nuclear.

Relevant legislation, regulation and practice

The IRP and its revisions, IEP and other relevant policy. GUMP?

Key potential effects and options

[~4 pages] Energy security, energy cost, delivery of modern energy to disadvantaged populations.

Risk assessment

How the risks and opportunities are measured

0.5 pages – PJ, reliability, cost

Limits of acceptable change

0.5 pages, based on strategic considerations in NDP and IRP

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Energy security	National	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Energy cost	National	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages]

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[If needed and useful to decision makers]

Air Quality and the Emission of Greenhouse Gases

Integrating Author/s	Harald Winkler,
Contributing Authors	Katye Altieri, Simon Clarke, Rebecca Garland, Gerrit Kornelius, Louise Naude
Corresponding Authors	

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

Key definitions and abbreviations

GHG

Particulates

VOC

What is covered under Air Quality? Primarily particulates and ozone precursors (NOx, VOCs). Direct emissions from the following activities: shale gas exploration, development and production, their points in life-cycle – transport related (water, waste, products); settlement related (spatial planning); energy use and supply related (energy chapter, scenarios); links to Health, Ecological impacts, Energy, Senses of place. Not included: physical impacts of climate change; air quality impacts of pipelines. Key assumptions.

Overview on international trends in GHGs following shale gas development

Review the two SA studies – DEA 2014: Cohen & Winkler 2014; review of international literature seems largely on methane, for additions; further literature search); GHG need to align with national energy planning in terms of quantities of gas for various end uses, energy demand.

Special features of the Karoo environment in relation to air quality

Existing perceived good air quality. High sunlight environment, inversions. One current ambient station near study area.

What is covered under Greenhouse Gases?

CO_2, CH_4 (especially fugitive emissions), N_20. Not in scope: GHGs: PFCs, HFC, SF6; short lived climate forcers.

International experience regarding the greenhouse gas budget impacts of shale gas development

Critical effect of fugitive emissions and what the shale gas displaces from the mix

Special features of South Africa with respect to greenhouse gas emissions

Historical high greenhouse gas intensity

Relevant legislation, regulation and practice

The South African INDC

Potential key impacts on air quality and their mitigation

The key potential impacts under shale gas exploration and development: emissions, their atmospheric transport and transformation (photochemical ozone, secondary particles) and resultant impact on ambient air quality - is it material or not? Exposure, health and ecosystem impacts. Opportunities for improved air quality if gas replaces dirtier fuels in households, industry, electricity generation. Other mitigation strategies. Key uncertainties

Risk and opportunity analysis for Air quality

Metrics of Air quality

Volume/mass fraction in air for NOx, particulates, ozone; exceedances for given periods

Limits of Acceptable Change

National ambient air quality standards, WHO standards, Occupational standards. Emissions standards in SA and internationally

Risk table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Worsened ambient air quality	Within atmos transport footprint	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Improved experienced air quality	In popn using gas in place of dirtier fuels	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Potential impact on the national GHG budget

[1 page]

Graphic of effect on GHG budget over time for various scenarios.

Gas as a low carbon intensity fuel. Reduction in national GHG emissions if it displaces coal or oil, increase in GHG budget if it displaces solar, wind, hydro or nuclear, or leads to greater energy consumption. Difference between national use and exports. Potential to lose much of the GHG benefit if fugitive emissions are not controlled; options for doing so.

Risk assessment for South African GHG budget

How the risks and opportunities are measured

Carbon intensity of energy technologies, using 100-year horizon GWP (t CO2-eq / energy unit – GWh or bbl or PJ)

Limits of acceptable change

Defined by INDC

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Failure to meet GHG obligations	National	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Reduce GHGs beyond INDC	National	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated assumed emissions from types of activities

Digital Appendices (GIS Surfaces of projected air quality under different scenarios)

Tremors and Earthquakes

Integrating Author/s	Ray Durrheim
Contributing Authors	Vunganai Midzi, Moctar Doucoure
Corresponding Authors	Andrzej Kijko

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? The issue covered in the chapter is limited to earthquakes triggered by fluid injection. The injection of fluids into rock and the subsequent extraction of fluid and gas will cause the rock to fracture, triggering seismic events. The events may range in size from microseismic events (M<0) associated with the deliberate formation of fractures to liberate gas, to large events (M>5) that may alarm residents and cause damage to vulnerable structures such as heritage buildings or buildings built from unreinforced masonry.What is included and excluded? Links to heritage and human health. Key assumptions.

Key definitions

Magnitude

Overview of international experience

Seismicity following shale gas exploration and development. Most of the events will be small (M<0) and deep (> 2 km) and not felt on the surface events. However, the increase in pore fluid pressure may trigger occasional large events (M>5). The associated shaking of the ground may alarm residents and even cause damage to vulnerable structures. This has occurred elsewhere in the world, for example; Oklahoma (USA), Groningen (The Netherlands).

Special features of the Karoo seismic environment

Generally seismically stable. Existing seismic stations

Relevant legislation, regulation and practice

DMR technical regulation for hydraulic fracturing, other regulations governing exploration activities.

Key potential impacts and their mitigation

[5 pages] Earthquakes are induced by at least three mechanisms related hydraulic fracturing:

(i) Cracking or rupturing of rocks during fracturing creates microearthquakes of very small magnitude less than ML0 (reference);

(ii) Interaction between fractures and nearby faults (fracking fluid entering faults) results in change in pore pressure that can trigger earthquakes of ML> 0 and observed to reach 3 (reference) and rarely, but possibly, greater;

(iii) Interaction between fracking fractures and nearby faults through stress transfer (ML up to 3 or sometimes greater)

Figures illustrating mechanisms and past seismic history

Ground motion from induced seismicity can cause damage to (i) structures at fracking sites, including the well itself due to displacement (e.g. de Pater and Basich, 2011) (ii) nearby community /towns infrastructure (buildings / dwellings, roads, bridges, lifelines, etc.) (iii) nearby SKA infrastructure (telescopes).

Amplification of ground motion at nearby communities with structures built on thick soil layers or on hills. Contamination of ground water through interaction of fracking fractures and faults as fracking fluids flow through faults. Deformation of aquifers and geological strata due to injection and / or extraction of fluids (can also trigger seismicity).

Options for mitigation (the authors have a detailed list of these)

Risk assessment

How the risks (and opportunities where appropriate) are measured

Siesmic measurements and their return time distributions.

