Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa

Appendix C
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C.1.1 – Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Fynbos Biome
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Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa

Appendix C.1

Integrated Biodiversity and Ecology

(Terrestrial and Aquatic Ecosystems, and Species Assessment Report)

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

BIODIVERSITY AND ECOLOGY
TERRESTRIAL AND AQUATIC ECOSYSTEMS, AND SPECIES

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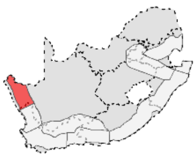
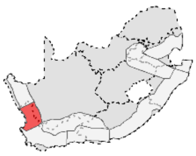
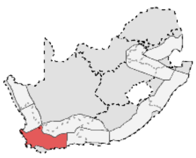
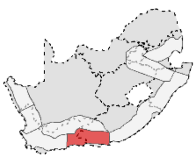
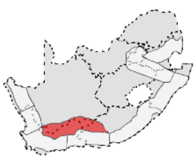
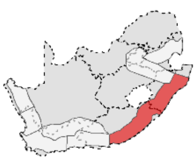
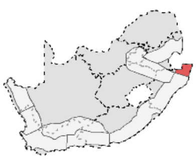
ABBREVIATIONS AND ACRONYMS

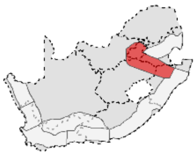
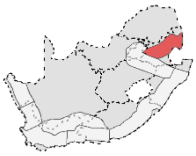
AOO	Area of Occupancy
EOO	Extent of Occurrence
CARA	Conservation of Agricultural Resources Act (43/1983)
CBA	Critical Biodiversity Area
CR	Critically Endangered
DEA	Department of Environmental Affairs
ECBCP	Eastern Cape Biodiversity Conservation Plan
EC	Eastern Cape Province
ESA	Ecological Support Area
EN	Endangered
EWT	Endangered Wildlife Trust
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EFZ	Estuary Functional Zone
GA	General Authorisation
GIS	Geographic Information System
HDD	Horizontal Directional Drilling
IDP	Integrated Development Plan
IUCN	International Union for Conservation of Nature
IAP	Invasive Alien Plant
KZN	KwaZulu-Natal
MLRA	Marine Living Resources Act (18/1998)
MAR	Mean Annual Runoff
MBSP	Mpumalange Biodiversity Sector Plan
NEMA	National Environmental Management Act (107/1998)
NEM:BA	National Environmental Management: Biodiversity Act (10/2004)
NEM:ICM	National Environmental Management: Integrated Coastal Management Act (24/2008)
NEM:PAA	National Environmental Management: Protected Areas Act (57/2003)
NEM: WA	National Environmental Management: Waste Act (59/2008)
NFA	National Forest Act (84/1998)
NFEPA	National Freshwater Ecosystem Priority Areas
NP	National Park
NPAES	National Protected Area Expansion Strategy
NWA	National Water Act (36/998)
NWRS	National Water Resource Strategy
NT	Near Threatened
PES	Present Ecologcial State
PA	Protected Area
QDGC	Quarter Degree Grid Cell
ROW	Right of Way
SACAD	South African Conservation Areas Database
SANParks	South African National Parks
SAPAD	South African Protected Areas Database
SABAP	Southern African Bird Atlas Project
SADC	Southern African Development Community
SDF	Spatial Development Frameworks
SPLUMA	Spatial Planning and Land Use Management Act (16/2013)
SCC	Species of Conservation Concern
SEA	Strategic Environmental Assessment
SWSA	Strategic Water Source Areas
ToPS	Threatened or Protected Species Regulations (2013)
VU	Vulnerable
WC/WDM	Water Conservation and Water Demand Management
WUL	Water Use License
WCBSP	Western Cape Biodiversity Spatial Plan
WHS	World Heritage Site

1 SUMMARY

This chapter consolidates the potential impacts from the development of gas transmission pipeline infrastructure on terrestrial and aquatic ecology and biodiversity in nine proposed gas pipeline corridors in South Africa (Table i). The ecological and biodiversity environmental aspects of the proposed gas pipeline phases have been grouped according to the biomes that are found within the corridors, which act as the point of departure for terrestrial ecosystems and the fauna that inhabit these systems. The aquatic ecosystems considered include freshwater and estuarine habitats, and associated species.

Table i: Summary of key environmental features of the proposed gas pipeline corridors. Section references for the environmental description and sensitivity mapping for each corridor is indicated in the last column.

Proposed gas pipeline corridor	Brief description	§
Phase 6 	• Fynbos, Succulent Karoo, Nama Karoo, Desert vegetation types in the Northern Cape and Western Cape Provinces. • Mostly arid environment, with prominent protected areas that include the Richtersveld and Namaqua National Parks (NPs), with extensive areas earmarked as potential National Protected Areas Expansion Strategy (NPAES) focus areas. • Relatively untransformed when compared to the other proposed gas pipeline corridors.	4.2.1 5.2.1
Phase 5 	• Fynbos, Succulent Karoo vegetation types in the Northern Cape and Western Cape Provinces. • Notable protected environments include the Cederberg and Winterhoek Mountains. • Relatively transformed by settlements and cultivation.	4.2.2 5.2.2
Phase 1 	• Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket vegetation types in the Western Cape Province. • Extensively transformed by settlements and cultivation, as such many of the remaining ecosystems are of conservation importance and currently protected.	4.2.3 5.2.3
Phase 2 	• Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket, Grassland vegetation types in the Western Cape and Eastern Cape Provinces. • Extensively transformed around major towns (Mossel Bay, George, Port Elizabeth) due to urban settlement and agriculture.	4.2.4 5.2.4
Inland 	• Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket, Grassland vegetation types in the Western Cape, Northern Cape and Eastern Cape Provinces. • Relatively untransformed when compared to the other proposed gas pipeline corridors.	4.2.5 5.2.5
Phase 7 	• Fynbos, Nama Karoo, Albany Thicket, Savanna, Grassland, Indian Ocean Coastal Belt vegetation types in the Eastern Cape and KwaZulu-Natal Provinces. • Transformed by urban settlement and agriculture, especially between Durban and Richards Bay in the KwaZulu-Natal Province. • Many aquatic systems (rivers, wetlands and estuaries) present.	4.2.6 5.2.6
Phase 4 	• Savanna, Indian Ocean Coastal Belt vegetation types in the KwaZulu-Natal Province. • Relatively untransformed when compared to the other proposed gas pipeline corridors, with many protected areas associated with large wetlands present.	4.2.7 5.2.7

Proposed gas pipeline corridor	Brief description	§
Phase 3 	• Savanna, Grassland vegetation types in the KwaZulu-Natal, Free State, Mpumalanga, Gauteng, and North-West Provinces. • Extensively transformed by settlements, agriculture and mining.	4.2.8 5.2.8
Phase 8 	• Savanna, Grassland vegetation types in the Mpumalanga Province. • Extensively transformed by settlements, agriculture and mining, with the Kruger NP occupying the eastern part of the corridor. • Kruger NP occupies most of the eastern corner of this corridor.	4.2.9 5.2.9

Highly sensitive ecological features exists in all corridors, and are mainly related to protected areas and areas identified in Provincial Conservation Plans as Critical Biodiversity Areas (areas characterised by key ecological processes, ecosystems and species required to meet conservation targets and protect South Africa's biodiversity) (Figures i and ii), as well as estuaries (Figure iii). Areas that have already been transformed by anthropogenic activities such as urbanisation and agriculture are mainly of low sensitivity (Figure i). Aligning the proposed pipeline routings to follow existing disturbance corridors presents an (environmental) opportunity.

Proposed gas pipeline corridors in more arid areas (i.e. Phases 6 and Inland) are less sensitive from an aquatic ecology perspective due to the relatively limited presence of aquatic features. Due to existing pressures from other anthropogenic activities many of the aquatic ecosystems in the rest of the country are threatened and are resultantly highly sensitive to new development (Figure ii). The most sensitive aquatic ecosystems must be avoided as far as reasonably possible, else mitigated using engineering solutions and best practice to reduce potential impact.

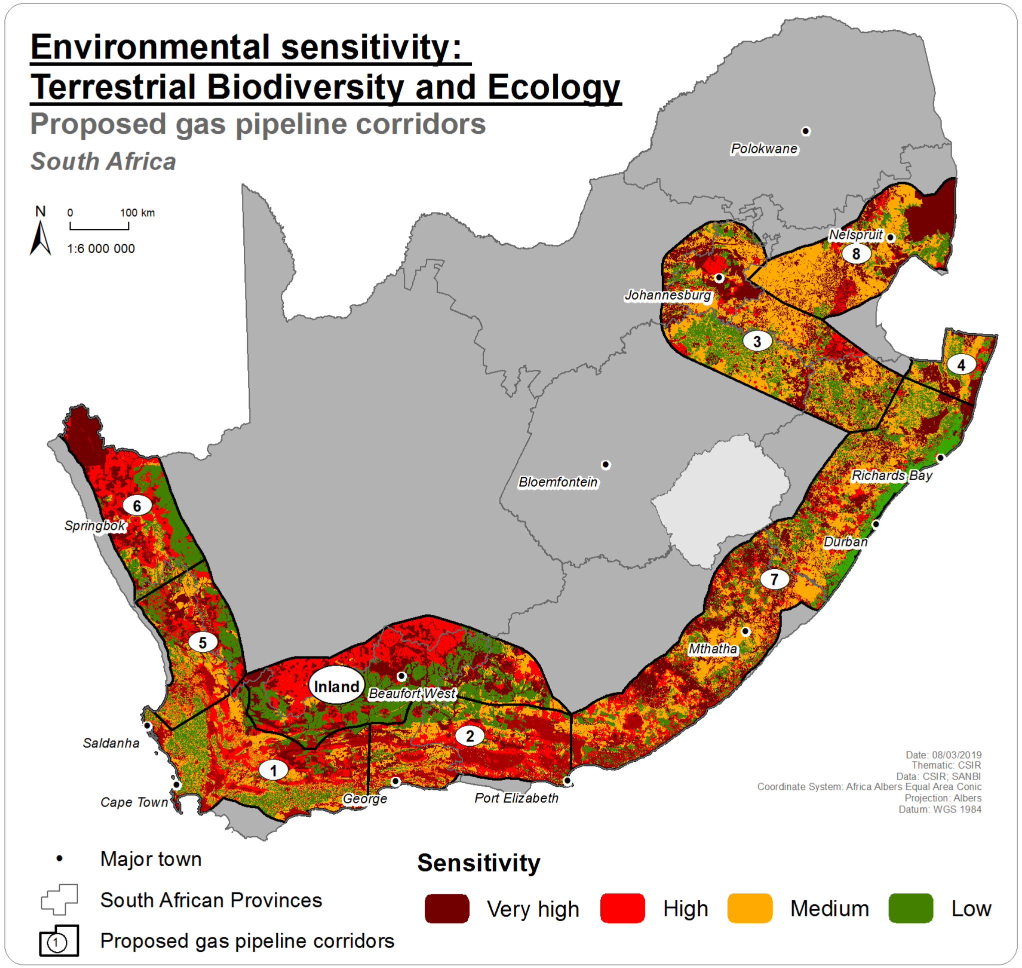


Figure i: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development.

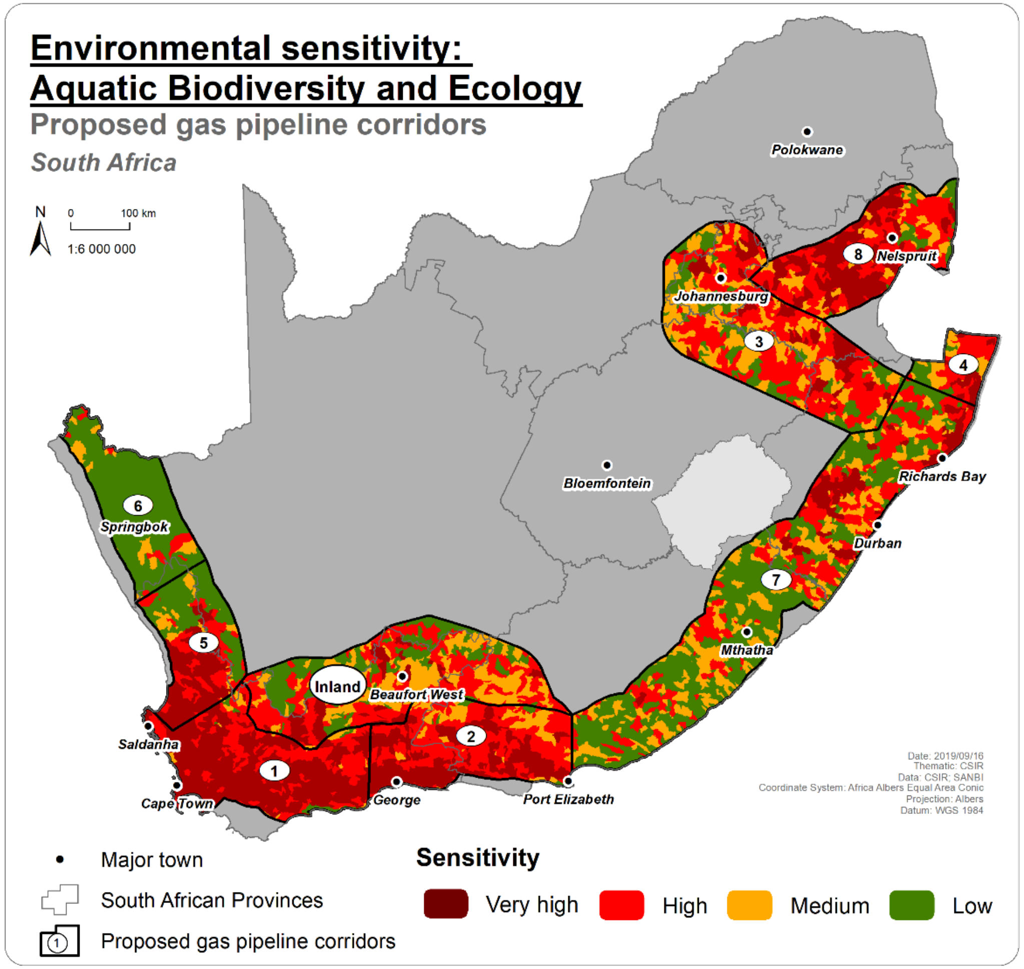


Figure ii: Environmental sensitivity of aquatic ecosystems to proposed gas pipeline development.

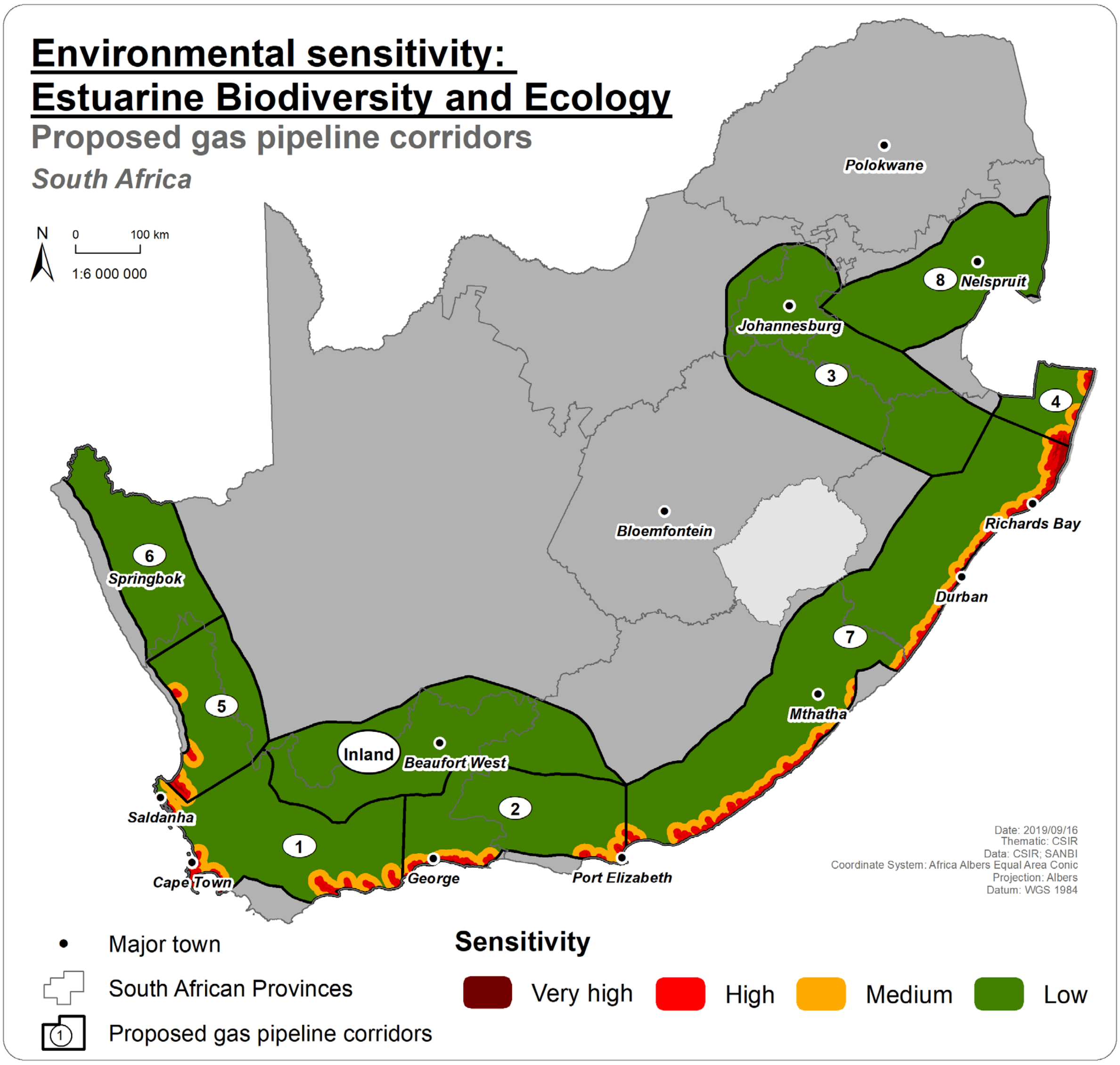


Figure iii: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development.

Key potential impacts of proposed gas pipeline development to terrestrial and aquatic ecosystems and biodiversity are mainly related to vegetation clearance and digging of trenches during construction, which may have consequences for terrestrial fauna directly (e.g. animals becoming trapped in open trenches), as well as birds (especially ground-dwelling species, and through habitat alteration and loss) and bats (mainly via habitat alteration and loss) (Figure iv) (Section 6).