Limits of acceptable change

Based on risks of loss of life and structural damage as a result of a magnitude>5 quake.

Risk assessment table

		Without mitigation			With specified mitigation		
Scenario	**Area**	**Likelihood**	**Consequence**	**Risk**	**Likelihood**	**Consequence**	**Risk**
No exploration	within 50 km of wells	very unlikely	substantial	very low	very unlikely	moderate	very low
Exploration only		unlikely	substantial	low	unlikely	moderate	low
Small gas development		very likely	substantial	moderate	very likely	moderate	low
Large gas development		almost certain	substantial	high	almost certain	moderate	moderate
No exploration	beyond 50 km of wells	very unlikely	substantial	very low	very unlikely	substantial	very low
Exploration only		very unlikely	substantial	very low	very unlikely	moderate	very low
Small gas development		unlikely	substantial	moderate	unlikely	moderate	moderate
Large gas development		not likely	substantial	moderate	not likely	moderate	moderate

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide “best practice” (or “good practice”) guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

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Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Baseline information on seismicity and active faults. It is clear from available information that there are active structures in the region. However, given the sparse seismograph station distribution in the country, especially in the Karoo (SEA region), the available data is not adequate to identify and characterise the active structure. Improved monitoring by densifying the network would certainly assist. Detailed geological and geophysical studies of identified structures would also be necessary [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[If needed and useful to decision makers]

List of Digital Appendices (e.g. GIS Surfaces)

Water Resources, both on the Surface and Underground

Integrating Authors	P. Hobbs and L. Day
Contributing Authors	H. Coetzee, D. Hohne, M. Mosetsho, L. Chevallier, P. Rosewarne J. Ewart-Smith; N. Rivers-Moore, M. Kemp S. Esterhuyse
Corresponding Authors	Many

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages, General discussion about the scarcity and value of water in the Karoo environment and its role as a key constraint in the proposed activity (shale gas development or SGD). Include extent of existing water use allocations in relation to available water, and issues of water quality (fitness/suitability for use) in some areas and for some sources.

What is meant by this topic? Ground and surface water which is accessible and of usable quality.. The issue excludes the treatment and disposal of waste water, although it does consider the impacts / risks associated with a failure in waste collection (e.g. spills). This issue has links to most other issues included in the SEA, reflecting the importance of water resources for most landuse and activity types. The confidence levels associated with predictions made in this issue should be similarly reflected in linked chapters, drawing information from the Water Resources chapter of the SEA. Direct links to the Waste Management, Biodiversity and Agriculture issues will be specifically made during compilation of this section. Key assumptions.

Key definitions

Aquifer

Flowback

Produced water

Overview of international experience

Contamination of groundwater and rivers/streams by shale gas exploration and development of an associated industry, based on available literature.

Special features of the Karoo environment

Brief overview of main issues affecting water resources in semi-arid and arid areas.

Relevant legislation, regulation and practice

Relevant water related legislation.

Key potential impacts and their mitigation

[~6 pages]

A geological analysis will form the basis for the conceptualisation of groundwater and surface water flowpaths and interactions between surface water and groundwater. The issue will rely on existing data and guidelines that are most relevant to the study area and possible threats posed by fracking. New

information generated by the three deep exploration boreholes being drilled as part of the CIMERA-KARIN programme will further inform this assessment.

[Graphics: showing comparable water uses (e.g. sheep, cattle, game, human, game, fracking) in relation to windpump hours / small farm dam volumes, to aid understanding.]

The authors have a detailed tabulation of potential impacts and impact mechanisms under each phase.

This section will comprise brief descriptions of the main water resource components considered namely:

Groundwater

Quantity & availability (supply versus demand, existing use), Quality & suitability (fitness for use)

[Both aspects will be based on available data (mainly DWS) for depth to water table, groundwater quality, borehole yield (aquifer productivity) and aquifer type. The All Town Survey data (DWS) will provide an indication of the reliance of towns and communities on groundwater resources and the quantum of this use. The 1:500 000 scale hydrogeological map coverages will provide the basis for the description. Data and information generated by the Karoo Groundwater Expert Group such as their Groundwater Atlas will also be utilized in the assessment.]

Surface water

Quantity & availability, Quality & suitability, Aquatic habitat types

These sections will draw on existing hydrological and water quality data (mainly DWS data but some data included in published literature) as well as NFEPA data relating to aquatic ecosystem types, to tie in with biodiversity assessments.

Surface / groundwater interactions

A 3-dimensional diagram will be provided to illustrate surface groundwater interactions.

Risk assessment

How the risks (and opportunities where appropriate) are measured

Quantities (m^3), flows (m^3/y) and water quality metrics and standards

Limits of acceptable change

The approach to this section will be developed further during development of this chapter. It will however make use of existing relevant guidelines; policies and legislation, including Water Quality Guidelines for various user groups (e.g. stock watering, aquatic ecosystems, etc.).

Legislated setbacks (e.g. 1000m setback from watercourses) will also be included in this section as well as reference to the DMR Technical Regulations relevant to water resources.

For groundwater, limits will need to consider acceptable change in both quantity (e.g. magnitude of natural fluctuation over time versus impacted state) and quality (e.g. naturally versus polluted).

Risk assessment table

Supporting documentation for the risk assessment would include generation of maps, showing areas of different sensitivity to specified impacts. Generation of the surface water resources sensitivity map would (at this stage) be based largely on an annotated overlay of the (existing) layers for: groundwater – dependent ecosystems (GDEs); NFEPA wetlands; springs (DWS data); and the 1:500 000 scale hydrogeological map coverage. This might be further broken down into quinary (or other) catchments, annotated with regard to proportion of existing water allocations, out of the allowable total. Risk to groundwater resources will be assessed on the basis of the material available, primarily depth to water table, aquifer type and groundwater quality. The risk assessment itself would refer directly to the impacts described in above sections, and would be tabulated. Those areas (catchments?) where Reserve Determinations have been carried out will also factor in the risk assessment. Supporting documentation would be provided in Appendices.

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Reduction in usuable water for people and other economic activities	In wellfield vicinity or region where water is being sourced	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Contamination of surface water resources through spills and discharge	Downstream of potential waste discharge							
Contamination of groundwater resources	In vicinity of wellfields							

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide “best practice” (or “good practice”) guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

This section will address specific data, policy and institutional gaps identified during the course of the study.

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulation of risk assessment assumptions

Digital Appendices (GIS Surfaces of groundwater resources and surface water features)

Impacts on Human Health

[This issue was a late addition to the list, and the authors did not meet at the first author meeting. What follows in a rough outline only]

Integrating Author/s	Bettina Genthe
Contributing Authors	Jessica Chamier
Corresponding Authors	Authors from Water, Air, Planning and Social Fabric Chapters

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Reductions in human life expectancy, or increases in disability, as a result of shale gas exploration and development, through air and water contamination. Links to Water and Air quality affecting quality of life. This chapter excludes occupation health and safety risks.. Key assumptions.

Sidebar on key definitions and abbreviations

Overview of international experience

In relation to human health impacts of shale gas exploration and development

Special features of the Karoo environment from a health perspective

Perceived healthy environment, but many impoverished and health-compromised communities

Relevant legislation, regulation and practice

Text here

Key potential impacts and their mitigation

[3 pages] Draws on water, air quality, social fabric, noise, infrastructure chapters and own sources.

Diagrams and maps encouraged.

For each distinct impact type, discusses how it comes about, what the drivers (SGD-related causes), who/what/where and when impacts are experienced and their consequences, and what actions can be taken to mitigate the impacts.

Risk assessment for human health

How the risks are measured

Carcinogenic and toxic risks.

Limits of acceptable change

Based on national benchmarks for mortality and morbidity

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Risk identification	Near to SGD areas	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

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Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules). Principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

List of Digital Appendices (e.g. GIS Surfaces of populations at health risk)

Biodiversity & Ecological Impacts: Landscape Processes, Ecosystems and Species

Integrating Author/s	Driver, Holness
Contributing Authors	Todd, Daniels, Snaddon, Hamer, Raimondo
Corresponding Authors	Many

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Elements of biodiversity: landscapes, ecosystems, species and how they interact, ecological infrastructure, fundamental underpinning of biodiversity issues. Includes aquatic biodiversity and ecosystems. Links to: Water Resources, Tourism, Visual, Noise, Sense of Place, Agriculture. Key assumptions.

Key definitions

Biodiversity

Overview of international experience

In relation to ecology and biodiversity as affected by shale gas exploration and development

Special features of Karoo ecology and biodiversity

Endemism, resilience and fragility of arid systems

Relevant legislation, regulation and practice

NEMA Biodiversity, NBSAP

Key potential impacts and their mitigation

[6 pages] Supporting boxes on Fairy shrimps (ephemeral species - landscapes that are more sensitive than they look, actually are an aquatic feature), Persistence of long term impacts from short term activities – e.g. driving through arid landscape and disturbing soil crust; Alien species – e.g. Prosopis (response to disturbance);Riverine rabbit as a critically endangered habitat specialist; Ecosystem drivers (e.g. aardvark, why are they important, risk by noise, light, roadkill).

Which activities associated with shale gas development are relevant for ecology (e.g. we are not particularly interested in the actual drilling process, the actual drilling footprint is probably less significant than the ancillary infrastructure, noise and light may be an issue for specific species, roads/vehicles).

Road construction, Noise sources, Light Pollution, Human Presence/Activity, Direct Vehicle impacts, Dust, Vegetation clearing / Direct Habitat Loss (especially for key species), Chemical Spills, Erosion &

Siltation, Alien plant invasion, Waste water impacts, Ecological processes – habitat fragmentation, loss of overall habitat integrity.

Within each of these there will be a description of the impact and how it comes about and the mitigation options.

Cumulative Impacts – why we are not very worried about the specific sites so long as there is local level adjustment – ecological integrity of the landscape far more critical.

Basis for spatial mapping of sensitive areas – what is included, why, and how we mapped it. Categories of distinct receiving areas – Varying levels of Ecological Importance

- Not intact – all areas that are not intact and are nor servicing some other important ecological need, e.g. urban, larger scale highly degraded areas, large arable intensive lands.
- Moderate-Low - Other natural and semi-natural landscapes - without specifically identified important features or sensitivities. For aquatic systems they play an insignificant ecological role in moderating the quality and quantity of water in the region.
- High ecological importance – natural areas with a high biodiversity value, sensitivity or important ecological role/service/process.
- Highest ecological importance – unique habitats and critical areas that serve as key habitat for rare, endemic and endangered species, or perform critical ecological functions.

Risk assessment

How the risks (and opportunities where appropriate) are measured

Reduction of populations, loss of ecosystem area of various levels importance

Limits of acceptable change

Critical ecosystem and population thresholds

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Loss of critical ecosystems	In SGD area	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Loss of threatened species	In SGD area and exploration area							
Loss of ecosystem	In SGD area							

function								

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

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Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Incomplete mapping of wetlands and water courses; Incomplete mapping of species of special concern; Incomplete knowledge of ecological requirements of certain species of special concern; and interactions, cascading effects and impacts on process; Poor knowledge about specific response to impacts (e.g. light impacts on nocturnal impacts, and soil vibrations impact on ground living species).

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[Species at risk]

List of Digital Appendices (GIS Surfaces of ecosystems sensitivity)

Impacts on National and Local Economic Performance

Integrating Author/s	Hugo van Zyl
Contributing Authors	Barry Standish, Tony Leiman, Saliem Fakir
Corresponding Authors	To be added

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

[1000 words] Discuss what key issues are, why they are important and what is broadly known. Include brief description of the economy focusing on the region with some key macro-economic considerations included.

Key economic terms

What is meant by this topic? Separate treatment of macroeconomic and local impacts to the degree possible. It is recognised that there would be overlap between some economic impacts. The primary focus is on the generation of management and mitigation measures including measures for the enhancement of opportunities. Key assumptions: the production scenarios essentially assume financial viability. The numerous key factors that will ultimately determine viability are, however, highlighted. Draws on selected other specialist studies especially Tourism and agriculture, energy. Comparisons between alternative energy sources and their economic and other strategic implications will not be considered here

Overview of international experience

Emerging evidence primarily for the United States indicates that shale gas development has the potential to result in highly significant economic opportunities and risks. It is therefore important to consider these when undertaking a strategic assessment.

Special features of shale gas from an economic perspective

Potential to have macro-economic impacts such as on the balance of payments and in providing additional energy supplies, value addition opportunities. Potential to foster regional and local economic development. Potential to result in risks particularly to the agricultural and tourism sectors.