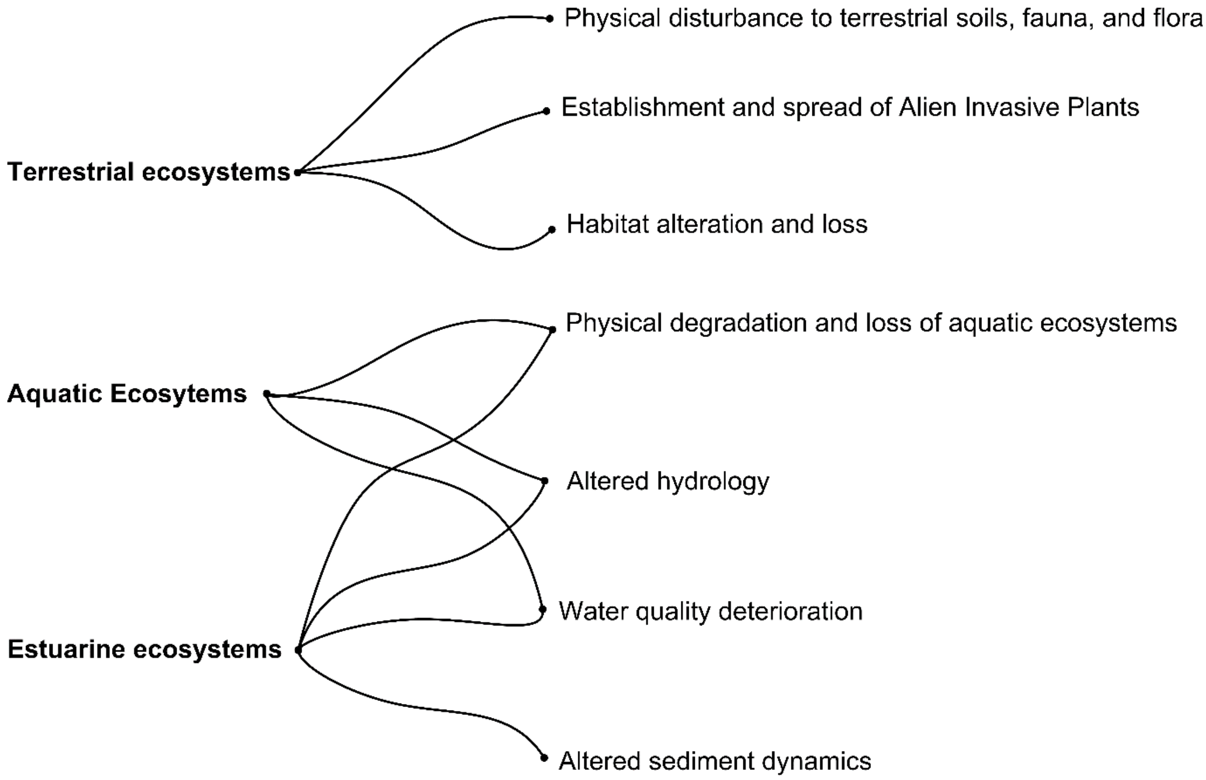


Figure iv: Key potential impacts of proposed gas pipeline development to terrestrial and aquatic systems.

The mitigation hierarchy must be applied for during all development phases of the proposed gas pipeline. Key mitigation measures include (Section 6):

- Avoid, as far as possible, the most sensitive areas identified in this assessment and areas identified by specialists in the field during subsequent environmental assessment (as and where required);
- Minimise footprint and construction duration;
- Minimise new development footprints through utilising existing infrastructure and disturbance corridors as far as possible;
- Minimise the potential impacts to terrestrial fauna through measures to ensure they do not get trapped in trenches and can continue to move freely;
- Manage and continuously control Invasive Alien Plants;
- Manage and continuously control soil erosion;
- Manage people and vehicles on- and around the site through proper induction, environmental awareness and monitoring of their activity; and
- Rehabilitate to a near-natural state as far as possible.

If mitigation and best practice measures are adhered to, it is expected that the risk to terrestrial and aquatic ecosystems and biodiversity from gas pipeline development can be reduced to acceptable levels (Section 7).

2 INTRODUCTION

This chapter consolidates and summarises the key findings from several independent specialist investigations (included as separate annexures to this chapter) as part of a Strategic Environmental Assessment (SEA) of the potential impacts from the development of gas transmission pipeline infrastructure in nine proposed corridors/phases (study areas) (Figure 1) on terrestrial and aquatic biodiversity and ecology. Furthermore, it recommends management actions and best practice mechanisms to avoid and minimise any potential negative impacts to sensitive ecosystems, the ecological processes that underpin their functioning, and the plant and animal species inhabiting those ecosystems.

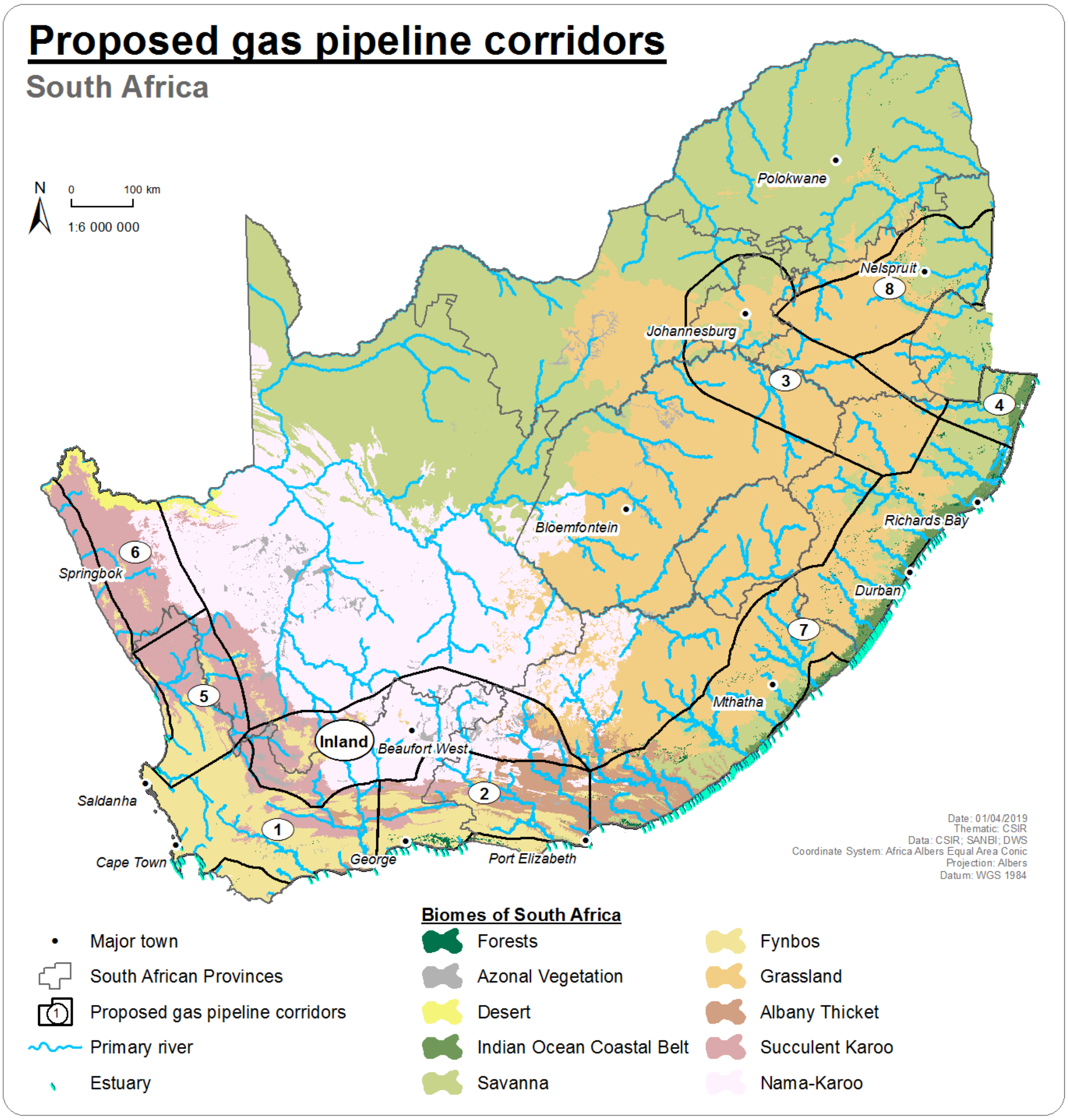


Figure 1: Location of the proposed gas pipeline corridors in South Africa with the key terrestrial and aquatic ecosystem components considered in this assessment.

2.1 Overview of gas pipeline development

Gas pipeline developments[1] are linear in nature and require total clearance of the aboveground vegetation for the installation of the underground pipes. Although this is a relatively narrow strip (~ 50 m wide for the construction right-of-way (ROW)), the cumulative length of hundreds of kilometres of pipelines can translate to thousands of hectares of destroyed biodiversity, if not restored appropriately. Furthermore, the soil disturbance during pipeline installation can leave these areas highly susceptible to invasion by invasive alien plant (IAP) species (e.g. Tyser & Worley, 1992), which will require active and long term control to prevent a number of secondary environmental impacts, such as sedimentation of watercourses.

The trench in which the pipeline is buried represents a substantial disruption of soil and drainage to a depth of approximately 2 m and width of 1.5 m, some effects of which, despite restoration, can persist for centuries. During construction, the trench acts as a temporary, but significant obstruction to animal movement.

Post-installation, and assuming full revegetation with indigenous flora, impacts are expected to be substantially less, although the vegetation in a narrow corridor (i.e. a 10 m wide operational servitude) will mostly exclude deep-rooted vegetation and large trees. Subsequently, the habitat along the pipeline may differ in species composition and structure from the original habitat, fragmenting the landscape, and impeding the movement of insects, small animals, birds, and plant propagules (Forman & Gordon, 1986; Xiao et al., 2014), especially if not fully restored to its initial biodiversity and vegetation structure. Additionally, if the routing of the pipeline is placed parallel to environmental gradients it is likely to have greater potential impacts on species movement and migration, and also may well cut through a large proportion of any one vegetation type as the vegetation also tends to follow gradients.

3 SCOPE OF BIODIVERSITY AND ECOLOGY FOR THIS ASSESSMENT

The ecological and biodiversity environmental aspects of the proposed gas pipeline phases have been grouped according to the biomes that are found within the proposed gas pipeline corridors (Figure 2). These act as the point of departure for terrestrial ecosystems and the fauna that inhabit these systems. Aquatic ecosystems considered include freshwater and estuarine habitats, and associated species (Figure 2). The Forest biome has not been included in this assessment (see Section 3.1 for all assumptions underpinning this assessment). Impacts to avifauna and bats posed by gas pipeline development is indirect, specifically due to habitat destruction potentially resulting in displacement and/or mortality.

[1] See Part 2 of the SEA report (Identification of gas pipeline corridors) for a detailed project description.

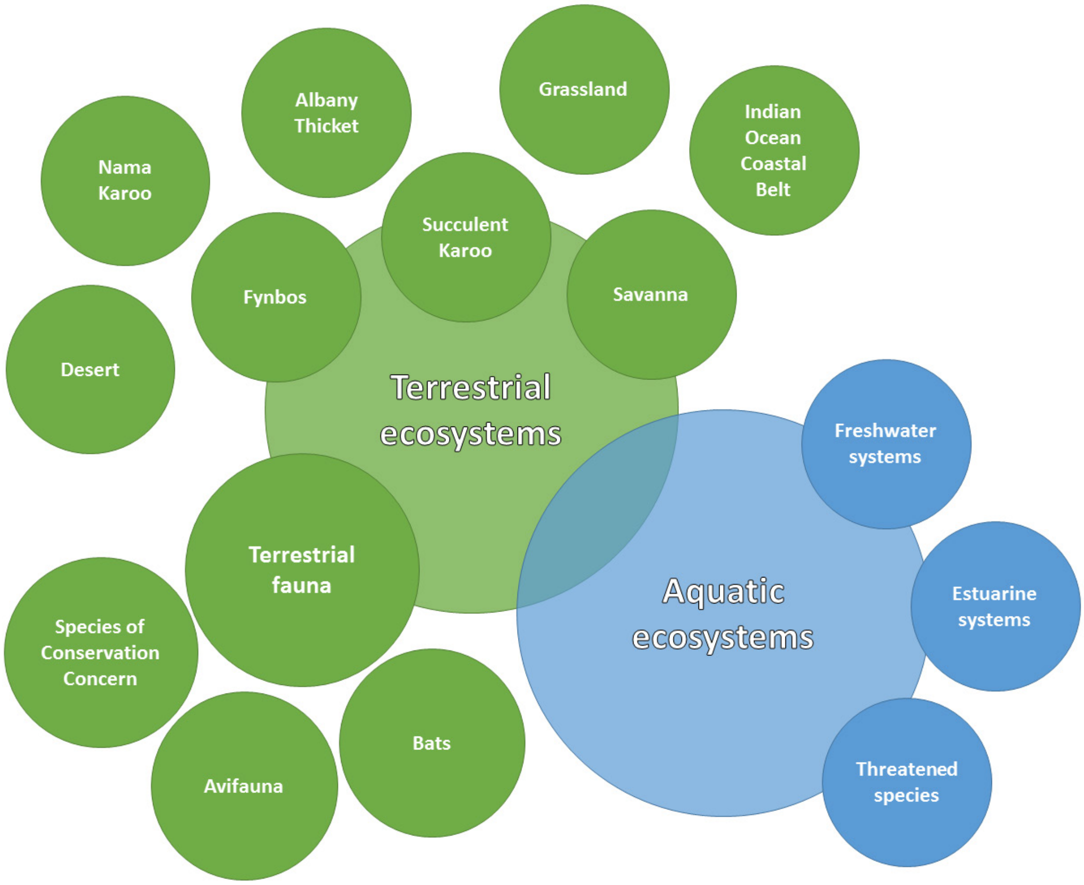


Figure 2: Overview of the terrestrial and aquatic ecosystem topics forming part of this strategic assessment, focussing on biomes, sensitive ecosystems, the ecological processes that underpin their functioning, and the plant and animal species inhabiting those ecosystems.

3.1 Assumptions and Limitations

The following assumptions and limitations form the point of departure for this assessment:

General

- This is a strategic-level, desktop assessment, aimed to identify potential environmental sensitivities based on existing spatial data at a high-level. The consideration of ecological pattern and process is limited by the resolution and scale of the spatial data. For site-specific routings of gas pipeline infrastructure, real-world conditions must be verified on the ground.
- This assessment makes use of information available and in a useable format. No fieldwork was done and no additional raw data were collected and/or processed.
- The onshore gas pipeline infrastructure considered in this assessment excludes:
    - associated infrastructure such as compressor stations, onshore facilities at the landfall and the facilities at the termini of the gas pipeline for distributing the gas (e.g. receiving terminals).
    - other facilities for servicing the line and detecting gas leaks; and
    - other aspects such the specific location and impacts of access routes, worker site camps, lay down and storage areas, waste disposal or borrow pits.
- Species records are limited to primarily areas which are easy to access and where monitoring is safe to undertake e.g. in Protected Areas (PAs). Datasets used in this study are likely to contain sampling bias. This has not been adjusted for or improved.

Terrestrial ecology

- The scales and spatial resolutions of input data varies (e.g. 30x30 m for land cover to units mapped at approximately 1:250 000 scale such as vegetation types). This heterogeneity is inappropriate for fine-scale analysis and interpretation, but can inform strategic, high-level planning.
- Provinces use separate approaches in their Biodiversity Spatial Plans to determine areas of high biodiversity importance and conservation concern. Provincial biodiversity conservation plans are used subject to all the assumptions that underpin the creation of those plans.
- The Forest biome has not been included in this assessment as it represents an engineering constraint for the gas pipeline due to the deep rooted systems. Therefore, the forest biome will be avoided for the routing of the gas pipeline. However, where the forest biome cannot be avoided by the gas pipeline route, due to the rare and sensitive environments that are associated with the biome, developers would be required to fulfil the requirements of the Environmental Impact Assessment (EIA) Regulations at the time.
- Biodiversity value, equates to biodiversity sensitivity, implying that for any given activity (like vegetation clearing) the associated impacts will be higher on areas of 'high biodiversity' value than on areas with 'medium' or 'low' value biodiversity. However, it requires the assumption that the same sensitivity designations will respond to impacts in a similar way. This is not always true as there may be different reasons (biodiversity features) for sensitivity classifications, and these biodiversity features may not respond the same to any particular stress.

Freshwater

- Quinary/sub-quaternary catchments were used as the primary unit of scale for analyses allowing for integration of multiple datasets (e.g. points, lines, polygons) to ensure continuity in the output that are also comparable.
- The conservation importance/threat status of wetlands was determined using the national wetland vegetation groups.
- PA layers were not used for the freshwater ecosystems assessment. Freshwater features are inherently less sensitive given the levels of protection. It was assumed that PAs will be accounted for in the main integration of all data layers and development of the cost surface - in this regard all freshwater ecosystems and features will be treated with a high sensitivity.

Estuaries

- This assessment assumes that only below-ground construction methods will be considered for estuary crossings by gas pipelines. Three below-ground methods have been investigated, namely wet open-cut construction, isolated (dry-open cut) construction and Horizontal Directional Drilling (HDD).
- Given elevated water tables, corrosion associated with salt water and scouring potential associated with estuaries, above ground construction methods for the proposed gas pipeline (i.e. diverting over the river bed in the form of pipe-bridges or suspension below existing bridge infrastructure) were also assessed for completeness.
- At the broad, overview scale of this strategic assessment, operational phases involving pipeline maintenance is assumed largely to be similar for all of the above-mentioned pipeline construction options.
- Due to the strategic nature of the assessment and the expansive area under investigation, a generic approach was applied, selecting a suite of key estuarine attributes considered appropriate, to assess impact and associated risks for various construction methods, and during operation.
- This assessment provides a broad scale sensitivity rating for estuaries in the various corridors. As all estuaries are sensitive to altered sediment and hydrodynamic processes, more detailed spatially scaled sensitivity demarcation within the study areas will need to be refined during the detailed planning and construction phases.

Species

- The potential presence of fauna species, in particular terrestrial invertebrate groups in each of the assessed biomes was evaluated based on existing literature and available databases. However, data contained within some of these species databases are coarse and insufficient to be able to identify endemics with any certainty, and the threat status of most invertebrate groups has not been assessed according to the International Union for Conservation of Nature (IUCN) criteria. A further limitation was that some datasets are outdated, or lacking data for certain areas of ecological importance within each biome.

3.2 Spatial Data

This analysis made extensive use of data resources arising from the following spatial datasets listed Table 1 - Table 6.

3.2.1 Terrestrial ecology

Table 1: Available spatial data pertaining to terrestrial ecological features used in this assessment.

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
Provincial conservation planning	Northern Cape DENC. 2016. Critical Biodiversity Areas of the Northern Cape. http://bgis.sanbi.org/.	The Northern Cape Critical Biodiversity Area (CBA) Map identifies biodiversity priority areas, called CBAs and Ecological Support Areas (ESAs), which, together with protected areas, are important for the persistence of a viable representative sample of all ecosystem types and species as well as the long-term ecological functioning of the landscape as a whole.
	Western Cape CapeNature. 2017. Western Cape Biodiversity Spatial Plan 2017. http://bgis.sanbi.org/. Cape Town CoCT. 2016. City of Cape Town Biodiversity Network. http://bgis.sanbi.org/.	The Western Cape Biodiversity Spatial Plan (WCBSP) is the product of a systematic biodiversity planning assessment that delineates, on a map (via a Geographic Information System (GIS)), CBAs and ESAs which require safeguarding to ensure the continued existence and functioning of species and ecosystems, including the delivery of ecosystem services, across terrestrial and freshwater realms. These spatial priorities are used to inform sustainable development in the Western Cape Province. This product replaces all previous systematic biodiversity planning products and sector plans with updated layers and features.
	Eastern Cape DEDEAT. 2017. Eastern Cape Biodiversity Conservation Plan Handbook. DEDEAT: King Williams Town. Compiled by G. Hawley, P. Desmet and D. Berliner. Draft version, December 2017.	Significant strides have been made with respect to refining the spatial representation of biodiversity pattern and biodiversity processes, as well as establishing standardised minimum requirements for spatial biodiversity planning that ensure a level of consistency throughout the country (SANBI, 2017). The Eastern Cape Biodiversity Conservation Plan (ECBCP) 2017 replaces the ECBCP 2007 in its entirety, and is a tool that guides and informs land use and resource-use planning and decision-making by a full range of sectors whose policies, programmes and decisions impact on biodiversity, in order to preserve long-term functioning and health of priority areas – CBAs and ESAs.
	KwaZulu-Natal Ezemvelo KZN Wildlife. 2016. KwaZulu-Natal Biodiversity Sector Plans. http://bgis.sanbi.org/.	Critical biodiversity assets in KwaZulu-Natal District Municipalities with associated management guidelines which aim to maintain the integrity of these biodiversity features. The key purpose is to assist and guide land use planners and managers within various district and local municipalities, to account for biodiversity conservation priorities in all land use planning and management decisions, thereby promoting sustainable development and

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
		the protection of biodiversity, and in turn the protection of ecological infrastructure and associated ecosystem services.
	Mpumalanga MTPA. 2014. Mpumalanga Biodiversity Sector Plan. http://bgis.sanbi.org/.	Mpumalanga Biodiversity Sector Plan (MBSP) terrestrial assessment is based on a systematic biodiversity planning approach to identify spatial priority areas that meet both national and provincial targets in the most efficient way possible, while trying to avoid conflict with other land-uses. It actively tries to build-in landscape resilience to a changing climate. These spatial priorities are used to inform sustainable development within Mpumalanga. It replaces the MBCPv1 product with updated layers and features. Terminology follows that of South Africa's Biodiversity Act governing the gazetting of Bioregional Plans. A 2010 land-cover map is used based on SPOT5 imagery, as well as old lands mapped of earliest 1: 50 000 topographical maps and earliest suitable Landsat 7 imagery.
	Gauteng GDARD. 2011. Gauteng CPlan Version 3.3. http://bgis.sanbi.org/.	The C-Plan serves as the primary decision support tool for the biodiversity component of the Environmental Impact Assessment (EIA) process; informs protected area expansion and biodiversity stewardship programmes in the province; and serves as a basis for development of Bioregional Plans in municipalities within the province.
	North West NW READ. 2015. North West Terrestrial Critical Biodiversity Areas. http://bgis.sanbi.org/.	A refined and updated CBA map for the North West Province planning domain was developed through integrating existing and new data.
	Free State DESTEA. 2015. Free State Biodiversity Plan. http://bgis.sanbi.org/.	A key output of the systematic biodiversity planning process is a map indicating CBAs and ESAs. CBAs are areas that are important for conserving biodiversity while ESAs are areas that are important to ensure the long term persistence of species or functioning of other important ecosystems. Degradation of CBAs or ESAs could potentially result in the loss of important biodiversity features and/or their supporting ecosystems.
**Aquatic components of provincial conservation plans were also considered in the spatial sensitivity analysis for freshwater ecosystems*		
Protected and Conservation Areas	DEA. 2018a. South African Protected Areas Database (SAPAD). Q2, 2018. https://egis.environment.gov.za/. DEA. 2018b. South African Conservation Areas Database (SACAD). Q2, 2018. https://egis.environment.gov.za/.	Protected areas as defined in the National Environmental Management: Protected Areas Act, (Act 57 of 2003) (NEM:PAA). Protected areas: • Special nature reserves; • National parks; • Nature reserves; • Protected environments (1-4 declared in terms of the National Environmental Management: Protected Areas Act, 2003); • World heritage sites declared in terms of the World Heritage Convention Act;

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
		• Marine protected areas declared in terms of the Marine Living Resources Act; • Specially protected forest areas, forest nature reserves, and forest wilderness areas declared in terms of the National Forests Act, 1998 (Act 84 of 1998); • Mountain catchment areas declared in terms of the Mountain Catchment Areas Act, 1970 (Act 63 of 1970). <u>Conservation Areas:</u> • Biosphere reserves; • Ramsar sites; • Stewardship agreements (other than nature reserves and protected environments); • Botanical gardens; • Transfrontier conservation areas; • Transfrontier parks; • Military conservation areas; • Conservancies.
**Protected and conservation areas were considered used in the spatial sensitivity analysis for avifauna*		
National Protected Area Expansion Strategy (NPAES) focus areas	DEA. 2016. National Protected Areas Expansion Strategy for South Africa.	Focus areas for land-based protected area expansion are large, intact and unfragmented areas of high importance for biodiversity representation and ecological persistence, suitable for the creation or expansion of large protected areas. Representative of opportunities for meeting the ecosystem-specific protected area targets set in the NPAES, and were designed with strong emphasis on climate change resilience and requirements for protecting freshwater ecosystems.
Vegetation of South Africa	SANBI. 2018. Vegetation Map of South Africa, Lesotho and Swaziland. http://bgis.sanbi.org/.	Update of the Vegetation Map of South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006; SANBI, 2012) based on decisions made by the National Vegetation map Committee and contributions by various partners.
Threatened ecosystems	DEA. 2011. South African Government Gazette. National Environmental Management: Biodiversity Act: National list of ecosystems that are threatened and in need of protection. Government Gazette, 558(34809). http://bgis.sanbi.org/.	The Biodiversity Act (Act 10 of 2004) provides for listing of threatened or protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or protected. The purpose of listing threatened ecosystems is primarily to reduce the rate of ecosystem and species extinction. This includes preventing further degradation and loss of structure, function and composition of threatened ecosystems. The purpose of listing protected ecosystems is primarily to preserve sites of exceptionally high conservation value.
**Vegetation of South Africa was also considered in the spatial sensitivity analysis for avifauna.*		

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
National Land Cover	Geoterraimage. 2015. 2013-2014 South African National Land-Cover. Department of Environmental Affairs. Geospatial Data. https://egis.environment.gov.za/.	Recent global availability of Landsat 8 satellite imagery enabled the generation of new, national land-cover dataset1 for South Africa, circa 2013-14, replacing and updating the previous 1994 and 2000 South African National Landcover datasets. The 2013-14 national land-cover dataset is based on 30x30m raster cells, and is ideally suited for ± 1:75,000 - 1:250,000 scale GIS-based mapping and modelling applications. Land cover are categorised into different classes, which broadly include: • Bare none vegetated • Cultivated • Erosion • Grassland • Indigenous Forest • Low shrubland • Mines/mining • Plantation • Shrubland fynbos • Thicket /Dense bush • Urban • Water • Woodland/Open bush
**National Land Cover was also considered in the spatial sensitivity analysis for avifauna and bats.*		
Ecoregions	Burgess et al. 2004. Terrestrial ecoregions of Africa and Madagascar: A conservation Assessment. Island Press: Washington DC. Geospatial data by SANBI.	Biodiversity patterns, threats to biodiversity, and resulting conservation priorities of biological units (rather than political units).
National Forests	DAFF. 2016. National Forest Inventory. https://www.daff.gov.za/daffweb3/Branches/Forestry-Natural-Resources-Management/Forestry-Regulation-Oversight/Forests/Urban-Forests/Forestry-Maps	Indigenous forest patches protected in terms of the NFA.
Karoo ecological and biodiversity sensitivity	Holness et al. 2016. Shale Gas Development in the Central Karoo: A Scientific Assessment of the Opportunities and Risks. CSIR/IU/021MH/EXP/2016/003/A, ISBN 978-0-7988-5631-7, Pretoria: CSIR. Available at http://seasgd.csir.co.za/scientific-assessment-chapters/	Terrestrial and aquatic ecosystem sensitivities specific to Karoo ecology and biodiversity, including fauna and flora that were mapped in the Shale Gas Strategic Environmental Assessment (SEA) are specific to that SEA and Shale Gas development as such, and these are not considered directly transferrable to the current Gas Pipeline Corridor study. But areas that were mapped as Very High sensitivity are considered in this study to represent biodiversity priority areas and are also used here within the area of overlap of these two assessments.

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
	Skowno et al. 2015. Terrestrial and Aquatic Biodiversity Scoping Assessment. In: Van der Westhuizen, C., Cape-Ducluzeau, L. and Lochner, P. (eds.). (2015). Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa. Department of Environmental Affairs, 2015. CSIR Report Number: CSIR/CAS/EMS/ER/2015/0001/B. Stellenbosch. Available athttps://redzs.csir.co.za/wp-content/uploads/2017/04/ Wind-and-Solar-SEA-Report-Appendix-C-Specialist-Studies.pdf	Terrestrial and aquatic ecosystems sensitivities specific to Karoo ecology and biodiversity, including fauna and flora that were mapped in the Wind and Solar SEA (REDZ) are specific to that SEA and renewable energy development as such, and these are not considered directly transferrable to the current Gas Pipeline Corridors SEA study. But areas that were mapped as Very High sensitivity are considered in this study to represent biodiversity priority areas and are also used here within the area of overlap of these two assessments.
Field crop boundaries	DAFF. 2014. Field Crop Boundaries. Available at: http://bea.dirisa.org/resources/metadata-sheets/WP03_00_META_FIELDCROP.pdf	Data on field crop extent and type of cultivation DAFF for South Africa.

3.2.2 Aquatic ecosystems

3.2.2.1 Freshwater ecology

Table 2: Available spatial data pertaining to freshwater ecological features used in this assessment.

Feature	Source	Summary
FRESHWATER		
SQ4 sub-quaternary drainage regions (referred to as SQ4 catchments)	DWS. 2009. Working copies of sub-quaternary catchments for delineation of management areas for the National Freshwater Ecosystem Priority Areas (NFEPA) in South Africa project - 2009 draft version. http://www.dwa.gov.za/iwqs/gis_data/.	Catchment areas that define the drainage regions of the NEFPA river reaches, which include 9 433 catchments ranging from 0.25 to 400 000 hectares. The gas pipeline corridors include 4 843 SQ4 catchments ranging from 0.1 to 115 000 hectares. These catchment areas are used as the primary spatial unit for analysis in the freshwater component.
River Ecoregions (Level 1 and 2)	Kleynhans, C.J., Thirion, C. & Moolman, J., 2005. A level I river ecoregion classification system for South Africa, Lesotho and Swaziland. Pretoria: Department of Water Affairs and Forestry.	A delineation of ecoregions for South Africa as derived from terrain, vegetation, altitude, geomorphology, rainfall, runoff variability, air temperature, geology and soil. There are 31 Level 1 and 219 Level 2 River Ecoregions in South Africa, of which 25 Level 1 and 97 Level 2 River Ecoregions occur within the gas pipeline corridors.
River Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity	DWS. 2014. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa.	A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa conducted in 2013.

Feature	Source	Summary
FRESHWATER		
(ES)	https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx.	
NFEPA Rivers and Wetlands	Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. Pretoria: Water Research Commission, WRC Report No. K5/1801.	The NFEPA coverages provide specific spatial information for rivers according to the DWS 1:500 000 rivers coverage, including river condition, river ecosystem types, fish sanctuaries, and flagship/free-flowing rivers. The NFEPA coverages also provide specific information for wetlands such as wetland ecosystem types and condition (note: wetland delineations were based largely on remotely-sensed imagery and therefore did not include historic wetlands lost through transformation and land use activities).
Ramsar Sites	Ramsar Convention. 2018. Convention on Wetlands of International Importance especially as Waterfowl Habitat. https://www.ramsar.org/	Distribution and extent of areas that contain wetlands of international importance in South Africa.
National Wetland Vegetation Groups	Nel, J.L. and Driver, A. 2012. South African National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component. Stellenbosch: Council for Scientific and Industrial Research. CSIR Report Number: CSIR/NRE/ECO/IR/2012/0022/A.	A vector layer developed during the 2011 NBA to define wetland vegetation groups to classify wetlands according to Level 2 of the national wetland classification system (SANBI, 2010). The wetland vegetation groups provide the regional context within which wetlands occur, and is the latest available classification of threat status of wetlands that are broadly defined by the associated wetland vegetation group. This is considered more practical level of classification to the Level 4 wetland types owing to the inherent low confidence in the desktop classification of hydrogeomorphic units (HGM) that was used at the time of the 2011 NBA.
Provincial Wetland Probability Mapping	Collins, N. 2017. National Biodiversity Assessment (NBA) 2018. Wetland Probability Map. https://csir.maps.arcgis.com/apps/MapJournal/index.html?appid=8832bd2cbc0d4a5486a52c843daebcba#	Mapping of wetland areas based on a concept of water accumulation in the lowest position of the landscape, which is likely to support wetlands assuming sufficient availability water to allow for the development of the indicators and criteria used for identifying and delineating wetlands. This method of predicting wetlands in a landscape setting is more suitable for certain regions of the country than in others.
Mpumalanga Highveld Wetlands	SANBI. 2014. Mpumalanga Highveld Wetlands. http://bgis.sanbi.org/.	Wetland delineations for the Mpumalanga Highveld based on desktop mapping using Spot 5 imagery, supported by Google Earth, 1:50 000 contours, 1:50 000 rivers, exigent data, and NFEPA wetlands. This is an update of previous mapping through desktop digitising, ground-truthing and reviewing mapped data. Additional analysis was conducted to determine changes to ecosystem threat status, protection level and FEPAs.
**Wetlands and rivers were also considered in the spatial sensitivity analysis for bats.* **Coastal rivers, wetlands and seeps above or adjacent to estuaries were also considered in the spatial sensitivity analysis for estuaries.*		

3.2.2.2 *Estuarine ecology*

Table 3: Available spatial data pertaining to estuarine ecological features used in this assessment.

Feature	Source	Summary
ESTUARINE		
Estuarine health	Van Niekerk, L. & Turpie, J.K. (Eds). 2012. National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch. http://bgis.sanbi.org/nba/project.asp.	A desktop national health assessment for n early 300 estuaries in South Africa. Estuary health assessment was based on the Estuarine Health Index developed for South African ecological water requirement studies that has been applied systematically to over 30 estuaries at various levels of data richness and confidence.
	Van Niekerk, L. et al. 2013. Country-wide assessment of estuary health: An approach for integrating pressures and ecosystem response in a data limited environment. Estuarine, Coastal and Shelf Science, 130: 239-251.	A country-wide assessment of the ~300 functional South African estuaries examined both key pressures (freshwater inflow modification, water quality, artificial breaching of temporarily open/closed systems, habitat modification and exploitation of living resources) and health statue.
	SANBI. 2018. Interim findings of the National Biodiversity Assessment (work in progress). As available.	Assessment of the state of South Africa's estuarine biodiversity based on best available science, with a view to understanding trends over time and informing policy and decision-making. In progress – to be published in 2019.
Estuary ecological classification	Van Niekerk, L. et al. 2015. Desktop Provisional Ecoclassification of the Temperate Estuaries of South Africa. Water Research Commission Report No K5/2187.	EcoClassification for estuaries that provided a comparative, regional scale assessment. The Provisional EcoClassification refers to the Present Ecological Status (PES), the ecological importance and protection status, a Provisional Recommended Ecological Category (REC), as well as mitigation measures towards achieving the Provisional REC.
Estuaries in Formally /desired protected areas	Turpie, J.K. et al. 2012. National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa. Anchor Environmental Consulting Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.	Marine, estuarine and terrestrial areas that are under formal protection or estuaries identified as desired protected areas in the National Estuaries Biodiversity Plan.
Estuaries of high biodiversity importance	Turpie, J.K., Adams, J.B., Joubert, A., Harrison, T.D., Colloty, B.M., Maree, R.C., Whitfield, A.K., Wooldridge, T.H., Lamberth, S.J., Taljaard, S., & Van Niekerk, L. 2002. Assessment of the conservation priority status of South African estuaries for use in management and water allocation. *Water SA,* 28: 191-206.	In South Africa, estuary biodiversity importance is based on the importance of an estuary for plants, invertebrates, fish and birds, using rarity indices. The Estuary Importance Rating takes size, the rarity of the estuary type within its biographical zone, habitat and the biodiversity importance of the estuary into account.

Feature	Source	Summary
ESTUARINE		
Important nurseries	Van Niekerk, L. et al. 2017. A multi-sector Resource Planning Platform for South Africa's estuaries. Water Research Commission Report No K5/2464 Lamberth, S.J. & Turpie, J.K. 2003. The role of estuaries in South African fisheries: economic importance and management implications. *African Journal of Marine Science*, 25: 131-157.	Estuaries that are critically important nursery areas for fish and invertebrates and make an important contribution towards estuarine and coastal fisheries.
Important estuarine habitats		Estuaries that support important rare or sensitive habitats (saltmarsh, mangroves, swamp forest) that provide important ecosystem services.
Natural or near natural condition estuaries		Estuaries in good condition (designated by an A or B health category are more sensitive to development (likely to degrade in overall condition).
**Estuaries were also considered in the spatial sensitivity analysis for avifauna*		

3.2.3 Species

3.2.3.1 Terrestrial and aquatic fauna

Table 4: Available spatial data pertaining to terrestrial and aquatic species used in this assessment.

Feature	Source	Summary
TERRESTRIAL AND AQUATIC FAUNA		
Red Data species	<u>Mammals</u> Child et al. (*Eds*). 2016. The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho. SANBI & EWT: South Africa	Known spatial locations for recorded Red Listed mammals in South Africa.
	<u>Reptiles</u> Bates et al. (*Eds*). Atlas and red data list of the reptiles of South Africa, Lesotho and Swaziland. SANBI: Pretoria (Suricata series; no. 1).	Known spatial locations for recorded Red Listed reptiles in South Africa.