Relevant legislation, regulation and practice

Text here

Key potential impacts and their mitigation

[~5 pages] Conceptual diagram to be produced that introduces all impacts being considered. Focus of assessment would be on:

Macro-economic impacts

[2000-3000 words] (Assess macro-economic opportunities and risks at strategic level. These are likely to include impacts on the balance of payments, fiscal impacts and risks such as Dutch Disease).

Impacts from project spending and commercial activity

[3000-4000 words] (Mostly at a local and regional level); Shale gas development would result in a spending injections and catalytic effects on commercial activity. These can be assessed with a focus on the regional scale and including a consideration of the following indicators: jobs and skills development; Incomes; Business opportunities; Catalytic effects (e.g. lower energy prices, new source of energy).

Impacts on agricultural and tourism economies

[750 words] Agriculture and Tourism are the key sectors in the regional economy that are likely to face increased risks. These risks are to be assessed fully in the relevant specialist studies including a consideration of socio-economic risks. This section thus provides a brief synopsis of the findings of Agriculture and Tourism Studies in order to ensure that risks to this sector are considered when assessing overall economic impacts.

Impacts on municipal finances

[1000 words] Impacts are likely to stem from development activities, increased workers and from job seekers who place a greater burden on services without necessarily contributing to municipal finances. Social Fabric team to assess level of influx which is then point of departure for Spatial Planning team to assess increased strain on infrastructure/ services. The focus of the economic assessment would be on what these impacts may imply for municipal finances and how risks in this regard can be mitigated. This section would also address the more general issue around covering potential damage and closure costs that are not only a risk to municipalities.

Impacts on property values

[1000 words] The nature of shale gas development implies that it would have the potential to result in negative and positive impacts on property values. Potential for such impacts would be assessed with reference to findings regarding impacts principally for the United States.

Risk and opportunity assessment

How the risks (and opportunities where appropriate) are measured

Macroeconomic indicators, jobs (by type), local economic activity

Limits of acceptable change

Not yet clear how this would apply to economic impacts – to be considered.

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Macro-economic impacts	National	Scen 1						
		Scen 2						
		Scen 3						

		Scen 4						
Impacts from project spending and commercial activity	Regional/local	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Risks to agriculture and tourism	Regional/local	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Impacts on municipal finances	Regional/local	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Impacts on property values	Regional/local	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

List of Digital Appendices (GIS Surfaces e.g. of economic activity)

Electromagnetic Interference with Radioastronomy

Integrating Author/s	Adrian Tiplady
Contributing Authors	Paul van der Merwe, Braam Otto
Corresponding Authors	Rob Millenaar ?

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Risk to radio astronomy infrastructure investment - Strategic national policy for investment in radio astronomy infrastructure, National and international investment into the Square Kilometre Array

Sidebar on key definitions and abbreviations

Overview of international experience

In relation to radio interference in shale gas exploration and development

Special features of the Karoo Radio Astronomy environment

Summary of previous work on Electromagnetic Interference and the SKA – Report by the Working Group of the Inter-Ministerial Task Team on Hydraulic Fracturing, SKA SA and SKAO EMC Requirements Definitions, Links to other topics.

Relevant legislation, regulation and practice

Special Astronomy Area Act

Key potential impacts and their mitigation

Description, in generic manner, of impact of EMI on radio astronomy. Map and diagram of highest Impacted Telescope or Telescope Systems. Technological Activity leading to EMI, extent of Spectrum Interference. Description of EMI, key sources as expected during construction, operation and decommissioning, both on-site and supporting activities and infrastructure, expected levels of EMI and acoustic noise – possible on a 'per site/per phase' basis, assessment of dependencies – magnitude (quantity of sources) and time (when, and for how long).

Risk assessment

How the risks are measured

Modelled EMI fields from known sources relative to defined receptors

Limits of acceptable change

Specified in Act, Threshold of acceptable emissions, received by the impacted telescope systems, as determined by appropriate legislation, gazetted South African Radio Astronomy Service (SARAS) levels, and adopted standards.

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Impairment of SKA	SKA area	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Key areas where assumptions had to be made as a result of lack of detailed information. This will primarily be a lack of representative measurement data on the types of equipment, quantity and time of use. Should this data be acquired for exploration, operation and decommissioning phases, it will help improve the accuracy of the propagation predictions used in the impact assessments, and hence risk assessment [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[If needed and useful to decision makers]

List of Digital Appendices (GIS maps of modelled EMI propagation)

Noise Generated by Shale Gas-related Activities

Integrating Author/s	Andrw Wade
Contributing Authors	Adrian Jongens
Corresponding Authors	

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Relevance of Acoustic Noise on Humans and Biodiversity. What is included and excluded? Why is it important? Links to Biodiversity, Senses of Place. Key assumptions.

Sidebar on key definitions and abbreviations

Overview of international experience

In relation to noise from shale gas exploration and development

Special features of the Karoo acoustic environment

Has reputation of being very quiet

Relevant legislation, regulation and practice

Noise protection regulations

Key potential impacts and their mitigation

[2 pages] Description, in a generic manner, of impact of acoustic noise on humans. Map and diagram of highest impact on Land Use. Machinery and Associated Equipment. Noise Level Difference – conceptual map. Description of Acoustic noise, and key sources as expected during construction, operation and decommissioning, both on-site and supporting activities and infrastructure, on a 'per site/per phase' basis, assessment of dependencies – magnitude (quantity of sources) and time (when, and for how long).

Risk assessment

How the risks are measured

dB and difference relative to background

Limits of acceptable change

Regulations? Limits of audability? Significant difference to background?