Feature	Source	Summary
TERRESTRIAL AND AQUATIC FAUNA		
	<u>Amphibians</u> Minter, L.R. 2004. Atlas and red data book of the frogs of South Africa, Lesotho, and Swaziland. Avian Demography Unit: UCT.	Known spatial locations for recorded Red Listed ambhibians in South Africa.
	<u>Plants</u> Raimondo et al. 2009 (as updated in 2018). Red list of South African plants 2009, 2018 update. South African National Biodiversity Institute.	Known spatial locations for recorded Red Listed terrestrial and aquaticplants in South Africa.
	<u>Fish distributions</u> IUCN. 2017. The IUCN Red List of Threatened Species, 2017. http://www.iucnredlist.org/	Distribution data for selected fish species where point data was found to be lacking/insufficient was obtained from the IUCN Red List of Threatened Species Map Viewer with data presented as catchment distributions. The IUCN distributions were spatially inferred using the SQ4 catchments for 22 of the selected fish species.
	<u>Freshwater fish</u> Coetzer, W. 2017. Occurrence records of southern African aquatic biodiversity. Version 1.10. The South African Institute for Aquatic Biodiversity. https://doi.org/10.15468/pv7vds	Known spatial locations for recorded Red Listed freshwater fish in South Africa.
	<u>Aquatic macro-invertebrates</u> DWS. 2015. Invertebrate Distribution Records. [online] Department of Water and Sanitation RQIS-RDM, Pretoria. Available at: http://www.dwa.gov.za/iwqs/biomon /inverts/invertmaps.htm/ and http://www.dwa.gov.za/iwqs/biomon/inverts/ invertmaps_other.htm/	Known spatial locations for recorded aquatic macro-invertebrate Families from 4 350 monitoring sites on South African rivers.
	<u>Butterflies</u> Henning, G.A., Terblanche, R.F. and Ball, J.B., 2009. South African red data book: butterflies. Mecenero S, Ball JB, Edge DA, Hamer ML, Henning GA, Kruger M, Pringle EL, Terblanche RF, Williams MC (*Eds*). 2013. Conservation assessment of butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas.	Known spatial locations for recorded Red Listed butterflies in South Africa.

Feature	Source	Summary
TERRESTRIAL AND AQUATIC FAUNA		
	Saftronics, Johannesburg and Animal Demography Unit, Cape Town.	
	Dragonflies and damselflies (Odonata) IUCN. 2017. The IUCN Red List of Threatened Species, 2017.3. http://www.iucnredlist.org/ Samways, M.J. & Simaika, J.P. 2016. Manual of Freshwater Assessment for South Africa: Dragonfly Biotic Index. SANBI: Pretoria: Suricata 2, p. 224.	Known spatial locations for recorded dragonflies and damselflies taken from a total of 38 887 records within South Africa. This data includes records of the conservation important Odonata selected for this assessment.

3.2.3.2 Birds

Table 5: Available spatial data pertaining to avifauna species and their environment used in this assessment.

Feature	Source	Summary
AVIFAUNA		
The Southern African Bird Atlas 1 (SABAP1)	UCT.1997. The Southern African Bird Atlas 1 (SABAP1). Animal Demography Unit, UCT.	The Southern African Bird Atlas Project (SABAP) was conducted between 1987 and 1991.Because a new bird atlas was started in southern Africa in 2007, the earlier project is now referred to as SABAP1. SABAP1 covered six countries: Botswana, Lesotho, Namibia, South Africa, Swaziland and Zimbabwe. At the time, Mozambique was engulfed in a civil war, and had to be excluded. The resolution for SABAP1 was the quarter degree grid cell (QDGC), 15 minutes of latitude by 15 minutes of longitude, 27.4 km north-south and about 25 km east-west, an area of about 700 km^2. Fieldwork was conducted mainly in the five-year period 1987–1991, but the project coordinators included all suitable data collected from 1980–1987. In some areas, particularly those that were remote and inaccessible, data collection continued until 1993. Fieldwork was undertaken mainly by birders, and most of it was done on a volunteer basis. Fieldwork consisted of compiling bird lists for the QDGCs. All the checklists were fully captured into a database. The final dataset consisted of 147 605 checklists, containing a total of 7.3 million records of bird distribution. Of the total 3973 QDGCs, only 88 had no checklists (2.2% of the total).
The Southern African Bird	UCT. 2007 - present. The Southern African Bird	SABAP2 is the follow-up project to the Southern African Bird Atlas Project (for which the acronym was

Feature	Source	Summary
AVIFAUNA		
Atlas 2 (SABAP2)	Atlas 2 (SABAP2). Animal Demography Unit, UCT.	SABAP, and which is now referred to as SABAP1). This first bird atlas project took place from 1987-1991. The second bird atlas project started on 1 July 2007 and plans to run indefinitely. The current project is a joint venture between the Animal Demography Unit at the University of Cape Town, BirdLife South Africa and the South African National Biodiversity Institute (SANBI). The project aims to map the distribution and relative abundance of birds in southern Africa and the atlas area includes South Africa, Lesotho and Swaziland. SABAP2 was launched in Namibia in May 2012. The field work for this project is done by more than one thousand five hundred volunteer birders. The unit of data collection is the pentad, five minutes of latitude by five minutes of longitude, squares with sides of roughly 9km. At the end of June 2017, the SABAP2 database contained more than 189,000 checklists. The milestone of 10 million records of bird distribution in the SABAP2 database was less than 300,000 records away. Nine million records were reached on 29 December 2016, eight months after reaching 8 million on 14 April 2016, which in turn was eight months after reaching seven million on 22 August 2015, and 10 months after the six million record milestone. More than 78% of the original SABAP2 atlas area (i.e. South Africa, Lesotho and Swaziland) has at least one checklist at this stage in the project's development. More than 36% of pentads have four or more lists.
Crane, raptor and vulture nests	EWT. 2006a (as supplemented by more recent unpublished data). Nest database for cranes, raptors and vultures. Endangered Wildlife Trust.	Data on crane, vulture and raptor nests collected by the various programmes of the EWT. Absence of records does not imply absence of the species within an area, but simply that this area may not have been surveyed. All recorded nesting sites were included, no verification of current status of nests were conducted.
National vulture restaurant database	VulPro 2017. National vulture restaurant database. http://www.vulpro.com/.	The register contains a georeferenced list of vulture restaurants throughout South Africa as compiled by VulPro. All recorded vulture restaurants were included; no verification of current status of vulture restaurants was conducted.
Eagle nests on Eskom transmission lines in the Karoo	EWT. 2006b (as supplemented by more recent unpublished data). List of eagle nests on Ekom transmission lines in the Karoo.	The dataset contains a georeferenced list of Tawny Eagle, Martial Eagle and Verreaux's Eagle nests on transmission lines in the Karoo as at 2006. All recorded nesting sites were included, no verification of current status of nests were conducted.
Locality of Red Data nests	Unpublished data from pre-construction monitoring at renewable energy projects from 2010 - 2018, obtained from various avifaunal specialists.	Nests of various raptors, including Verreaux's Eagle, Martial Eagle, Tawny Eagle, African Crowned Eagle, Wattled Crane, White-backed Vulture collected in the course of pre-construction monitoring at proposed renewable energy projects in the Western, Northern, and Eastern Cape, and KZN.
Cape Vulture colonies	VulPro & EWT. 2018. The national register of Cape Vulture colonies.	The dataset contains a georeferenced list of Cape Vulture colonies, as well as the results of the 2013 aerial survey of Cape Vulture colonies conducted by Eskom, EWT and Birdlife South Africa (BLSA) in the former Transkei, Eastern Cape.
Blue Swallow breeding areas	Ezemvelo KZN Wildlife. 2018. Blue Swallow breeding areas.	The KZN Mistbelt Grassland Important Bird Area (IBA) which incorporates all the known patches of grassland where Blue Swallows are known to nest and forage, plus additional nests sites outside the IBA. No verification of current status of nests was conducted.

Feature	Source	Summary
AVIFAUNA		
Southern Ground Hornbills nesting areas.	MGHP. 2018. Potential nesting areas of Southern Ground Hornbills. http://ground-hornbill.org.za/	The data consists of a list of pentads where the species was sighted in Kwa-Zulu-Natal, Mpumalanga and the Eastern Cape. Data was provided in pentad format. The assumption was made that the species would be breeding within the pentad.
Various Red Data bird species nests	CSIR. 2015. Information on various Red Data species nests obtained from the Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa.	The data comprise nest localities of Black Harrier, Martial Eagle, Verreaux's Eagle, Blue Crane, Lanner Falcon, in the 8 solar and wind focus areas where they overlap with the gas pipeline phases.
Southern Bald Ibis breeding colonies.	BLSA. 2015a. Nest localities of Southern Bald Ibis. https://www.birdlife.org.za/	The data comprises nest localities of Southern Bald Ibis collected by Dr. Kate Henderson as part of her PhD studies.
Important Bird and Biodiversity Areas of South Africa	BLSA. 2015b. Important Bird and Biodiversity Areas of South Africa. https://www.birdlife.org.za/	National inventory of the Important Bird or Biodiversity Areas of South Africa, compiled by BirdLife South Africa.
Potential Bush Blackcap, Spotted Ground-Thrush and Orange Ground-Thrush breeding habitat.	BLSA. 2018a. A list of potential Bush Blackcap, Spotted Ground-Thrush and Orange Ground-Thrush breeding habitat. https://www.birdlife.org.za/.	The results of a modelling exercise undertaken by BirdLife South Africa to identify critical breeding habitat for three key forest – dwelling Red Data species.
Yellow-breasted Pipit core distribution	BLSA. 2018b. Yellow-breasted Pipit core distribution mapping. https://www.birdlife.org.za/.	Map of core distribution/breeding areas based on the modelling of key aspects of the species' biology.
Rudd's Lark core distribution	BLSA. 2018c. Rudd's Lark core distribution mapping. https://www.birdlife.org.za/.	Map of core distribution/breeding areas based on the modelling of key aspects of the species' biology.
Botha's Lark core distribution	BLSA. 2018d. Botha's Lark core distribution mapping. https://www.birdlife.org.za/.	Map of core distribution/breeding areas based on the modelling of key aspects of the species' biology.
White-winged Flufftail confirmed sightings 2000 – 2014	BLSA. 2014. White-winged Flufftail confirmed sightings 2000 – 2014. https://www.birdlife.org.za/.	A list of wetlands where this Critically Endangered (CR) species has been recorded in South Africa which includes the locality where the first breeding for the region has recently been confirmed.
Bearded Vulture nest sites in KwaZulu – Natal	Ezemvelo KZN Wildlife. 2013. Bearded Vulture nest sites in KwaZulu – Natal Maloti-Drakensberg Vulture Project, Dr Sonja Krűger.	The results of nest surveys conducted from 2000 -2012
Red Data nest localities in the Western Cape	CapeNature. 2018. Red Data nest localities in the Western Cape. https://www.capenature.co.za/	A list of nest localities of Black Harrier, Blue Crane, Verreaux's Eagle.

3.2.3.3 Bats

Table 6: Available spatial data pertaining to bat species and their environment used in this assessment.

Feature	Source	Summary
BATS		
Terrestrial Ecoregions	TNC. 2009. Terrestrial ecoregions. http://maps.tnc.org/gis_data.html	The terrestrial ecoregions for South Africa, Swaziland and Lesotho. From numerous monitoring assessments, Inkululeko Wildlife Services has calculated average bat passes per hour for the seven of the ecoregions to gain an understanding of the bat activity levels in each.
Geology	CGS. 1997. 1: 1M geological data.	Four main lithologies were selected as relevant to bats in terms of bat roosting potential: Limestone, Dolomite, Arenite and Sedimentary and Extrusive rock.
Bat Roosts	Published and unpublished data obtained from a variety of scientists and bat specialists, including: Animalia fieldwork database. Obtained from Werner Marais in July 2013. Bats KZN fieldwork database. Obtained from Leigh Richards and Kate Richardson in July 2017. David Jacobs fieldwork database. Obtained from David Jacobs in May 2018. Herselman, J.C. and Norton, P.M. 1985. The distribution and status of bats (Mammalia: Chiroptera) in the Cape Province. Annals of the Cape Province Museum (Natural History) 16: 73-126. Inkululeko Wildlife Services fieldwork database. Obtained from Kate MacEwan in March 2018. Rautenbach, I.L. 1982. Mammals of the Transvaal. No. 1, Ecoplan Monograph. Pretoria, South Africa. Wingate, L. 1983. The population status of five species of Microchiroptera in Natal. M.Sc. Thesis, University of Natal.	A few of the points known to not be true bat roost locations were removed. Some points were moved, as the projection had put them in the ocean. Due to mainly construction phase impacts being the concern for bats, a minimum 500 m radial buffer was placed on each roost, irrespective of size or species.
Bat species occurrence data	Database from a collection of scientists and organisations. Collated by SANBI and the EWT	Extent of Occurrences (EoOs) were compiled for conservation important and certain high-risk bat species using the Child et al. (2016) species point data. These are simply points where one or more

Feature	Source	Summary
BATS		
	in 2016 for use in the National Bat Red Data listings. Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D., Davies-Mostert, H.T. (*Eds*). 2016. The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.	individuals from a particular species were confirmed from museum and scientific records. Because bats travel extensive distances nightly and some seasonally, these points are an under-estimation of the area each individual will occupy in their lifetime. Therefore, an arbitrary 50 km radius was placed around each confirmed point record to buffer for some or all of the potential movement or habitat spread. Then, a best fit polygon (the tightest possible polygon) was drawn around these radii to create an EoO for each relevant species. This is deemed as the maximum known extent that each species occurs in. However, the process did not exclude areas within the polygon where the bats are unlikely to occur due to disturbance or unfavourable habitat, i.e. the polygons did not represent the true area of occupancy (AoO). AoO is defined as the area within its EoO which is occupied by a taxon, excluding cases of vagrancy. In other words, the AoO is a more refined EoO that takes the detailed life history of each species into account. An AoO reflects the fact that a taxon will not usually occur throughout its entire EoO because the entire area may contain unsuitable or unoccupied habitats. To compile more AoOs per species is a significant task, beyond the scope of this SEA.

3.3 Relevant international, provincial and local legal instruments

Table 7 presents legislation and legal instrument relating to sustainable development and nature conservation that would have to be taken into account and adhered to (where relevant) for the development of gas pipeline infrastructure in South Africa.

Table 7: Key international, provincial and local legal instruments that aim to guide and promote sustainable development and nature conservation in South Africa.

Instrument	Key objective
INTERNATIONAL INSTRUMENTS	
Ramsar Convention (The Convention of Wetlands of International Importance (1971 and amendments)	Protection and conservation of wetlands, particularly those of importance to waterfowl and waterfowl habitat.
Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by UNESCO in 1972 (World Heritage Convention)	Preservation and protection of cultural and natural heritage throughout the world.
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	Aims to conserve terrestrial, marine and avian migratory species throughout their range.
The Agreement on the Conservation of African- Eurasian Migratory Waterbirds, or African- Eurasian Waterbird Agreement (AEWA)	Intergovernmental treaty dedicated to the conservation of migratory waterbirds and their habitats across Africa, Europe, the Middle East, Central Asia, Greenland and the Canadian Archipelago.

Instrument	Key objective
International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	To protect and conserve biodiversity, maintain the benefits from ecosystem services, and promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities through the adoption of practices that integrate conservation needs and development priorities.
Convention on Biological Diversity (1993) including the CBD's Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets	The objectives of this Convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.
Conservation of Agricultural Resources Act (Act 43 of 1983) (CARA) and associated regulations	This Act provides for, inter alia, restrictions on the cultivation of land, the protection of soils and water courses, the combating and prevention of erosion, and the prevention of the weakening or destruction of water sources on agricultural land. One of the provisions of the Act includes measures to protect wetlands and watercourses by maintaining uncultivated buffers along water courses and around water bodies to reduce sedimentation and for reducing agro-chemical pollution. Other key aspects include legislation that allows for: Section 6: Prescription of control measures relating to the utilisation and protection of vleis, marshes, water sponges and water courses. These measures are described in regulations promulgated in terms of the Act, as follows; Regulation 7(1): Subject to the Water Act of 1956 (since amended to the Water Act 36 of 1998), no land user shall utilise the vegetation of a vlei, marsh or water sponge or within the flood area of a water course or within 10 m horizontally outside such flood area in a manner that causes or may cause the deterioration or damage to the natural agricultural resources. Regulation 7(3) and (4): Unless written permission is obtained, no land user may drain or cultivate any vlei, marsh or water sponge or cultivate any land within the flood area or 10 m outside this area (unless already under cultivation).
NEMA Bioregional Planning regulations (Government Gazette No. 32006, 16 March 2009)	Guideline regarding the Determination of Bioregions and the Preparation and Publication of Bioregional Plans. Sets out the standards for Bioregional Planning including systematic conservation plans such as those consulted for this assessment.
Spatial Planning and Land Use Management Act (No 16 of 2013) (SPLUMA)	Provides for a uniform, effective and comprehensive system of spatial planning and land use management. The Act recognizes that development be sustainable and aligned with everyone's right to have their environment protected. It also requires all levels of government to work together to realise these outcomes.
REGIONAL INSTRUMENTS	
Southern African Development Community (SADC) Protocol on Shared Watercourse Systems (1995)	The protocol provides for the utilisation of a shared watercourse system for the purpose of agricultural, domestic and industrial use and navigation within the SADC region. The protocol established river basin management institutions for shared watercourse systems and provides for all matters relating to the regulation of shared watercourse systems.
NATIONAL INSTRUMENTS	
National Environmental Management: Protected Areas Act (57 of	No development, construction or farming may be permitted in a nature reserve without the prior written approval of

Instrument	Key objective
2003) (NEM:PAA)	the management authority (Section 50 (5)). Also in a 'protected environment' the Minister or Member of the Executive Committee may restrict or regulate development that may be inappropriate for the area given the purpose for which the area was declared (Section 5).
National Environmental Management Act (107 of 1998) (NEMA)	Restrict and control development and potential harmful activities through the Environmental Impact Assessment (EIA) regulations and the undertaking of relevant assessments prior to commencement of listed activities (Section 24 (5) and 44). Imposes "duty of care" (Section 28) which means that all persons undertaking any activity that may potentially harm the environment must undertake measures to prevent pollution and environmental degradation.
National Environmental Management Act, EIA 2014 Regulations, as amended in 2017	These regulations provide listed activities that require environmental authorisation prior to development because they are identified as having a potentially detrimental effect on natural ecosystems. Different sorts of activities are listed as environmental triggers that determine different levels of impact assessment and planning required. The regulations detail the procedures and timeframes to be followed for a Basic Assessment or full Scoping and EIA.
National Water Act (36 of 1998) (NWA)	This act provides the legal framework for the effect and sustainable management of water resources. It provides for the protection, use, development, conservation, management and control of water resources as a whole. Water use pertains to the consumption of water and activities that may affect water quality and condition of the resource such as alteration of a watercourse. Water use requires authorisation in terms of a Water use licence (WUL) or General Authorisation (GA), irrespective of the condition of the affected watercourse. Includes international management of water.
National Environmental Management: Integrated Coastal Management Act (24 of 2008) (NEM:ICM)	To determine the coastal zone of South Africa and to preserve and protect coastal public property. To control use of coastal property (Section 62, 63 and 65) and limitation of marine pollution (Chapter 8). Recreational waters. Water quality guidelines for the coastal environment: Recreational use (DEA, 2012). Set water quality targets for recreational waters to protect bathers. Protection of aquatic ecosystems. Water quality guidelines for protection of natural coastal environment (DWAF, 1995, in process of being reviewed by DEA). This will set targets for use of specific chemicals in marine waters and sediments to protect ecosystems.
National Forest Act (84 of 1998) (NFA)	Protection of natural forests and indigenous trees species through gazetted lists of Natural Forests and Protected Trees (Sections 7 (2) and 15 (3) respectively). Disturbance of areas constituting natural forest or the disturbance of a protected tree species requires authorisation from the relevant authority.
National Environmental Management: Biodiversity Act (10 of 2004) (NEM:BA)	Protection of national biodiversity through the regulation of activities that may affect biodiversity including habitat disturbance, culture of and trade in organisms, both exotic and indigenous. Lists of alien invasive organisms, threatened and protected species and threatened ecosystems published and maintained (Sections 97 (1), 56 (1) and 52 (1) (a) respectively). The NEMA provides for listing threatened or protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Protected. Activity 12 in Listing Notice 3 (Government Notice R324 of April 2017 as per the 2014 EIA Regulations, as amended) relates to the clearance of 300 m^2 or more of vegetation, within Critical Biodiversity Areas.
National Environmental Management: Waste Act (59 of 2008)	Minimising the consumption of natural resources; avoiding and minimising the generation of waste; reducing, re-

Instrument	Key objective
(NEM:WA)	using, recycling and recovering waste; treating and safely disposing of waste as a last resort; preventing pollution and ecological degradation; securing ecologically sustainable development while promoting justifiable economic and social development; promoting and ensuring the effective delivery of waste services; remediating land where contamination presents, or may present, a significant risk of harm to health or the environment: and achieving integrated waste management reporting and planning; to ensure that people are aware of the impact of waste on their health, well-being and the environment; to provide for compliance with the measures set out in paragraph (a) and generally, to give effect to section 24 of the Constitution in order to secure an environment that is not harmful to health and well-being.
Threatened or Protected Species Regulations of 2013 (ToPS)	The TOPs relates to Section 56 of NEMBA. Species categorised as CR, EN, VU or Protected require permits for activities relating to: i. Hunt / catch / capture / kill ii. Gather / collect / pluck iii. Pick parts of / cut / chop off / uproot / damage / destroy iv. Import into South Africa / introduce from the sea v. Export (re-export) from South Africa vi. Possess / exercise physical control vii. Grow / breed / propagate viii. Convey / move/ translocate ix. Sell / trade in / buy / receive / give / donate/ accept as a gift / acquire /dispose of x. Any other prescribed activity
Draft National Biodiversity Offset Policy	A Draft National Biodiversity Offset Policy was gazetted in March 2017 (NEMBA, 2017), and is in the process of being finalised. The offset policy is intended to establish the foundation for establishing an offset for biodiversity (including river and wetland ecosystems), ensuring that offset procedures are properly integrated into the EIA process to make sure that the mitigation hierarchy is exhausted. Should it be determined in the EIA that there will be residual impact that cannot be avoided and/or mitigate, then an offset will need to be established to account for the loss of biodiversity. The core principles for offsetting, as set out in the policy, should be used to guide the process of evaluating, designing and implementing an offset. It is essential that the offset process is introduced from the outset of the EIA. Provinces also have provincial offset strategies and policies in place that should be considered, where applicable.
National Water Resource Strategy (NWRS) 2004 and NWRS 2013	Facilitate the proper management of the nation's water resources; provide a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole; provide a framework within which water will be managed at regional or catchment level, in defined water management areas; provide information about all aspects of water resource management; identify water-related development opportunities and constraints.
The Water Services Act (108 of 1997)	The right of access to basic water supply and the right to basic sanitation necessary to secure sufficient water and an environment not harmful to human health or well-being; the setting of national standards and norms and standards for tariffs in respect of water services; the preparation and adoption of water services development plans

Instrument	Key objective
	by water services authorities; a regulatory framework for water services institutions and water services intermediaries; the establishment and disestablishment of water boards and water services committees and their duties and powers; the monitoring of water services and intervention by the Minister or by the 5 relevant Province; financial assistance to water services institutions; the gathering of information in a national information system and the distribution of that information; the accountability of water services providers: and the promotion of effective water resource management and conservation. Water supply services in an efficient equitable manner, as well as measures to promote water conservation and demand management which through Water Conservation and Water Demand Management (WC/WDM) strategies
Marine Living Resources Act (18 of 1998) (MLRA)	Marine Living Resources Act. The management and control of exploited living resources in estuaries fall primarily under the Marine Living Resources Act (MLRA) (No. 18 of 1998). The primary purpose of the act is to protect marine living resources (including those of estuaries) through establishing sustainable limits for the exploitation of resources; declaring fisheries management areas for the management of species; approving plans for their conservation, management and development; prohibit and control destructive fishing methods and the declaration of Marine Protected Areas (MPAs) (a function currently delegated to the DEA). The MLRA overrides all other conflicting legislation relating to marine living resources.
National Estuarine Management Protocol	National Estuary Management Protocol sets the standards for Estuarine Management in South Africa (Regulation No. 341 of 2013 promulgated in support of section 33 of the ICM Act).
National Port Act (12 of 2005)	Legal requirements as stipulated in terms of the National Ports Act (No. 12 of 2005) must be complied with in commercial ports – relevant to estuaries which have ports in them.
PROVINCIAL INSTRUMENTS	
Catchment Management Strategies applicable to all provinces	Progressively develop a catchment management strategy for the water resources within its water management area. Catchment management strategies must be in harmony with the national water resource strategy. CMA must seek cooperation and agreement on water -related matters from the various stakeholders and interested persons. CMA must be reviewed and include a water allocation plan, set principles for allocating water to existing and prospective users, taking into account all matters relevant to the protection use, development conservation, management and control of resources.
Eastern Cape	
Eastern Cape Nature and Environmental Conservation Ordinance (19 of1974)	This Ordinance includes rules for conservation areas, and enables the protection of wild animals and plants including lists of protected species. Note: Much of the Eastern Cape legislation relies on the pre-1994 legislation of the Eastern Cape, Transkei and Ciskei.
Transkei Environmental Conservation Decree (9 of 1992); Ciskei Nature Conservation Act 1987	Legislation promulgated for the former Transkei and Ciskei proved lists of indigenous fauna and flora and outline various management measures such as hunting seasons, bag limits and other recreational activities. Allowances are

Instrument	Key objective
	made for the proclamation of nature reserves and the general protection of the environment.
Cape Local Authorities Gas Ordinance 7 of 1912	Regulates gas and control gas related water pollution
Divisional Councils Ordinance 18 of 1976	Provides for the regulation and control of effluents refuse and stormwater
Free State	
Free State Nature Conservation Ordinance, 1969 (Act 8 of 1969)	To provide for the conservation of fauna and flora and the hunting of animals causing damage and for matters incidental thereto.
Gauteng	
Gauteng Nature Conservation Bill 2014	This bill provides rules for conservation areas; and enables the protection of wild animals and plants including lists of protected species.
KwaZulu-Natal	
Natal Nature Conservation Ordinance No. 15 of 1974 and KwaZulu-Natal Nature Conservation Management Act, (Act 9 of 1997)	According to the Natal Nature Conservation Ordinance No. 15 of 1974 and the KwaZulu-Natal Nature Conservation Management Act, 1992 (Act 9 of 1997), no person shall, among others: damage, destroy, or relocate any specially protected indigenous plant, except under the authority and in accordance with a permit from Ezemvelo KZN Wildlife (EKZNW). A list of protected species has been published in terms of both acts.
The KwaZulu-Natal Environmental, Biodiversity and Protected Areas Management Bill, 2014	The Management Bill, 2014 was passed to provide for the establishment, functions and powers of Ezemvelo KZN Wildlife; the protection and management of the environment and biodiversity; the protection and conservation of indigenous species, ecological communities, habitats and ecosystems; the management of the impact of certain activities on the environment; the sustainable use of indigenous biological resources; the declaration and management of protected areas; and to provide for matters connected therewith. The Bill includes lists of provincial protected animal and plant species, and it sets rules for activities in protected areas, as well as for the protection of biodiversity.
Various KZN Ordinances (e.g. South Barrow Loan and Ext Powers Ordinance 12 of 1920; South Shepstone Loan and Extended Powers Ordinance 20 of 1920; Water Services Ordinance 27 of 1963; Kloof Loan and Extended Powers Ordinance 16 of 1967; Umhlanga Extended Powers and Loan Ordinance 17 of 1975; Durban Extended Powers Cons Ordinance 18 of 1976; Kwa-Zulu and Natal Joint Services Act 84 of 1990)	Regulation of matters relating to water, water pollution and sewage in various areas in Kwa-Zulu Natal.
Mpumalanga	
Mpumalanga Nature Conservation Act, No. 10 of 1998	This Act relates to the establishment and management of conservation areas, and provides legislation relating to protected animals and plants
Northern Cape	
Northern Cape Nature Conservation Act, 2009	To provide for the sustainable utilization of wild animals, aquatic biota and plants: to provide for the implementation

Instrument	Key objective
(Act 10 of 2009).	of the Convention on International Trade in Endangered Species of Wild Fauna and Flora; to provide for offences and penalties for contravention of the Act: to provide for the issuing of permits and other authorisations: and provide for the matter connected therewith.
Divisional Councils Ordinance 18 of 1976	Provides for the regulation and control of effluents refuse and storm water
Western Cape	
Western Cape Nature Conservation Board Act, 1998 (Act 15 of 1998)	To provide for the establishment, powers, functions and funding of the Western Cape Nature Conservation Board and the establishment, funding a control of a Western Cape Nature Conservation Fund, and to provide for matters incidental thereto. The object of the board shall be, (a) promote and ensure nature conservation and related matter in the Province.
Western Cape Nature Conservation Laws Amendment Act, 2000. (Act 3 of 2000)	To provide for the amendment of various laws on nature conservation in order to transfer the administration of the provisions of those laws to the Western Cape Nature Conservation Board; to amend the Western Cape Nature Conservation Board Act, 1998 to provide for a new definition of Department and the deletion of a definition; to provide for an increase in the number of members of the Board; to provide for additional powers of the Board; to amend the provisions regarding the appointment and secondment of persons to the Board; and to provide for matters incidental thereto.
LOCAL INSTRUMENTS	
Local Government: Municipal Systems Act (Act 32 of 2000)	Requires municipalities to develop Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs). The IDP is a comprehensive five-year plan for a municipal area that gives an overall framework for development, land use and environmental protection. The SDF is a compulsory core component of an IDP that must guide and inform land development and management by providing future spatial plans for a municipal area. The SDF should be the spatial depiction of the IDP, and should be the tool that integrates spatial plans from a range of sectors.
Regulations 21 (published in terms of section 120 of the Municipal Systems Act)	Municipal Planning and Performance Management standards require SDFs to include a Strategic Environmental Assessment (SEA) which must be aligned with those of neighbouring municipalities. A municipal SEA identifies spatial constraints on developments and highlights sensitive areas for inclusion of detailed spatial information and policy guidelines for incorporation into a Strategic Environmental Assessment map.
Municipal Bylaws	Numerous municipalities have promulgated bylaws that relate to conservation of the environment and these may include the application of land uses through the town planning scheme. E.g. eThekwini Municipality's Open Space System as well as the iLembe and uMhlathuze Municipal bylaws. These will need to be considered in more detail during the detailed planning and project specific Environmental Authorisation phases.
OTHER	
Bophuthatswana Nature Conservation Act, 1973 (Act 3 of 1973; still in force)	To provide for the protection of game and fish, the conservation of flora and fauna and the destruction of vermin in the former Bophuthatswana.
Transvaal Nature Conservation Ordinance No 12 of 1983 as amended (still in force)	Provides for the protection of fauna and flora in the North-West and Gauteng Provinces (former Transvaal Province).

Instrument	Key objective
Cape Nature Conservation Ordinance, No. 19 of 1974 (still in force)	Provides for the protection of fauna and flora in parts of the North-West Province and the Northern, Western and Eastern Cape Provinces (former Cape Province).
Water Resource Directed Measures including: the Ecological Reserve, National Water Resource Classification System and Resource Quality Objectives	The main objective of the Chief Directorate: Resource Directed Measures is to ensure protection of water resources, as described in Chapter 3 of NWA and other related water management legislation and policies. The role of Resource Directed Measures is to provide a framework to ensure sustainable utilization of water resources to meet ecological, social and economic objectives and to audit the state of South Africa's water resources against these objectives The aim of Water Resource Quality Objectives is to delineate units of analysis and describe the status quo of water resources, initiate stakeholder process and catchment visioning, quantify ecological water requirements and changes in ecosystem services, identify scenarios within IWRM, draft management classes, produce Resource Quality Objectives (EcoSpecs, water quality).

4 KEY ENVIRONMENTAL ATTRIBUTES AND SENSITIVITIES

4.1 Overview

4.1.1 Terrestrial ecosystems (per biome)

4.1.1.1 Desert

The Desert biome of South Africa is broadly divided into two bioregions, namely (i) the Southern Namib Desert bioregion and (ii) the Gariep Desert bioregion. The former comprises the desert areas stretching from the Atlantic coast near the mouth of the Orange River penetrating inland along the course of the lower Orange River to Sendelingsdrift and is characteristic of winter rainfall. The Gariep Desert is characterised by summer rainfall and includes the desert areas from Sendelingsdrift further east to the vicinity of Onseepkans and Pofadder in northern Bushmanland. The Desert biome borders the Nama Karoo biome to the east, and the Succulent Karoo biome in its western parts (Jürgens, 2006).

This arid environment is characteristic of extreme ecological conditions with erratic rainfall across the area (MAP <70 mm), high maximum daily temperatures (>48°C), high incidence of coastal fog, strong winds and frequent sandstorms. The desert landscape is highly dissected ranging from tall, rugged mountains with deep gorges to broad, sloping valley plains. The desert substrate is generally very rocky with little to no soil present. Desert soils, where present, are slow-forming, shallow alluvial sands created from a variety of rock types that are easily eroded by wind and high-impact rainfall from thunderstorms (Jürgens, 2006).

The Southern Namib Desert vegetation is characteristic of stem- and leaf-succulent trees and shrubs such as the Quiver tree (*Aloidendron dichotomum*) and the Giant Quiver tree (*Aloidendron pillansii*), with species from key genera including *Euphorbia, Fenestraria, Mesembryanthemum* (formerly *Brownanthus*)*, Monsonia* (formerly *Sarcocaulon*), *Salsola, Stoeberia* and *Tylecodon* dominating the desert plains and rocky hilly landscape. The Gariep Desert, in addition to the presence of stem- and leaf-succulents such as *Aloidendron dichotomum, Commiphora* species*, Euphorbia* species and *Pachypodium namaquanum* ('halfmens'), is typified by non-succulent woody perennials such as *Boscia albitrunca* (Shepherds tree), *Parkinsonia africana* (Green-hair thorn tree) and *Schotia afra* (Karoo boer-bean tree) with grasses like *Stipagostis* and *Enneapogon* species being distinctive of the sandy plains (Van Jaarsveld, 1987; Jürgens, 2006).

The Gariep Desert flora is dominated by ephemeral plants, often annual grasses and non-woody forbs, especially after a good rainy season. Normally the vast desert plains appear barren and desolated with aboveground vegetation persisting underground in the form of seed, but following abundant rainfall in winter the desert plains and lower mountain slopes can be covered with a sea of short annual grasses and striking mass flowering displays of short-lived forbs and succulents in spring. Perennial plants such as stem- and leaf succulent trees and shrubs, including some non-succulent plants, are usually encountered in specialised habitats associated with local concentrations of water, like dry river beds, drainage lines and rock crevices. Lichen fields are also a conspicuous marvel of the open coastal belt utilising the moisture-filled fog originating from the adjoining Atlantic Ocean (Van Jaarsveld, 1987; Jürgens, 2006).

Plant species richness of the vegetation types included in the Desert biome is exceptionally high when compared to other desert environments with similar aridity levels globally (Jürgens, 2006). The most profound feature of the Desert biome is the Gariep Centre of Endemism which covers the northern most part of the biome stretching inland along the Lower Orange River Valley. The Richtersveld forms the core of the centre boasting a total of approximately 2 700 vascular plant species of which more than 560 species are endemic and near-endemic to the Gariep Centre. More than 80% of species among these endemics are succulents (Van Wyk and Smith, 2001). Also, the Orange River Mouth is located at South Africa's coastal border with Namibia and contains two threatened vegetation types which are both highly disturbed, namely the Arid Estuarine Salt Marshes that is a National Freshwater Ecosystem Priority Area (NFEPA) and Endangered Wetland, as well as the Critically Endangered Alexander Bay Coastal Duneveld (SANBI, 2011; Driver et al*.,* 2012; Holness and Oosthuysen, 2016).

The Desert biome, interfacing with the highly diverse and species-rich Succulent Karoo biome, is considered to be one of the most biologically diverse and environmentally sensitive deserts in the world. Although the region is sparsely populated with only few small villages, communal livestock farming (mainly sheep and goats) across large areas of the biome has had a significant impact on vegetation cover. Overgrazing due to overstocking, intensified by extended periods of drought, especially surrounding some permanent settlements in the Richtersveld, resulted in severe deterioration of veld condition, and in some places total desertification (Hoffmann et al., 1999; Jürgens, 2006; Hoffmann et al., 2014).

Commercial scale crop farming along the lower Orange River has also substantially increased during the past century now having extensive areas cultivated with inter alia vineyards, dates and subtropical fruit orchards. In addition to irrigation agriculture, open-cast diamond mining and exploration activities, mostly along the lower Orange River from Alexander Bay to Swartwater, have largely scarred the desert landscape adding to the human impact on this sensitive ecosystem. Although alien invasive plants such as *Prosopis* spp., *Nicotiana glauca, Ricinus communis* and *Atriplex lindleyi* are a common phenomenon of dry river beds, drainage lines and around human settlements, its distribution has been limited by the lack of subsurface water in the greater desert area (Milton et al., 1999; Jürgens, 2006). Unfortunately, unique species richness and high levels of endemism associated with the Desert biome have also seen the illegal removal of succulents by collectors and traders (Van Wyk and Smith, 2001).

So far, only approximately 22% of the Desert biome is formally protected in statutory and non-statutory reserves of which the Richtersveld National Park, the Nababieps Provincial Nature Reserve and the Orange River Mouth Provincial Nature Reserve constitute the largest area of conservation (Jürgens, 2006; Taylor and Peacock, 2018). The average conservation target for vegetation types in the Desert biome is 32%. Other efforts to preserve this unique desert ecosystem include the Richtersveld Community Conservancy and two proclaimed National Heritage Sites, namely (i) the lichen field near Alexander Bay and (ii) the renowned population of *Aloidendron pillansii* on Cornellskop (Jürgens, 2006).

Transformation of the Desert biome has so far been relatively limited transformed despite the effect of the aforementioned impacts on desert ecosystems (Jürgens, 2006). However, rising temperatures and decreasing rainfall as a direct result of climate change could intensify desertification of the Desert biome over the next 50 years (Hoffmann et al., 1999; Rutherford et al., 1999).

The Desert biome is not particularly rich in natural resources, hence providing employment to a relatively small number of people. The main economic drivers in this arid area are commercial scale crop cultivation and mining activities along the Lower Orange River Valley, whereas small stock farming is the main agricultural land use practised in most of the remaining biome. Ecotourism and conservation, as well as collection of plants for the horticultural trade, specifically succulents, add to the economic value of the Desert biome (Hoffmann et al., 1999; Jonas, 2004; Jürgens, 2006).