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Disturbance to humans due to noise	Within audible distance of activity centres	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Disturbance to sensitive species	Within distance of roads, wellpads							

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[1 page] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Key areas where assumptions had to be made as a result of lack of detailed information. This will primarily be a lack of representative measurement data on the types of equipment, quantity and time of use. Should this data be acquired for exploration, operation and decommissioning phases, it will help improve the accuracy of the propagation predictions used in the impact assessments, and hence risk assessment [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[If needed and useful to decision makers]

List of Digital Appendices (e.g. GIS Surface of noise propagation)

Impact on Sense of Place Values

Integrating Author/s	Leanne Seeliger
Contributing Authors	Mike de Jongh, David Morris
Corresponding Authors	Doreen Atkinson, Katie du Toit and Jocelynn Minnaar

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Examine different definitions of sense of place values to demonstrate the scope of sense of place values. In so doing we will demonstrate how sense of place values link to people's sense of identity, their attachment to places and their livelihoods. We will stress how sense of place values are subjective, socially constructed, not always linked to land ownership and how they shift over time. Physical and spatial surroundings have an influence on the interactions and relations of humans as well as on the construction of identity by way of concretising space within the world i.e. the contexts within which 'life takes place'. The special challenge is to develop a focus on the way space is imagined as a way to explore the processes through which such conceptualising of place-making meets the changing regional economic, demographic and political conditions of lived spaces---the relation between place and space. The experience of space is always socially constructed. With meaning-making understood as a practice, how are spatial meanings established? Who has/had (historically) the power, or lack of power, to make places of spaces? Who contests this (and how)? What is at stake? Such questions are particularly important where the meaningful association of places and people/communities is concerned. There is also the, sometimes, problematic link between identity and place. And finally, there might be the assumed isomorphism of space, place and socio-cultural practices. This strategic issue links with all the

> "Sense of place is a multi-theoretical, complex and contested concept (Convery, Corsane, & Davis, 2012, p. 6), which has been approached from a phenomenological and behavioural perspective. Location as such is not a sufficient condition to create a sense of place, attachment or a sense of belonging. There is a need for a long and deep experience of a place, and preferably involvement in the place (Shamai, 1991). Ritual, myths and symbols help in strengthening the attachment to place (Relph, 1976) and bind people to a place (Tuan,1977). Carter, Dyer and Sharma (2007) argue that because meanings invoke personal emotions and are formed from diverse experiences and values, a sense of place may be both shared and contested at a single locality (Arefi, 1999), producing 'territories of meaning' (Relph, 2002)." In Values in place: A value-orientated approach toward sustainable place-shaping. L.G. Horlings Regional Studies, Regional Science Volume 2, Issue 1, 2015.

other strategic issues, be it economic (tourism and fracking), social (Karretjie People, South Africans, non-South Africans) or ecological (water, biodiversity) because each will defend sense of place in a specific way.

Overview of international experience

How shale gas exploration and development has affected the sense of place in other countries?

Special features of the Karoo as an iconic place

The diversity of perspectives that we will explore includes: landowners (sheep, angora, cattle, game farmers), absentee landlords, lifestyle farmers, retirees, townspeople (South Africans and non-South Africans), developers (fracking and property), informal settlement dwellers, migrants, landless poor, artists, labourers, tourists, conservationists, palaeontologists and hunters. We will also describe some of the perceptions of sense of place that emerge between generations both from the youth and the aged.

Relevant legislation, regulation and practice

[Probably no formal regulations, but there are practices and case law]

Key potential impacts and their mitigation

[~4 pages] What elements contribute to senses of place, among whom, and how is the sense of place altered by shale gas development activities, and how impacts can be mitigated.

Risk assessment

How the risks are measured

Expert judgement, perhaps using a very broad panel

Limits of acceptable change

Expert judgement, as above

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Loss of sense of place to key stakeholders	Places within sight or sound of wellfields or other facilities	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Loss of sense of place to key stakeholders	‘Karoo’ as a region/landscape							

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages]

Topics on which information is inadequate for decision-making

Inadequacy of current data and understanding on this issue. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

List of Digital Appendices (GIS Surfaces of Senses of Place sensitivities)

Impact on Waste Planning and Management

Integrating Author/s	Prof Suzan Oelofse
Contributing Authors	Dr Johan Schoonraad
Corresponding Authors	Dr Dave Baldwin

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Hydraulic fracturing and the production of natural gas from fracked wells yield wastes that must be managed responsibly to avoid potential harm to the environment and human health. The wastewaters generated are known as "flowback" and "produced water" and both contain potentially harmful pollutants including salts, organic hydrocarbons (oils and grease) inorganic and organic additives and naturally occurring radioactive materials (NORM). These pollutants are toxic, radioactive or corrosive in nature. They can cause degradation of ecosystem health by depleting oxygen or causing algal blooms, or they can interact with disinfectants at drinking water plants to form cancer-causing chemicals (Hammer and van Briesen, 2012). The solid wastes produced are mostly drill cuttings (mud) or sludges from the wastewater treatment. Municipal solid waste associated with worker deployment to the area and opportunistic migrants looking for employment and other economic opportunities are also considered. Issues not covered in this issue paper are: Non-water related impacts of wastewater management (with limited exceptions). Such impacts include air emissions from open wastewater storage pits and trucks used to haul wastewater, noise and traffic impacts from those trucks, soil contamination, land disturbance impact from the construction of wastewater management facilities, and energy demand associated with wastewater treatment processes. Impacts of spills during off-site transport of wastewater or waste. Such spills may result from accidents, from inadequate management or training, or from illicit dumping. Linkages to infrastructure, water, health. Assumptions: Operators/prospectors must fully disclose the composition of the fracturing fluid additives as this will determine the classification of the waste and the treatment options required to ensure correct treatment and proper management of the waste streams. The expected volumes of waste and wastewater to be produced as this will determine whether onsite or off-site treatment and disposal will be required.

Key definitions and abbreviations

"Flowback" refers to fracturing fluid injected into a gas well that returns to the surface when drilling pressure is released

"Produced water" refers to all wastewater emerging from the well after production begins, much of which is salty water contained within the shale formation.

Source: Hammer and van Briesen, 2012

Overview of international experience
How shale gas exploration and development has affected waste flows in other places.

Special features of the Karoo in relation to waste
Currently no specialized facilities, only (overloaded) municipal dumps.

Relevant legislation, regulation and practice
There is extensive legislation on this topic, as well as industry practices.

Key potential impacts and their mitigation
The authors have a comprehensive list of waste-generating pathways and handling options, including inter alia Drilling fluids, Drilling muds, Fracturing fluids, Lubricating oils and greases, Contaminated land (spills on-site), Domestic waste, Sewage, Construction waste etc. Composition of the waste is important in terms of classification and management of the waste-it is likely that most of the waste will be Type 1 hazardous waste. NNR is important player for radio-active waste; can the municipalities handle the additional waste loads at facilities (landfill and sewage plant)?