Due to the ecologically sensitive nature of this biome, not all of the aforementioned land uses are sustainable. Clearance of vegetation and removal of topsoil for irrigated croplands as well as large scale surface mining along the Orange River have resulted in total biodiversity loss and increased soil erosion. In addition to overstocking of small livestock, which leads to overgrazing, unsustainable land use exacerbated by global climate change is causing desertification which could have a negative impact on the socio-economic value of the Desert biome (Hoffmann et al., 1999; Jonas, 2004; Jürgens, 2006; Milton, 2009).

Box 1: Terrestrial fauna of the Desert Biome

More than 60 different mammal species are known to occur in the Desert biome (UCT, 2018a). Three species are considered Vulnerable, namely the Hartmann's zebra (*Equus zebra hartmannae*), the Black-footed cat (*Felis nigripes*) and the Cape leopard (*Panthera pardus*). A further three mammals have a Near-Threatened status including the Brown Hyena (*Hyaena brunnea*), the African Clawless Otter (*Aonyx capensis*) and Littledale's Whistling Rat (*Parotomys littledalei*). Antelope species common to the desert plains include Gemsbok (*Oryx gazella*), Springbok (*Antidorcas marsupialis*), Steenbok (*Raphicerus campestris*) and Kudu (*Tragelaphus strepsiceros*) (Williamson, 2010; Child et al., 2016; Walker et al., 2018).

The reptile diversity of the Desert biome is fairly high with about 84 species (UCT, 2018b), three of which are of conservation concern. These include the Near-Threatened Richtersveld Pygmy Gecko (*Goggia gemmula*), the Critically Endangered Namib Web-footed Gecko (*Pachydactylus rangei*) and the Vulnerable Speckled Padloper (*Chersobius signatus*) (Bates et al*.,* 2014).

A total of 13 frog species can potentially occur in the Desert biome (UCT, 2018d) of which two species are listed as being Vulnerable, namely the Desert Rain Frog (*Breviceps macrops*) and the Namaqua Stream Frog (*Strongylopus springbokensis*) (Minter, 2004).

The Desert Biome includes an abundant insect fauna which includes many Scarabaeidae and Tenebrionidae beetles. Its insect diversity further includes about 69 species of moths and butterflies, 20 species of dragonflies and 32 species of lacewings (Mecenero et al*.,* 2013). Up to 24 scorpion species could potentially be found in this desert environment (UCT, 2018c).

4.1.1.2 Succulent Karoo

The Succulent Karoo biome covers an area of approximately 103 000 km² and extends from the coastal regions of southern Namibia through the western parts of the Northern Cape and Western Cape provinces of South Africa, as well as inland of the Fynbos biome to the Little Karoo in the south (Rundel and Cowling, 2013). The Succulent Karoo biome interfaces with the Albany Thicket to the east, the Nama Karoo to the north and west, and the Desert biome to the north (Jonas, 2004; Mucina et al., 2006a).

The Succulent Karoo biome is a semi-desert region that is characterised by the presence of low winter rainfall, with a mean annual precipitation of between 100 and 200 mm, and daily temperature maxima in summer in excess of 40°C the norm. Fog is a common occurrence in the coastal region and frost is infrequent. Desiccating, hot berg winds may occur throughout the year (Desmet and Cowling, 1999; Jonas, 2004; Mucina et al., 2006b; Walker et al., 2018).

Topographically the Succulent Karoo varies from flat to gently undulating plains at altitudes generally below 800 m that are situated to the west and south of the escarpment and are typical of the Knersvlakte and Hantam/Roggeveld/Tankwa Karoo, towards a more hilly and rugged mountainous terrain characteristic of the Namaqualand, Robertson Karoo and Little Karoo at higher elevations reaching up to 1 500 m in the east. The geology of the Succulent Karoo is ancient and complex with weakly developed, lime-rich sandy soils that easily erode and are derived from weathering of sandstone and quartzite (Allsopp, 1999). An unusual but abundant feature of the Succulent Karoo soils are low, circular mounds called 'heuweltjies' which were created by harvester termites thousands of years ago (McAuliffe et al., 2018; McAuliffe et al., in press). Their rich soils support an entirely different vegetation from the surrounding land cover making them truly unique (Jonas, 2004; Mucina et al., 2006b; Jacobs and Jangle, 2008).

The Succulent Karoo is an arid to semi-arid biome which is known for its exceptional succulent and bulbous plant species richness, high reptile and invertebrate diversity, as well as its unique bird and mammal life (Rundel and Cowling, 2013). It is also recognised as one of three global biodiversity hotspots in southern

Africa with unrivalled levels of diversity and endemism for an arid region (Cowling et al., 1999; Desmet, 2007; Hayes and Crane, 2008). The Succulent Karoo vegetation is dominated by dwarf leaf-succulent shrublands with a matrix of succulent shrubs and very few grasses, except in some sandy areas. Species of the plant families *Aizoaceae* (formerly the *Mesembryanthemaceae*), *Crassulaceae* and *Euphorbiaceae*, as well as succulent members of the *Asteraceae*, *Iridaceae* and *Hyacinthaceae* are particularly prominent. Mass flowering displays of annuals (mainly *Asteraceae* species), often on degraded or fallow agricultural lands are a characteristic occurrence in spring.

The varied Succulent Karoo landscape lends itself to the adaptation of a diversity of plant growth forms, ranging from extensive plains often littered with rocks or pebbles such as the Knersvlakte to rocky areas occasionally dotted with solitary trees and tall bush clumps (e.g. *Ficus ilicina, Pappea capensis, Searsia undulata, Schotia afra* and *Vachellia karroo*) often found in deeper valleys and along drainage lines. In some higher altitude areas of the Succulent Karoo, particularly on rain shadow mountain slopes, the vegetation contains elements similar to an arid daisy-type fynbos (Mucina et al., 2006b; Jacobs and Jangle, 2008).

The Succulent Karoo biome is recognised as one of 25 internationally acclaimed biodiversity hotspots due to its exceptional abundance and rich diversity of unusual succulent plants and animal life (Myers et al*.,* 2000; Jonas, 2004; Noroozi et al*.,* 2018). Despite its amazing ecological and socio-economic diversity, the hotspot is a vulnerable ecosystem with about 8% of the Succulent Karoo biome formally protected in statutory and non-statutory reserves, including the Richtersveld, Namaqua and Tankwa Karoo National Parks, as well as the Goegap, Nababieps and Oorlogskloof Provincial Nature Reserves (Mucina et al., 2006b; Hoffmann et al*.,* 2018).

The predominant land use is agriculture with about 90% of the region subjected to livestock grazing (mainly sheep, goats and ostrich farming). Although crop farming is limited due to nutrient-poor soils with low agricultural potential and the lack of sufficient irrigation water, severe overgrazing and unsustainable cultivation practices have contributed to widespread loss of topsoil through sheet erosion and the accelerated degradation of veld condition reducing the overall species diversity in this arid environment (Mucina et al., 2006b; Le Maitre et al., 2009; Walker et al., 2018).

Mining for diamonds, gypsum and heavy metals, although an important economic driver which is only affecting about 1% of the biome, is another major threat to biodiversity in the Succulent Karoo as it irreversibly transforms landscapes making ecological restoration extremely challenging (Jonas, 2004; Milton and Dean, 2012). An increase in urban settlements due to a growing population, in addition to overharvesting of fuel wood and the illegal harvesting of plants for the medicinal and horticultural trades, further threatens conservation efforts of the Succulent Karoo biome (Milton et al., 1999; Walker et al., 2018).

Cropping, mining, linear structures such as fences, roads, railways and power lines, and the eutrophication of water further exacerbate the spread and establishment of alien invasive plant species in the Succulent Karoo such as *Arundo donax*, *Atriplex lindleyi*, *Atriplex nummularia*, *Nerium oleander*, *Pennisetum setaceum*, *Prosopis glandulosa* and *Tamarix ramossissima* (Van Wilgen et al*.,* 2008; Rahlao et al*.,* 2009; Le Maitre et al*.,* 2016; Dean et al*.,* 2018; Walker et al., 2018). The invasion of members of the Cactaceae family such as the Bilberry cactus (*Myrtillocactus geometrizans*) is becoming an increasing conservation concern especially in the southern Karoo (Dean and Milton, 2019).

Furthermore, climate change has been identified as one of the most significant threats to biodiversity as increasing temperature levels and decreasing rainfall over the next five decades could exacerbate desertification of the Succulent Karoo biome (Hoffmann et al., 1999; Rutherford et al*.,* 1999; Walker et al., 2018). Also, a recent increase in renewable energy developments (solar and wind) in the Succulent Karoo has seen approval of about 160 applications for environmental authorisation to date of which another almost 50 are currently in process (DEA, 2019). Notwithstanding the effect of the aforementioned impacts on Succulent Karoo ecosystems, to date approximately 4% of the biome has been transformed (Mucina et al., 2006b).

Box 2: Terrestrial fauna of the Succulent Karoo Biome

The fauna of the Succulent Karoo biome does not reflect the same level of diversity or endemism shown by the flora (Vernon, 1999; Mucina et al., 2006b; Rundel and Cowling, 2013).

Mammal diversity in the Succulent Karoo biome is relatively high with about 75 species of mammals (UCT, 2018a) of which two are endemic, namely the Critically Endangered De Winton's golden mole (*Cryptochloris wintoni*) and the Namaqua dune mole rat (*Bathyergus janetta*). Another important species of conservation concern in the region is the Critically Endangered riverine rabbit (*Bunolagus monticularis*), the Near-Threatened brown hyena (*Hyaena brunnea*), the Vulnerable Hartmann's mountain zebra (*Equus zebra hartmannae*), the Vulnerable Cape leopard (*Panthera pardus*) and the Vulnerable Grant's golden mole (*Eremitalpa granti*) (Rundel and Cowling, 2013; Child et al. 2016).

Major concentrations of large mammals, including the African elephant (*Loxodonta africana*), the Critically Endangered black rhinoceros *(Diceros bicornis*), the hippopotamus (*Hippopotamus amphibious*) and the African buffalo (*Syncerus caffer*), used to roam the riverine forests along major rivers in the Succulent Karoo, but these populations have now all disappeared from this hotspot. Today, only smaller herds of gemsbok (*Oryx gazella*), mountain zebra (*Equus zebra*) and springbok (*Antidorcas marsupialis*) are commonly found mainly within the confines of formally protected areas and privately owned game farms (Williamson, 2010; Walker et al., 2018).

Reptile diversity is relatively high in the Succulent Karoo with approximately 94 species of which about 15 are endemic (UCT, 2018b). All of the endemics are geckos and lizards, representing about 25% of the nearly 60 gecko and lizard species in the biome. These endemics include seven species of girdled lizards of the genus *Cordylus*, including the armadillo girdled lizard (*Cordylus cataphractus*) that is endemic to the region. Tortoise diversity is very high in the Succulent Karoo with seven taxa of which two are endemic, namely the Namaqualand tent tortoise (*Psammobates tentorius trimeni*) and the Namaqualand speckled padloper (*Homopus signatus signatus*) (Bates et al*.,* 2014).

Amphibians are poorly represented in the Succulent Karoo with just over 20 species (UCT, 2018d). All of these species are frogs of which one is endemic, namely the Desert Rain Frog (*Breviceps macrops*). This frog species occurs along the Namaqualand coast of South Africa northwards to Lüderitz in the coastal south-west of Namibia. Also noteworthy is the Namaqua Stream Frog (*Strongylopus springbokensis*) that has a Near-Threatened status (Minter, 2004).

Invertebrate diversity is relatively high in the Succulent Karoo biome and evidence suggests that more than half of the species in some insect groups are endemic to this biodiversity hotspot. These include amongst others monkey beetles (*Clania glenlyonensis*), bee flies, long-tongued flies and bees, as well as a variety of masarid and vespid wasps (Rundel and Cowling, 2013). The Succulent Karoo also boasts 50 scorpion species of which nearly 22 species are endemic to the biome (Rundel and Cowling, 2013; UCT, 2018c).

Historically, the Succulent Karoo biome has mainly supported livestock farming, mostly sheep and goats, but it was not until the late 1700's that land occupation and urban settlement by colonial pioneers expanded throughout most of the area. By late 1800's both cattle and ostrich farming also became an important agricultural revenue stream and today almost 90% of the Succulent Karoo supports commercial and subsistence pastoralism, in addition to cropland farming in areas where irrigation water is readily available (Hoffmann et al., 1999; Smith, 1999; Jonas, 2004; Hoffmann et al., 2018; Walker et al., 2018).

A study by Jonas in 2004 revealed the following economic land uses in the Succulent Karoo:

- Agriculture – Livestock farming (e.g. sheep, goats, cattle and ostrich);
- Agriculture – Cropland farming (barley, lucern, dates, vineyards, etc.);
- Conservation (e.g. National Parks and Nature Reserves);
- Fuel wood (e.g. *Prosopis* spp).

- Game farming (e.g. trophy hunting, live game sales, venison sales, etc.);
- Horticulture (e.g. succulents);
- Medicinal bioprospecting (e.g. cancer bush and kougoed);
- Mining (e.g. diamonds, copper, zinc, etc.); and
- Tourism (including ecotourism).

Recent statistics have shown that wind and solar energy installations cover approximately 5.2% of land in the Succulent Karoo of which the largest percentage of affected areas is situated in the Namaqualand bioregions (Hoffmann et al*.,* 2018).

All life and economic activities occurring within the Succulent Karoo are highly driven by the availability of water. Both surface and groundwater are generally very limited and often of naturally poor quality, especially in the driest regions of the biome. Exacerbated by climate change and compounded by increased pressure from human demand, sufficient water quality and quantity pose serious challenges to current and future land use and development opportunities in the Succulent Karoo (Hoffmann et al., 2009; Le Maitre et al*.,* 2009; Milton, 2009; Hoffmann et al*.,* 2018; Walker et al., 2018).

4.1.1.3 Nama Karoo

The Nama Karoo biome occurs on the central plateau of the western half of South Africa and is the largest of the three biomes that comprise the semi-arid Karoo-Namib Region covering about 23% of the interior of southern Africa (Ndhlovu et al., 2011; Walker et al., 2018). The word 'Karoo' comes from the Khoi-San word *kuru* which means dry, an apt description for this vast, open, arid thirstland. The Nama Karoo interfaces with the Succulent Karoo biome to the west, the Desert biome in the extreme northwest, the Savanna biome to the north and northeast, the Fynbos and Albany Thicket biomes in its southern and south-eastern extremities, and the Grassland biome infringing on its eastern border (Mucina et al., 2006a).

The geology underlying the Nama Karoo biome is exceptionally varied and consists of a 3 km thick succession of millennia old sedimentary rocks rich in fossils (Lloyd, 1999; Mucina et al., 2006a). Shallow, weakly developed lime-rich soils with high erodibility cover more than 80% of the Nama Karoo landscape (Watkeys, 1999). The climate is typically harsh with considerable fluctuations in both seasonal and daily temperatures. Droughts are common with frost a frequent occurrence during winter. Rainfall is highly seasonal, peaking in summer with a mean annual precipitation (MAP) ranging from 100 mm in the west to about 500 mm in the east, decreasing from east to west and from north to south (Palmer and Hoffmann, 1997; Desmet and Cowling, 1999; Mucina et al., 2006a; Walker et al., 2018).

The Nama Karoo is mostly a complex of extensive, flat to undulating gravel plains dominated by grassy, dwarf shrubland vegetation of which its relative abundances are dictated mainly by rainfall and soil type (Cowling and Roux, 1987; Palmer and Hoffmann, 1997; Mucina et al., 2006a). Towards the Great Escarpment in the south and west, a much dissected landscape exists characteristic of isolated hills, koppies, butts, mesas, low mountain ridges and dolerite dykes supporting sparse dwarf Karoo scrub and small trees (Dean and Milton, 1999; Mucina et al., 2006a; Jacobs and Jangle, 2008).

Nama Karoo vegetation is not particularly species-rich and the biome does not contain any centres of endemism (Van Wyk and Smith, 2001). There are also very few rare or endangered indigenous plant species occurring in the biome. Dwarf shrubs (generally <1 m tall) and grasses dominate the current vegetation that is intermixed with succulents, geophytes and annual forbs. As a result, the amount and nature of the fuel load is insufficient to carry fires and fires are rare within the biome. Grasses tend to be more common in depressions and on sandy soils, whereas small trees occur mainly along drainage lines and on rocky outcrops (Palmer and Hoffmann, 1997; Mucina et al., 2006a).

Some of the more abundant shrubs include species of *Drosanthemum, Eriocephalus, Galenia, Lycium, Pentzia, Pteronia*, *Rhigozum*, and *Ruschia*, while the principal perennial grasses are *Aristida, Digitaria, Enneapogon*, and *Stipagrostis* species. Trees and taller woody shrubs are mostly restricted to watercourses such as rivers and wetlands, and include *Boscia albitrunca, B. foetida, Diospyros lycioides, Grewia robusta, Searsia lancea, Senegalia mellifera, Tamarix usneoides* and *Vachellia karroo* (Palmer and Hoffmann, 1997; Mucina et al., 2006a).

The Nama Karoo biome, considered the third largest biome in South Africa after the Grassland and Savanna biomes, comprises an area of approximately 248 278 km² of which only approximately 1.6% is formally protected in statutory reserves such as the Augrabies and Karoo National Parks (Hoffmann et al*.,* 2018). About 5% of the Nama Karoo has been transformed by human impact relative to other biomes in South Africa, leaving the majority of the land still in a state classified as Natural (Mucina et al., 2006a; Hoffmann et al*.,* 2018). However, according to Hoffmann and Ashwell (2001) approximately 60% of the Nama Karoo landscape is characterised by moderately to severely degraded soils and vegetation cover (Mucina et al., 2006a). Despite the increasing impact of mainly soil erosion and overgrazing (Atkinson, 2007), the ecosystem threat status of all 14 Nama Karoo vegetation types are considered least threatened (South African Government Gazette, 2011).

The large historical herds of Springbok (*Antidorcas marsupialis*) and other game native to the Nama Karoo no longer exist as most of the Nama Karoo has been converted to fenced rangeland for livestock grazing during the past century, in particular sheep and mohair goats (Hoffmann et al*.,* 1999). Although the habitat is mostly intact, heavy grazing has left certain parts of the Nama Karoo seriously degraded (Lloyd, 1999; Milton, 2009; Ndhlovu et al*.,* 2011; Ndhlovu et al*.,* 2015). Vegetation recovery following drought can be delayed due to increased stocking rates that in turn exacerbate the effects of subsequent drought periods. Under conditions of overgrazing many indigenous shrubs may proliferate, while several grasses and other palatable species may be lost (Mucina et al., 2006a), contributing to the gradual increase of land degradation in the Nama Karoo (Milton and Dean, 2012; Walker et al., 2018).

In addition to pastoralism, alien plant infestation, anthropogenic climate change, agricultural expansion, construction of linear structures, urban sprawl, the collection of rare succulents and reptiles for illegal trade, as well as the construction and failure of dams also threaten the Nama Karoo's biodiversity (Lovegrove, 1993; Lloyd, 1999; Rutherford et al., 1999; Mucina et al., 2006a; Milton, 2009; Dean et al*.,* 2018). The introduction of a number of alien, drought-hardy ornamental and forage plants have the potential to seriously alter the biome's ecology and hydrology (Milton et al. 1999). Alien invasive plants currently common in the Nama Karoo region include *Argemone ochroleuca*, *Arundo donax*, *Atriplex* spp., *Limonium sinuatum*, *Opuntia* spp., *Pennisetum setaceum*, *Phragmites australis, Prosopis* spp., *Salsola kali and Schkuhria pinnata,* as well as various members of the Cactaceae family such as *Echinopsis* spp. and *Tephrocactus articulates* (Van Wilgen et al*.,* 2008; Walker et al., 2018).

Box 3: Terrestrial fauna of the Nama Karoo Biome

The Nama Karoo never had the variety of wildlife that can be found for example in the Savanna biome; however, before pastoralism brought along fenced rangelands, vast herds of Springbok used to migrate through the region in search of water and grazing. Today, these free roaming herds are mostly replaced with livestock and game ranching. The majority of mammals in the Nama Karoo are species with a widespread distribution that originate in the Savanna and Grassland biomes (Dean et al*.,* 2018). The Nama Karoo boasts a mammal diversity of approximately 177 species of which more than 10 threatened species are known to occur in this biome. Common animals include the Bat-Eared Fox, Black-Backed Jackal, Spring Hare, Springbok, Gemsbok, Kudu, Eland and Hartebeest. Most noteworthy is the Critically Endangered Riverine Rabbit (*Bunolagus monticularis*) which is an endemic species of the central Nama Karoo (Holness et al., 2016; UCT, 2018a).

Other mammal species of conservation concern include the Endangered Southern Tree Hyrax (*Dendrohyrax arboreus*), as well as the Vulnerable Hartmann's Zebra (*Equus zebra hartmannae*), Cheetah (*Acinonyx* *jubatus*), Leopard (*Panthera pardus*), Black-footed Cat (*Felis nigripes*) and White-tailed Mouse (*Mystromys albicaudatus*). The Grey Rhebok *(Pelea capreolus*), Mountain Reedbuck (*Redunca fulvorufula* subsp. *fulvorufula*), Brown Hyena (*Hyaena brunnea*) and the Southern African Hedgehog (*Atelerix frontalis*) are all listed as Near-Threatened (UCT, 2018a).

Reptile diversity of the Nama Karoo is moderately high with nearly 221 species that can be found in this arid to semi-arid environment (UCT, 2018b). Important tortoise species include the Vulnerable Speckled Padloper (*Chersobius signatus*) and the Near-Threatened Karoo Padloper (*Chersobius boulengeri*). The Plain Mountain Adder (*Bitis inornata*), which is restricted to the Nuweveldberge, is the only snake species that is endemic to the Nama Karoo and it is categorised as Endangered. Also, the Elandsberg Dwarf Chameleon (*Bradypodion taeniabronchum*) is currently listed as endangered and the Braack's Pygmy Gecko (*Goggia braacki*) is considered Near-Threatened. Three other lizard species, the Dwarf Karoo Girdled Lizard (*Cordylus aridus*), the Karoo Flat Gecko (*Afroedura karroica*) and Thin-skinned Gecko (*Pachydactylus kladaroderma*) have much of their distribution in the Karoo.

The Nama Karoo boasts a fairly moderate diversity of Amphibia with about 50 frog species that could be found in this biome. Noteworthy species include the endemic Karoo Caco (*Cacosternum karooicum*) and the Near-Threatened Giant Bull Frog (*Pyxicephalus adspersus*) (Minter, 2004).

Terrestrial invertebrate diversity in the Nama Karoo is considerably high with up to 575 species of Lepidoptera (moths and butterflies), 84 species of dragonflies, 115 species of lacewings and more than 80 different species of dung beetle. Five butterfly species are wholly endemic to the Central Karoo (*Aloeides pringlei, Lepidochrysops victori, Thestor compassbergae, T. camdeboo* and *Cassionympha camdeboo*). The butterfly species, *Lepidochrysops victori* is categorised as Vulnerable (Mecenero et al. 2013; Holness et al., 2016). Nearly 40 species of scorpions could occur in the Nama Karoo region (Holness et al., 2016).

The Nama Karoo is also threatened by increased mining activities such as open-cast zinc mining at Black Mountain and the Gamsberg near Aggeneys, as well as the potential threat of uranium mining around Beaufort West and the greater Lower Karoo region. The possibility of large scale shale gas fracking presents a further threat to the Nama Karoo biodiversity (Khavhagali, 2010; Milton and Dean, 2012; Cramer, 2016). An increased need for renewable energy has already seen the impact of several wind farms being developed in the Karoo region and along its margins, as well as planning and construction of a number of solar power projects (Walker et al., 2018).

Furthermore, the increased clearing of natural vegetation for cultivation along the lower Orange River destroys the natural habitat of many Nama Karoo fauna and flora. Pesticides used to control Brown Locust (*Locustana pardalina*) and Karoo Caterpillar (*Loxostege frustalis*) outbreaks also impact wildlife habitat severely, with the highest concentration of pesticides particularly within the avifauna, specifically raptors (Lovegrove, 1993; Khavhagali, 2010; Walker et al., 2018).

The overall improvement of ecosystem health and to ensure ecological sustainability of the Nama Karoo biome will require a dedicated effort and strategic collaboration from a wide range of stakeholders to achieve the preservation, conservation and management of its biodiversity.

The Nama Karoo provides natural resources for a wide array of business activities; however, social wellbeing and economic viability of these enterprises greatly rely on the availability and spatial distribution of water. The main industry sectors underpinning economic growth in the Nama Karoo are agriculture (including game and livestock ranching, and crop cultivation), mining (including diamonds, granite, heavy metals and marble, as well as the potential for shale gas and uranium) and tourism (including ecotourism). All three of these sectors have potential to contribute to socio-economic growth of the region but are heavily dependent on sustainable water resources to exist (Hoffmann et al., 1999; Mucina et al., 2006a; Milton, 2009; Walker et al., 2018).

Other economic opportunities characteristic of the Nama Karoo relates to the development and commercial exploitation of medicinal plants (such as *Hoodia gordonii*), horticulture, manufacturing, biodiversity conservation (e.g. National Parks, Nature Reserves, game farms) and the significance of cultural heritage (Milton, 2009; Todd et al., 2016; Dean et al., 2018; Walker et al., 2018). A recent increase in renewable energy installations (solar and wind) in the Nama Karoo has shown a total land cover of about 3.6% to date (Hoffmann et al., 2018).

4.1.1.4 Fynbos

The Fynbos Biome is globally recognised for its high diversity of plant species with about 7 500 species, 69% of which are endemic (Bergh et al., 2014; Rebelo et al., 2006) and 1 889 are listed as threatened (Turner, 2017). The biome is centred in the south-western part of the Western Cape with areas extending north-westwards for about 650 km, almost to the Orange River, and eastwards for 720 km to the Kap River mountains east of Grahamstown. Fynbos is closely associated with the north-south and east-west ranges of mountains comprising the Cape Folded Belt mountain ranges, some inselbergs, the lowlands between the coast and the coastal ranges and also the wetter inland valleys. It also occurs inland on the Roggeveld mountains that are part of the Great Escarpment. The mountains are dominated by the quartzitic sandstones of the Table Mountain Group (TMG) which give rise to sandy soils that are low in nutrients (Bradshaw and Cowling, 2014; Rebelo et al., 2006). The lowlands and the Roggeveld are underlain by shales which give rise to more fertile clay-loam soils and granites with more fertile, sandy soils which also support Fynbos in places. Parts of the lowlands have deep, infertile sandy soils particularly the west coast and parts of the southern coast that support Fynbos.

On the inland side and in the drier valleys in the western part of the biome the Fynbos adjoins the Succulent Karoo, southern part Succulent Karoo and Albany Thicket in the inland valleys, and in the east Albany Thicket in low rainfall areas and Grasslands in high rainfall areas. Both the Succulent Karoo and the Albany Thicket biomes are fire sensitive and the boundaries appear to be largely fire-maintained. There are numerous patches of Afromontane Forest in fire-protected kloofs throughout the Fynbos with extensive areas of forest on the coastal slopes in the Outeniqua-Tsitsikamma region (Geldenhuys, 1994; Mucina et al., 2006c). The Forests embedded within the Fynbos are excluded from this analysis as they are considered no-go areas.

The western part of the biome receives its rainfall primarily in the winter months (June to August) and the eastern part has peaks in the spring and summer with some rain every month (Bradshaw and Cowling, 2014; Rebelo et al., 2006). The temperatures are hot in summer and cold in winter, especially when there is snow. The summers are also characterised by strong, desiccating, south-easterly winds and the winters by the passage of cold fronts with north-westerly and south-westerly winds. Warm to hot berg winds occur when warm air drains from the interior prior to the passage of cold fronts and can lead to fires (Geldenhuys, 1994; Heelemann et al., 2008). The hot, dry conditions in summer dry out plant litter and dead fuels, creating high-fire danger conditions in the west but in the east, large fires can occur at any time of the year (Kraaij et al., 2013b; Kraaij and Wilgen, 2014). Lightning strikes are infrequent, around 1 per km^2 per year but were, historically the main cause of fires; most fires are now caused by people (Van Wilgen et al., 2010).

> **Box 4: Fire dependent ecosystems and gas pipeline infrastructure**
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> During a vegetation fire, heat reduces significantly within the upper layers (~ 30 cm) of the soil (e.g. Badía et al., 2017; Valette et al., 1994; Raison, 1979). Therefore, a gas pipeline buried at 1 m below the soil surface is at low risk of being exposed to heat that may damage the pipe or cause an explosion. With deep-rooted vegetation, a surface fire may cause roots in deeper soil layers to combust (if conditions are right, e.g. enough oxygen is present). Thus, keeping the operational servitude above the pipeline clear of deep-rooted vegetation reduces the risk of underground root-fires coming in close proximity to the gas pipeline.

The vegetation types in the Fynbos can be divided into three major types (Bergh et al., 2014; Rebelo et al., 2006): (a) the typical Fynbos vegetation on the nutrient poor soils which is a mixture of reeds (Restionaceae), sedges and grasses (Cyperaceae, Gramineae), ericoid (fine-leaved) shrubs (e.g. Ericaceae, Asteraceae) and an overstorey of broad leaved shrubs (e.g. Proteaceae); (b) Renosterveld vegetation on more nutrient-rich soils with a mixture of evergreen fine leaved shrubs, mainly Asteraceae and herbaceous species including a rich flora of geophytes; and (c) Western Strandveld with a dense overstorey of evergreen shrubs and herbaceous species in the gaps. Fynbos is found in two main settings on the shallow, rocky soils of the TMG sandstones of the mountains and foothills (montane Fynbos) and on the deep, leached sands of the lowlands and wetter inland valleys (sand plain Fynbos). Renosterveld is found on the shale-derived soils of the lowlands, the dry lower slopes and valleys, including the Roggeveld mountains. Strandveld generally occurs near the coast on more calcium-rich deep sands and on limestone soils.

The ecology of these major vegetation types differs as well. Sandstone, Granite, Shale, Limestone and Sand Plain Fynbos all require fires at intervals of 10-30 years to maintain their biodiversity and ecosystem functioning (Kraaij and Wilgen, 2014; Le Maitre et al., 2014). Many species' seeds will only germinate after fires and many species require fires to flower, produce seed and reproduce. The fire-ecology of Renosterveld is less well understood than that of Fynbos. Fires do stimulate regeneration in the Renosterveld, which is dominated by sprouting species, lacks slow-maturing species, and has some species whose seeds require fire to germinate (Kraaij, 2010; Kraaij and Wilgen, 2014). Yet it is able to persist for decades without fires, especially in the drier areas such as the inland slopes of the mountains and the Roggeveld escarpment. Fires in western Fynbos and Renosterveld occur primarily in the dry summer months but fires can occur at any time, including winter in the southern and eastern parts of the biome (Kraaij et al., 2013b; Kraaij and Wilgen, 2014). In the western and southern Fynbos, fire season has a marked impact on the regeneration of non-sprouters such as the Proteaceae, being most successful after fires in summer and autumn and least successful after fires in late-winter or spring (Bond et al., 1990; Kraaij et al., 2013d; Kraaij and Wilgen, 2014; Le Maitre et al., 2014). In the eastern Fynbos fire season has relatively little impact. Fire return intervals need to be long-enough for slow-maturing, non-sprouting species like many Proteaceae to produce sufficient seeds to maintain their populations; this typically requires fire return intervals of at least 10-12 years, preferably longer (Kraaij and Wilgen, 2014; Van Wilgen et al., 2010). Strandveld rarely burns but can do so under extreme fire conditions and regeneration apparently is not fire-dependent.

> **Box 5: Fire and the germination of Fynbos plant species**
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> Although the seeds of many Fynbos species require some form of stimulation to germinate (e.g. shifts in soil temperature regimes, heat from the fire, chemicals from smoke) (Esler et al., 2014; Hall et al., 2017; Holmes and Richardson, 1999; Ruwanza et al., 2013), the level of knowledge at present is not sufficient to determine whether or not specific treatments should be given as part of the rehabilitation process.
>
> Soil removal and replacement may provide some stimuli for germination but heat would not be practical to apply. The effectiveness of smoke treatment in the field, as opposed to the nursery, needs more research. A precautionary approach would be to conduct tests in different communities, especially in arid Fynbos and Renosterveld vegetation types, during the initial stages of the construction, to see whether the results justify its continued use.

All forms of Fynbos are susceptible to invasion by alien (introduced) tree species, notably the Australian *Acacia* (wattle), *Hakea* and *Leptospermum* species, and *Pinus* species (pines) (Wilson et al., 2014). Sand-plain Fynbos is also very prone to invasion by alien herbaceous species, particularly grasses, and so is Renosterveld. Some of the grass invasion may be due to soil enrichment by the nitrogen-fixing *Acacia* species (Heelemann et al., 2010; Krupek et al., 2016; Le Maitre et al., 2011; Musil et al., 2005; Visser et al., 2017).

Arid Fynbos, especially on the deep sands of the Sandveld, would be expected to require fire, but fires are very infrequent in these Fynbos types. Only single occurrences of fires have been detected in the past 16 years and these affected <1% of the Fynbos in the area, with the largest fire being in the Kamiesberg (unpublished data, Advanced Fire Information System, Meraka Institute, CSIR). There have not been any studies of the effects of fire on these Fynbos vegetation types to assess the modes of regeneration (e.g. sprouting and non-sprouting, fire stimulated seed germination or flowering, seedling establishment) or of the time required for species to reach reproductive maturity. The low frequency of fires suggests that fire may not play a significant role in maintaining these communities so they may not require fire to maintain themselves.

There is a growing body of research on the restoration of Fynbos, but it is still a developing science (Gaertner et al., 2012a, 2012b, Heelemann et al., 2013, 2012; Holmes, 2008). There are some guides for restoration in books on the management of the Fynbos and Karoo but mainly developed for higher rainfall areas or the Nama Karoo (Esler et al., 2014, 2010; Esler and Milton, 2006; Krug, 2004). It is clear that removing the upper few centimetres of the topsoil and returning with minimal storage, and the use of treatments to stimulate seed-germination can facilitate recovery, but this it still the subject of active research (Hall et al., 2017). Most of this work and experience has been gained in the higher rainfall parts of the biome and there is little experience in the arid areas. Much of the Fynbos vegetation in Phase 5 and, particularly, Phase 6 is at the limits of the climatic tolerance which means that recovery after disturbance could be slow, with a high risk of failure, and probably will require active restoration, as demonstrated by experience at the Namaqua Sands mine in Strandveld vegetation (Blignaut et al., 2013; Pauw, 2011) which is in an area with higher and more reliable rainfall. There has been research on restoration in Namaqualand but the studies have been located in the Strandveld or Succulent Karoo and not in the Fynbos (Carrick et al., 2015; Carrick and Krüger, 2007; James and Carrick, 2016; Todd, 2008). The uncertainties about the role of fire and the poor understanding of the potential for restoring Fynbos in these areas are strong rationales for making every effort to avoid Fynbos in arid areas when selecting the final gas pipeline routes. Disturbance also facilitates invasion so regular monitoring and control operations will be required as part of the Environmental Management Plans (EMPs).

Many vegetation types (e.g. forests) follow the classical succession model where certain species will regenerate or colonise after a disturbance creates an opening. These initial or pioneer species will then create an environment which can be colonised by other species before they die off and so species replace each other. In Fynbos and Renosterveld all the species re-establish themselves after a fire (disturbance) from seeds or by sprouting, but different growth forms tend to recover at different rates so their prominence and the structure changes over time, creating an apparent succession (Kraaij and Wilgen, 2014; Kruger and Bigalke, 1984). The long evolutionary history of the dominance of regeneration from *in situ* sources in Fynbos after fires, combined with the stable soils, seems to be why Fynbos lacks a typical pioneer flora capable of colonising sites where the top soil (essentially the upper 50-100 mm) has been removed or markedly disturbed. A long period of dense invasion by alien plant species can also result in the loss of the seed banks and re-sprouting species (Holmes, 2005; Holmes et al., 2000; Holmes and Cowling, 1997). This means that successful recovery on such sites typically requires the reintroduction of seeds or plants. Fynbos and Renosterveld also have a remarkable flora of geophytic species, only a few of which seem to be able to survive soil disturbance. They may also not be well-dispersed and would need to be reintroduced during the rehabilitation of the pipeline corridor and construction areas.

Box 6: Terrestrial fauna of the Fynbos Biome

The diversity and endemism of the terrestrial fauna in Fynbos is not particularly high except for certain groups such as amphibians (60 species in the Western Cape, 36 endemic and 15 threatened), reptiles (146 species, 18 threatened), fossorial mammals (moles) and invertebrates (particularly butterflies, dragon flies, long-tongued flies, beetles) (Anderson et al., 2014; Colville et al., 2014; Turner, 2017). Many of the Fynbos shrub species are known to be deep rooted and the pipeline servitude would have to be kept clear of these plants. The loss of these plant species will change the habitat suitability for fauna that live or feed on, shelter under, or otherwise use or depend on them, so that areas without them may become a barrier to the movement of some terrestrial fauna, notably reptile and invertebrate species.

Biotic interactions are essential for the pollination of many species and many species depend on ants for seed dispersal (myrmecochory) (Anderson et al., 2014; Rebelo et al., 2006). Ant seed dispersal is disrupted by the Argentinian ant which is able to invade disturbed areas and care will be needed to ensure that invasions by this ant species are not facilitated by, for example, ensuring that construction material does not contain colonies of this species (Anderson et al., 2014; Bond and Slingsby, 1990; Wilson et al., 2014).