On-site storage impoundments and tanks
As with any liquid in storage there is a risk of accidental spills and mismanagement that can cause releases to the environment and associated impacts on water, soils and communities.

Off-site management and disposal
The current off-site treatment options are limited to two licensed hazardous waste treatment facilities in PE and Cape Town for hazardous waste. Municipal wastewater treatment works are unlikely to have the capacity or required technologies to treat the wastewater from this process.

Deep well injection
This is a common disposal option in the USA, but due to the South African geology it is not an option.

Surface water discharge
Surplus water not recycled back into the operations may be discharged into surface water resources. There is a risk of pollution if the water quality is not sufficient.

Land application
Application of produced water to roads for dust control has several potential impacts.

Residuals management
Regardless of the treatment options selected, residuals – the concentrated brines and solids containing the chemicals removed from the produced water – will be created as a waste.

Risk assessment

How the risk are measured
Tonnes of various types of waste generated in relation to handling capacity.

Limits of acceptable change

Handling capacity of facilities.

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Exposure to hazardous waste	Near disposal or spillage site	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

List of Digital Appendices (GIS Surfaces)

Impact on Land, Infrastructure and Settlement Development

Integrating Author/s	Elsona van Huyssteen and Cheri Green
Contributing Authors	Mark Oranje, Phil Paige-Green Sharon Lewis, Stephen Berrisford
Corresponding Authors	Gerbrand Mans

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? Unconventional gas area land development implications, land use change approvals, local infrastructure requirements and implications, growth implications for towns and broader region, broader regional infrastructure and logistic implications. Linkages to social fabric, economics, waste.

Sidebar on key definitions and abbreviations

Overview of international experience

How shale gas exploration and development has affected spatial development, planning and infrastructure in other places.

Special features of the Karoo region focusing on towns infrastructure

Very sparse rural population, but often under developed and under capacitated towns, limited capacity for maintenance, location to and dependent on major transport corridors.

Relevant legislation, regulation and practice

Complex array of current and new spatial planning legislation and requirements se,g, SPLUMA.

Key potential impacts and their mitigation

The impact system across spatial scales: On site context, towns most likely to be affected and regional corridors. Per scenario:

Pressure of use on regional infrastructure and logistic networks

Localised construction, upgrading and maintenance of infrastructure

Infrastructure and resource implications of rapid development to handle required service delivery

Complex and interlinked land development regulatory processes

Co-ordinated and aligned spatial and infrastructure investment

Risk assessment

How the risks and opportunities are measured

Infrastructure capacity in relation to demand

Limits of acceptable change

Assess the percentage increase in local road and infrastructure construction volumes and densities in relation to available raw material and footprint on local landscape. Assess capacity and heavy vehicle flows on lifespan of regional through-routes / logistic corridors. Assess procedural bottlenecks in regulatory requirements, municipal resource capacity to handle land use applications and or to access cumulative impacts. Assess potential for unintended settlement growth and service delivery requirements and pressures for timeous infrastructure and spatial planning to address consequences.

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	Likelihood	risk	level	likelihood	risk
Pressure on regional road infrastructure	Along transport corridors	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Extensive development of minor roads	Within SGD area	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Increased demand for municipal capacity (manpower and expertise) to deal with land use applications/changes	Within SGD area	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Demand for new settlement development and local infrastructure	Within existing towns	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Increased requirements to conduct intergovernmental spatial planning	Entire Region	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[~2 pages] For minimising impacts related to governance, land, infrastructure and settlement development in exploration, development and closure phases. This section will provide “best practice” (or “good practice”) guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

List of Digital Appendices (GIS Surfaces)

Impact on Agriculture

Integrating Author/s	Noel Oettle
Contributing Authors	Lehman Lindeque, Justin du Toit, Igshaan Samuels, Mariné Pienaar
Corresponding Authors	Antony Osler, Susi Vetter, Emma Archer Van Garderen

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages, Agriculture is the primary land use in the Karoo.

Dryland cultivation

Rangelands

Azonal vegetation

What is meant by this topic? Agriculture in the context of this chapter is understood to mean the production of food and fibre from natural resources to support the livelihoods, both within the cash economy and for subsistence and cultural purposes. It is the effective management of the synergies between climate, soil, vegetation, water and livestock that sustains the livelihoods of most people in the Karoo. Primary types of farming: Livestock, both extensive and intensive, Dryland cultivation, including subsistence, small-scale and commercial, Cultivated irrigated land, both small scale and commercial, Game farming, Tourism related production, including both eco-tourism and farm-stays. Links to other topics: Linkages: ***Economics***: Investment and incomes from agriculture; valuation of non-monetised benefits derived from agricultural resources; value chain analyses. ***Biodiversity***: Contribution of farming to biodiversity loss and conservation; indications where farming contribute or impact negatively on biodiversity corridors; Impacts of tracks of heavy machinery in the landscape. ***Water***: Dependency of agriculture on surface and ground water; possible temporal and spatial impacts on water resources, water quality requirements for humans, game and livestock ***Sense of place***: Sustainability of farming communities and the role of farmers in the general sense of place associated with the Karoo. ***Tourism***: On-farm tourism activities and likely impacts; Niche market like Karoo lamb, organic food, trophy hunting etc. ***Geophysics***: Damage to infrastructure caused by exploration and exploitation activities, and compensation for this. ***Spatial planning***: Servitudes, sub-divisions, changes in land use. ***Social fabric***: Impacts on local communities (in-migration, job opportunities, divergent interests fuelling conflict, opportunities for transformation). ***Waste***: Impacts of storage and disposal of chemical waste; impacts of consumptive waste on livestock (plastic bags, etc.) Possible impacts of any fracking related activities, both above and underground on possible pollution of soil, surface and groundwater sources. Key assumptions.

Overview of international experience

Research on the impacts of unconventional gas exploration and development on the agricultural sector internationally indicates that the inevitable environmental disturbance that accompanies hydraulic fracturing will in all likelihood have negative effects on rangeland utilisation. Such

disturbance threatens the stability and integrity of soils, water sources and vegetation and the genetic integrity of livestock. However, rapid developments in the technologies used in the exploitation of unconventional gas, coupled with the intention of the South African government to ensure that adequate regulations are promulgated and enforced are likely to mitigate against some of the more devastating impacts experienced elsewhere in the course of shale gas extraction.

Special features of agriculture in the Karoo

A history of Karoo farming. Currently consisting of relatively small areas of irrigated pastures, crops and orchards, it is the rangelands (mostly bossieveld) of the Karoo and the grasslands of the adjoining Eastern Cape that produce the wealth of the region, in the form of Karoo lamb and mutton, mohair, wool, beef, ostriches and increasingly, game farming. The extensive rangelands of the area designated for exploration of shale gas reserves span a range of arid to semi-arid ecotypes from the Succulent Karoo in the far west, through vast landscapes of Nama Karoo vegetation in the centre to sourveld grasslands in the east, with elements Albany Thicket vegetation in the south-east and Azonal vegetation bisecting through these vegetation types.

Relevant legislation, regulation and practice

Protection of Agricultural Resources Act

Key potential impacts and their mitigation

[5 pages]

Rangeland resource

The impacts of exploration and extraction of shale gas on agricultural production systems will primarily impact upon the rangeland veld resource, upon which sustained production of livestock production depends. Use of heavy prospecting equipment is anticipated to cause long-term damage to veld (and in some cases, to soils) where it moves over the landscape.

Water resources for agriculture

The zones in which the hydraulic fracturing will take place are likely to be so far down in the rock strata as to render the danger of pollution of ground water used for agriculture insignificant. A proportion of the water that is used will be permanently lost, but what is returned or delivered to the surface as flowback and as wastewater will be a mixture of the originally injected fresh water (now contaminated with toxic fracking fluids) and so-called formation water (brackish water from the targeted shale). Indications from international experience are that between 15-80% of the water will be returned to the surface, where it will have to be contained before disposal or reuse, and leakages and pollution of surface and shallow ground water will be a threat to agricultural production. If ingredients similar to those that have been used elsewhere are utilised, the sites of containment dams may be rendered permanently contaminated by toxins, carcinogens and salts.

Demand for agricultural products and services

It is also likely to stimulate further in the area, and to create limited local employment opportunities.

Impacts on farm labour

Exploration and development will lead to an increase in the number of people in the area, will result in a change in the nature of social dynamics and will increase the accessibility of agricultural landscapes for all sorts of people. These disruptions are likely to change the way in which day to day farming activities take place.

Farm security

There are also the very real risks of increased lawlessness (farm murders, livestock theft, and other types of theft, trespassing and damage to structures.

Land fragmentation

Construction of roads for the installation of other infrastructure for gas extraction and transportation of inputs, outputs and waste will fragment the agricultural landscape, remove significant amounts of land from production and render even larger areas unproductive through other effects, advance soil erosion and create opportunities for invasive species to colonise disturbed areas.

Traffic on farm roads

Water will be required for the hydraulic fracturing process, and will have to be transported to the sites from source (the latter may well be outside the Karoo, because the Karoo is generally water stressed). Large volumes of water will thus have to be transported by road.

Four maps will be included in the second iteration of the Agriculture chapter. These are:

- a map with pie charts to indicate the spatial distribution of the main farming types;
- a map indicating the municipal location of farming production systems (subsistence, small-scale, large scale and mixed);
- a map indicating the Degradation and Conservation Index values for the area, based on the variables from the LADA assessment in the area, so as to provide the reader with an overview of which areas are perceived as being the most degraded and which currently have the most SLM measures in place to control land degradation; and
- a map reflecting the social aspects of the agricultural landscape, specifically the number of households depending on agriculture, forestry and fisheries in each local municipality.

Risk assessment

How the risks (and opportunities where appropriate) are measured

Loss of agricultural productivity

Limits of acceptable change

Viability of agricultural enterprises

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Loss of agricultural viability	In vicinity of wellfields	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Loss of agricultural viability	In region as a whole							

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[If needed and useful to decision makers]

List of Digital Appendices (GIS Surfaces of agricultural potential)

Impact on Cultural Heritage

Integrating Author/s	Dr Jayson Orton
Contributing Authors	Dr John Almond, Emeritus Prof. Roger Fisher, Nicholas Clarke
Corresponding Authors	Coenie de Beer (geological heritage), Assoc. Prof. Simon Hall, Patricia Kramer, Dr Antonia Malan, Dr Judy Maguire, Dr David Morris, Liana Muller – cultural landscape, Prof. Fransjohan Pretorius (South African War), Prof. Marainne Tredoux (Meteorites)

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

Palaeontology

Meteorites

What is meant by this topic? What is meant by "Cultural Heritage" in terms of structures, monuments and memorials, archaeology and graves, palaeontology, meteorites and geological heritage, cultural landscapes and living heritage. Why is Cultural heritage important? How is Cultural Heritage linked to other topics such as visual aesthetics, sense of place, tourism, social fabric. What are the assumptions and limitations of this study?

Overview of international experience

What does the literature demonstrate of the risks associated with shale gas development and the aspects of Cultural Heritage mentioned above, considering the various phases of development activities?

Special features of heritage in the Karoo

The study area is question demonstrates a range of Cultural Heritages derived from the built environment, archaeology and graves, palaeontology and cultural landscapes. Many of these sites and regions are of great significance to the people living in the region and recognised internationally for their importance. Use photographs to demonstrate special heritage features in the study area.

Relevant legislation, regulation and practice

List of important sections of the NHRA and what they protect.

Key potential impacts and their mitigation

[6 pages]

Structures, Monuments and memorials

Archaeology and Graves

Palaeontology, Meteorites and Geological heritage

Cultural landscapes

Risk assessment

How the risks are measured

Number and importance of sites affected

Limits of acceptable change

Based on precedent and regulation

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
SGD on built heritage, monuments & memorials Archaeology & graves		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
SCG on Palaeontology, meteorites & geological heritage		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
SGD on cultural landscapes		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
SGD on living heritage		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information on sites

List of Digital Appendices (GIS Surfaces of Heritage vulnerability)

Impact on Tourism in the Karoo

Integrating Author/s	Daan Toerien
Contributing Authors	Gerrie du Rand, Caroline Gelderblom, Melville Saayman
Corresponding Authors	

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? What is meant by tourism, especially in arid areas, what is the history of tourism in the Karoo and what are the key trends? A description of the tourist profile, tourism enterprise structures of Karoo towns, Karoo brand and other tourism products and services. What is the socio-economic importance of tourism in the Karoo? Links to other topics (see below) and key assumptions.

Karoo brand

'Die niks'

Overview of international experience

An assessment of the existing information with specific emphasis on cumulative impacts of shale gas development on tourism in other parts of the world.

Special features of tourism in the Karoo

Tourism routes, towns with high value (architectural tourism), festivals, hospitality facilities, attractions and products. National parks and corridors (biodiversity), agro tourism including game farms (agriculture), scenic assets (visual), archaeological (heritage), astronomy, 'Die Niks'. Use of maps and photographs of special tourism assets.

Relevant legislation, regulation and practice

A description of the legislative framework.

Key potential impacts and their mitigation

[5 pages]

Increased traffic volumes

For tourism in the Karoo, these will be primarily related to and road networks (planning)

Visual and noise disturbance, loss of sense of place

(Visual – spatial footprint, planning, noise)

Increased people impacts on services/infrastructure

(Scenarios team, social fabric, planning)

Karoo Brand

Specific concept of natural/historic, open and quiet area which is sold as tourism asset and which underpins products such as Karoo Lamb (sense of place, social fabric)

Risk assessment

How the risks are measured

Reduction in tourist visitors and spend

Limits of acceptable change

Viability of tourism enterprise

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Traffic		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Visual noise and disturbance		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Demands on services/infrastructure		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Karoo Brand		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information [eg tourist assets]

List of Digital Appendices (e.g. GIS Surfaces of tourism sensitivity)

Impact on Visual Aesthetics

Integrating Author/s	Bernard Oberholzer
Contributing Authors	Quinton Lawson, Graham Young, Menno Klapwijk
Corresponding Authors	

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

landscape typology

geomorphological types

What is meant by this topic? The term 'visual' implies aesthetic, scenic and amenity value of the natural and cultural landscape. Scenic features as a non-renewable resource. Importance of scenic resources to the region's identity and tourism economy. Links with other issues such as heritage, sense of place, agriculture, tourism, social fabric etc. An explanation of the relevance of visual aesthetics in the Karoo context and some of the key assumptions.

Overview of international experience

How have the development of shale plays around the world, particularly in the United States altered the visual aesthetics of regions considering the full life cycle of shale gas development activities from exploration through to closure?

Special visual features of the Karoo

Discuss the landscape typology (geomorphological types and character of each). Use maps to show special landscape features or resources (i.e. scenic features such as dark skies etc.). Show sensitivity of landscapes and receptors.

Relevant legislation, regulation and practice

A description of the legislative framework incl. shortcomings if applicable.

Key potential impacts and their mitigation

[3 pages]

Risk assessment

How the risks are measured

Visibility and contrast to surroundings. Risks measured against scenic value classes and sensitivity to change

Limits of acceptable change

Expert judgement, precedent. Assessed in terms of a recognised, measurable framework for visual resource management (VRM).

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Loss of visual aesthetic	Places from which SGD is visible	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages]. The lack of a scenic classification system and data base, with criteria for rating significance.

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

List of Digital Appendices (GIS Surfaces of visual sensitivity)

Impact on Social Fabric

Integrating Author/s	Doreen Atkinson
Contributing Authors	Rinie Schenk, Karin Badenhorst, Justine Burns, Zachi Mathebese
Corresponding Authors	

Executive Summary

<1 page, 4-8 headline statements with confidence language and pointers to underlying text

Introduction and scope

~2 pages

What is meant by this topic? What is meant by social fabric in terms of institutions, organisations and social units or networks? How is it informed by values, identity and practices? How does it interact with long-term cultural trends, history, and heritage, livelihoods and the natural environment? Why is social fabric important in the Karoo? Links to most of the strategic issue chapters. Key assumptions.

Social fabric: The term "social fabric" embraces a *multitude of phenomena*, ranging from demographic and economic factors (quantitative data) to behavioural issues (e.g. investment choices, political dynamics), to institutional dynamics (keeping in mind that the term "institutions" is also wide-ranging, including diverse entities such as families and municipalities) and, finally, to fairly subtle forms of social networks and relationships. "Social fabric" is, therefore, a very "broad church" of social phenomena, most of which are profoundly shaped by theoretical assumptions.

Overview of international experience

Research into shale gas development in other parts of the world suggests that the activities and broad socio-economic trends associated with the production gas from shales has the potential to alter the way in which social systems function within geographical regions. This will be invested further as part of the assessment.

Special features of the Karoo social fabric

The Karoo region demonstrates a unique but diverse Social Fabric. The dimensions of the social fabric in the study area are likely to be influenced by sudden social changes, whether positive or negative. Even positive changes, such as new factories (or the new independent power producers), may lead to sudden changes in income, which can disrupt fragile social systems. Boom-and-bust cycles of investment (as often found in mining investments) are likely to be even more disruptive. Individuals and families may make decisions which may increase, or decrease, their future resilience.

Relevant legislation, regulation and practice

A description of the legislative framework such as interaction with regional planning documents.

Key potential impacts and their mitigation

[5 pages]

Human migration

Physical security

Altered social relations and institutions

Create new power holders and gate keepers.

Risk assessment

How the risks are measured

[0.5 pages] What are proxies used for spatial risk assessment for each impact type?

Limits of acceptable change

[0.5 pages], based as far as possible on precedent and regulation

Risk assessment table

Impact	Location	Scenario	Without mitigation			With mitigation		
			level	likelihood	risk	level	likelihood	risk
Human migration	East-west of the study area	Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Physical security		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
Social and institutional relations through competition		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						
New power dynamics		Scen 1						
		Scen 2						
		Scen 3						
		Scen 4						

Notes on definition and assumptions regarding impact levels

Best practice guidelines and monitoring requirements

[Typically ~2 pages] This section will provide "best practice" (or "good practice") guidelines that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: Baseline (pre-activity) monitoring; During Planning, During exploration; During production, During closure/post-closure.

Planning

Construction

Operations

De-Commissioning

Monitoring and Evaluation

Topics on which information is inadequate for decision-making

Can raise issues where the information base is inadequate to take the immediate next logical steps (e.g. permitting or disallowing exploration evaluation of shale gas resources in particular areas and with given rules) if this is the case, but principally focused on the information gaps with respect to EIAs and shale gas development and post-development restoration. In general such information gathering will require a multi-year research effort [0.5 pages].

References [as long as needed, typically 1-2 pages, ~30-60 references]

Appendices

Tabulated detailed information

[If needed and useful to decision makers]

List of Digital Appendices (GIS Surfaces of social fabric sensitivity)