Although much has been said about the uniqueness of Fynbos and its high plant biodiversity, Fynbos has many other values which generally are not adequately appreciated by the public. These include the benefits derived from the sustained flows of high quality water from Fynbos catchment that support cities and towns and their economies and are used for the production of irrigated crops. Other benefits include species with commercial value in the form of flowers or herbal teas and medicinal products, fibre and thatch, crop pollination, and landscapes that attract tourists (Turpie et al., 2017, 2003). The impacts of unwise developments on the commercial benefits provided by these ecosystems also need to be taken into account.

4.1.1.5 Albany Thicket

Subtropical thicket is a closed shrubland to low forest dominated by evergreen, sclerophyllous or succulent trees, shrubs and vines, many of which have stem spines. It is often almost impenetrable, is generally not divided into strata, and has little herbaceous cover. According to certain definitions subtropical thickets can be considered as a low forest, however this definition is problematic, for several reasons, in that it often occurs in many areas with a rainfall too low to support forests (<800 mm/yr.), does not have the horizontal stratification of forests, and does not have the signature species typical of Southern African afrotemperate forests, (Vlok et al., 2003).

The vegetation of the Albany Thicket can be divided into three eco-regions: the dry, inland areas of the Fish, Sundays, and Gamtoos river valleys; the mesic coastal areas of these river valleys; and the intermontane valleys to the north and west. The vegetation contains a high proportion of both leaf and stem-succulent shrubs such as Spekboom (*Portulacaria afra), Euphorbia bothae* (dominant along the Fish River Valley), *Euphorbia ledienii* and Noorsdoring (*Euphorbia coerulescens*), (Vlok et al., 2003).

The distribution of Albany Thicket communities is determined by a complexity of interrelated factors. The most important of these appears to be soil type. Albany Thicket is restricted to deep, well-drained, fertile sandy loams with the densest thickets occurring on the deepest soils (Cowling, 1983). Soil moisture is another important limiting factor. The vegetation is adapted to grow in hot, dry river valleys where soil moisture is limited for extended periods. Soil moisture increases towards the east, resulting in thickets that are more open, less succulent and less thorny.

This biome was originally described as 'Valley Bushveld' (Acocks, 1953), for good reasons, it typically occurs within the steep slopes of river valleys. This has been a particularly problematic veld type in terms of its delimitation, origins, affinities and dynamics. Tinley (1975) was the first to recognise Valley Bushveld and allied types (Spekboomveld and Noorsveld) as part of a 'thicket biome', characterised by a closed-canopy vegetation consisting of an impenetrable tangle of shrubs and low tree. However, Cowling (1984) was the first to formalise the thicket concept in the South African phyto-sociological literature, and Low & Rebelo (1996) recognized the thicket biome in a revised map of Southern Africa vegetation types. The first comprehensive study of the vegetation patterns of diversity was done by Vlok et al., (2003). This yielded 112 unique thicket vegetation types, 78 of which comprised thicket clumps in a matrix of non-thicket vegetation (mosaics).

Box 7: Important aspects of the Albany Thicket biome

Albany Thicket vegetation has some unique characteristics that need to be considered in a biodiversity vegetation monitoring programme as well as in the restoration of natural habitat following pipeline construction. These include the following:

- High vulnerability to overgrazing by livestock, in particular *Portulacaria* dominated vegetation types. This is particularly relevant when rehabilitating sensitive habitat where livestock may be present.
- High vulnerability of some thicket types to fire damage;
- Invasive alien vegetation, especially rooikrans, (*Acacia cyclops*) poses a real threat to Thicket by increasing the fuel load. This renders it prone to hot fires that will severely damage if not destroy the succulent and tree component; and
- Slow re-growth and recovery after vegetation removal. This is particularly true for arid and some mesic thicket vegetation types.
- Disturbance in arid areas of succulent thickets are prone to invasion of karroid species and arid adapted alien vegetation (Milton, & Dean, 2010). This needs to be considered in restoration plans.

The Albany Centre is a major centre of botanical diversity and endemism for succulents of karroid affinity, especially in the Mesembryanthemeceae, Euphorbiaceae and Crassulaceae, as well as a centre for certain bulb groups. Subtropical thicket is renowned for its high plants species richness and levels of endemism (i.e. species that grow nowhere else). Vlok & Euston-Brown (2002a) provide a tally of 1 588 subtropical thicket species for the planning domain, 322 (20%) of which are endemic. Most of these endemics are succulents associated with the vygie, euphorbia, crassula, aloe and stapeliad plant groups (Vlok & Euston-Brown, 2002a). The subtropical thicket is associated with two globally recognised centres of succulent plant endemism, namely the Little Karoo Centre of the Succulent Karoo in the west and the Albany Centre in the east (van Wyk & Smith, 2001). The Albany Centre encompasses elements of the Cape, Succulent Karoo and Maputaland-Pondoland regions. The Subtropical Thicket biome comprises the south-western sector of the Maputaland-Pondoland hotspot.

According to Mucina and Rutherford (2006), overall 60% of this biome has been severely degraded, with only 11% still in pristine condition, and around 7.3% totally lost. The mesic thicket, which has the highest levels of endemism and species richness within the Thicket biome, is under the greatest pressure. A more detailed analysis by Lloyd et al. (2002) and Vlok & Euston-Brown (2002b) provides figures on levels of severely degraded and moderately degraded thicket for each vegetation sub-class. This analysis shows that except for the Mainland Montane Solid (Thicket) and Coastal Dune Solid Thicket, all the vegetation units described show high levels of severe and moderate degradation.

Forms of thicket vegetation that have been especially ravaged by overgrazing in the past century, are those rich in spekboom or igwanishe, *Portulacaria afra*. There is evidence that even in the short space of a decade, heavy browsing, especially by mohair-producing angora goats, can convert dense shrubland into a desert-like state (Vlok & Euston-Brown, 2002a). Of some 16,000 km^2 formerly covered in spekboom-rich thicket, some 46% has undergone severe degradation and 34% moderate disturbance. This is predominantly from overgrazing, although clearing for crop cultivation is another major threat to the Thicket vegetation. Land has been cleared along the rivers, and lucerne and other crops are grown under irrigation. Land has also been cleared for orange orchards in the Addo region (Vlok & Euston-Brown, 2002b).

The role that indigenous herbivores may have played in determining vegetation boundaries, as do domestic livestock today under certain management regimes has been the subject of much speculation (Hoffman & Cowling, 1990). Several studies have shown that African elephant (*Loxodonta Africana*) has a substantial impact on subtropical thicket composition (Stuart-Hill, 1992), however, these animals as well as black rhinoceros (*Diceros bicornis)*, even under exceptionally high population density (unlike goats) do not convert solid thicket into a mosaic savannah, as Thicket types are probably much more resilient to the impacts of indigenous herbivores. Overgrazing by domestic livestock, in particular goats, has caused dramatic changes in thicket vegetation, with Nama-Karoo shrub like elements invading Arid Thicket types, and subtropical grasses massively increasing in cover in some Valley Thickets, creating savanna-like vegetation that burns at regular intervals, further eliminating succulents and fire-sensitive shrubs (Hoffman & Cowling, 1990).

Box 8: Terrestrial fauna of the Albany Thicket Biome

The fauna of the Albany Thicket biome, although diverse, does not demonstrate the level of endemism shown by the flora (Vlok et al., 2002a).

Mammal diversity is relatively high, with 48 species of large and medium-sized mammals, a consequence of the diversity of biomes within the STEP planning domain. Unfortunately, many of these species have been extirpated and all have undergone extensive reductions in their distribution. The smaller mammals include at least two endemic species (long tailed forest shrew and Duthie's golden mole), none of which is restricted to subtropical thicket.

The avifauna is diverse, with 421 species of birds recorded within the planning domain (with no endemics), of which 307 species utilise thicket (Dean, 2002). Birds appear to play an important role in seed dispersal of thicket plants (Dean, 2002). A total of 10 "Important Bird Areas" occur within the planning domain, although only three of these include subtropical thicket (Dean, 2002).

The reptile fauna includes five tortoise species – an exceptional tally - as well as relatively high endemism (six species) among the lizards and snakes (Branch, 1998). The amphibian fauna includes at least three endemic species (Passmore & Carruthers, 1995). Although the invertebrate diversity and endemism is probably high, little is known about this group, other than charismatic species such as the flightless dung beetle (*Circellium bacchus*),which is restricted to subtropical thicket.

Unfortunately, removing livestock and resting the veld does not lead to natural recovery of the vegetation, as seedling establishment is constrained by the exposed soil's temperature extremes and reduced water-holding capacity. Essentially, to restore this thicket type requires active interventions (Vlok & Euston-Brown, 2002a).

4.1.1.6 Indian Ocean Coastal Belt

The climate of the east coast of southern Africa is controlled by the presence of a high pressure system lying to the east of the sub-continent and intermittently, the area is influenced by low pressure systems arising from the Southern Ocean, particularly during winter. In the late summer, cyclonic systems moving across the Indian Ocean often lead to catastrophic storm events along the coastline (Tinley, 1985). This meteorological regime plays a significant role in determining the form of habitats that are found within the Indian Ocean Coastal Belt (IOCB) (Mucina and Rutherford, 2006) and gives rise, in part, to fundamentally differing habitat types within the biome. For example, within the northern areas, grasslands and forest habitats that are proximal to the coastline, are subject to intensive storm activity associated with cyclonic activities, which play a key role in forest gap dynamics (Yamamoto, 1996) while the high level precipitation associated with these events is an important driver in grassland and woodland communities in the north of KZN. Rainfall in the southern extent of the IOCB is comparatively less than that encountered in the north, although less seasonal with a more bimodal rainfall regime. It is perhaps due to these drivers that these vegetation types are primarily grassland and open woodland-mosaic environments which form an association of habitats within any given range.

Additionally, edaphic form and function within the IOCB can also be considered a primary driver of many of these habitats, tempering growth in woody species through the availability of freshwater and nutrients. The influence of anthropogenic factors, mainly fire but often the grazing of livestock, must also be considered one of the major drivers of the habitat forms within the IOCB, particularly over the last 500 years (McCracken, 2008).

The main vegetation types comprising the IOCB are:

- Maputaland Coastal Belt (CB1): Flat coastal plain. Densely forested in places. Range of non-forest vegetation communities – dry grasslands/palmveld, hygrophilous grasslands and thicket.
- Maputaland Wooded Grassland (CB2): Flat coastal plain. Sandy grasslands rich in geophytic suffrutices, dwarf shrubs, small trees and rich herbaceous flora.
- Kwazulu-Natal Coastal Belt (CB3) - Highly dissected undulating coastal plains. Subtropical coastal forest presumed to have been dominant. *Themeda triandra* dominated primary grassland.
- Pondoland-Ugu Sandstone Coastal Sourveld (CB4): Coastal peneplains and undulating hills with flat table lands and very steep slopes of river gorges. Species rich grassland punctuated with scattered low shrubs or small trees.
- Transkei Coastal Belt (CB5): Highly dissected, hilly coastal country. Alternating steep slopes of low reach river valleys and coastal ridges. Grasslands on higher elevations alternative with bush clumps and small forests.

Parts of the IOCB are threatened by heavy metal dune mining - prospecting and extraction; IAP invasion; tourism development; exploitation for commercial and small scale woodlot plantation; urban settlement and other agriculture (Mucina & Rutherford, 2006).

Box 9: Terrestrial fauna of the Indian Ocean Coastal Belt Biome

The IOCB occupies a climatic niche identified using the Koppen – Geiger classification system as Cfa (*warm temperate; fully humid; hot summer*) (Kottek et al., 2006). This climatic regime, as explained above, as well as a topographically diverse environment and a relatively recent history of human settlement has given rise to some diverse ranges of habitat and a concomitantly diverse faunal assemblage. It follows that both **habitat form and structure** and **faunal presence** as well as the interface between these two elements forms the guiding pre-requisites for evaluation of suitable routes for the gas pipeline within the IOCB.

However, the rapid expansion of human settlement in the region, particularly following the nagana of the 1860s has seen the confinement of much of the larger fauna to protected areas and private game farms, while smaller species, including invertebrates are confined to niche environments, such as scarp forest, that are not affected by human activities. Notably, some species have benefitted from human settlement and agricultural activities, at the expense of others. The subtropical climate experienced by the IOCB, as well as the availability of water, offer suitable habitat for a wide range of fauna. The network of protected areas, particularly in the northern portion of the IOCB are critical for the maintenance of faunal biodiversity, in the wake of the extensive disturbance which has been associated with urbanisation, peri-urban settlement and agriculture in surrounding area with the IOCB.

More specific to the Margate region and the sandstone grasslands of the lower KwaZulu-Natal South Coast in particular, is the presence of two butterfly species, *Lepidochrysops ketsi leucomacula* (white blotched ketsi blue) and *Durbania amakosa albescens* (whitish amakhoza rocksitter). The presence of these two species has been verified by EKZN Wildlife during field reconnaissance undertaken as recently as March 2017 (Armstrong pers comm, 2017). *L. ketsi leucomacula*, according to Armstrong, is endemic to the coastal stretch between Margate and Port Edward and is probably only associated in the Margate region. Due to a complex lifecycle including an association with the presence of formicids (ants) (Woodhall, 2005), the species may be considered to be susceptible to impacts of both a direct and indirect nature. *D. amakosa albescens* is considered to be "vulnerable" from a conservation perspective, primarily on account of a decline in suitable habitat. Habitat includes "rocky ledges" and open lichen-encrusted terrain. Open areas of rugged terrain, unaffected by development, are considered to be important for the continued preservation of the species. This is an example of a faunal species that may be significantly impacted by the disturbance caused by the construction of a pipeline, due to its dependence on specific habitat, interactions and associations. Many larger, more mobile and adaptable fauna species may simply relocate temporarily and remain largely unaffected.

4.1.1.7 Grassland

Grasslands, as the name implies, are dominated by a grass layer. However, from a biodiversity perspective it is the huge diversity of non-grass species, often referred to as forbs, that give the Grasslands biome their high diversity (O'Connor and Bredenkamp, 1996; Mucina and Rutherford, 2006). It is also these forbs that are typically the rare and endangered species within the Grassland biome. Identifying and conserving these non-grass species will be of particular importance during the construction phase. In many cases these plants can be dug up and replanted once construction is completed.

Grasslands are arguably one of the most threatened biomes in the country, with many Grassland types very poorly conserved. In addition, Grasslands have some of the most transformed vegetation types, with a large proportion of the national cereal crop agriculture taking place in the Grasslands (Rayers, 2001; Fairbanks et al., 2000). Most of the plantation forestry, a large proportion of mining as well as some of the biggest metropolitan areas are also located within the Grasslands. In Gauteng, there is exceptionally limited natural or even semi-natural Grassland remaining. Similarly, large amounts of the Grassland in the Eastern Cape corridor have also been transformed. This places a high conservation importance on all remaining Grassland.

4.1.1.8 Savanna

The unique feature of Savanna that separates it from Grassland is the occurrence of a tree layer in addition to an herbaceous layer. Savanna, although having a high *alpha* diversity (i.e. species diversity at the plot level), the species turnover, *beta* diversity, and landscape (*gamma*) diversity is relatively low (Scholes, 1997). This attribute of Savanna makes them relatively resistant to small-scale disturbances as a small disturbance is unlikely to have catastrophic loss to any particular species. However, there are specific locations with threatened and endangered species where these species would need protection. In addition, a number of the individual tree species within Savannas are protected, such as Camel thorns, Baobabs, and Stinkwood, require a permit in terms of the NFA to be cut.

Box 10: Terrestrial fauna of the Grassland and Savanna Biomes

Savanna and Grassland are the home to a large number of mammals, and these animals move over considerable distances to locate grazing. During the pipeline construction phase it is feasible that the movement of animals might be hindered if not managed appropriately, but this is not likely to be a factor in the post-construction phase assuming adequate rehabilitation is conducted. Small mammals, rodents, reptiles, invertebrates and ground birds may also be hindered during construction. If the post-construction habitat does not have the same functional attributes (e.g. vegetation type and density) as the original habitat, then some of these species may have difficulty crossing or utilizing the new habitat. Many of the large and charismatic threatened mammal species such as both black and white rhinoceroses (*Diceros bicornis* & *Ceratotherium simum*), cheetah (*Acinonyx jubatus*) and cape hunting dogs (*Lycaon pictus)* are found in the Savanna and Grassland corridors. These species are almost exclusively limited to protected areas and private reserves and as such their distribution is easily identified. Despite preventative measures being in place, during construction there is a potential threat of these species falling into the construction trench, although post construction impacts will be minimal. A few large endangered mammals such as leopard (*Panthera pardus)*, mountain reedbuck (*Redunca fulvorufula)* and Oribi (*Ourebia ourebi)* may occur in suitable habitats outside of conservation areas and will need specialists to identify potential locations where these species may be encountered (Child et al. 2016).

The distribution of small mammals, reptiles and insects are far harder to ascertain, although a large number of Critically Endangered, Endangered and Vulnerable species occur within the pipeline corridors. In many cases these species have small ranges and often use burrows for shelter and breeding. As such the construction phase could potentially have high significance impacts. For instance, some of the golden moles e.g. the Critically Endangered rough-haired golden mole (*Chrysosphalax villosus)* or the endangered Juliana's golden mole (*Eamblysomus julianae)* are limited to a few sites. A pipeline trench could conceivably cut through a population and create a habitat that cannot be crossed by this burrowing species. A number of golden moles are found within the potential corridors. The sungazer lizard (*Smaug giganteus)* is an example of an endemic and Vulnerable reptile from the arid Grasslands.

Savanna as a biome, is well conserved; however, many of the specific Savanna vegetation types found within the corridors, are very poorly conserved (Mucina and Rutherford, 2006).

Both Savanna and Grassland are fire dependent environments. Fire frequency is dependent on mean annual precipitation, with fire return intervals being once every two to three years in moist area, but reducing in dry areas. Maintaining a fire frequency on the restored land is important for maintaining biological integrity of the vegetation type (Mucina and Rutherford 2006; O'Connor and Bredenkamp, 2006; Scholes, 1997).

4.1.2 Freshwater ecosystems

Freshwater ecosystems, i.e. wetlands and rivers, are valuable ecosystems and it is well documented that they provide numerous ecological and hydrological functions (Cowan, 1995; Breen et al., 1997; Mitchell, 2002). These functions include improving water quality (reductions in suspended sediments, excess plant nutrients and other pollutants), streamflow regulation (flood attenuation, water storage and sustaining streamflow), groundwater recharge, erosion control, and the maintenance of biodiversity for wetland-dependant fauna and flora (Kotze and Breen, 1994). Consequently, wetlands and rivers provide many important services to human society. At the same time, through continued negative perceptions by humanity, they remain ecologically sensitive and vulnerable systems (Turner et al., 2003).

Historically, freshwater ecosystems have been subjected to numerous pressures from surrounding developments and changing land use, to the extent that many wetlands and rivers have been severely degraded or completely lost (Kotze et al., 1995). This has largely been as a result of human activities, either through direct disturbance, or indirectly from impacts upstream (Breen et al., 1997). More than two decades ago, it was estimated that over half of South Africa's wetlands had been lost (Kotze et al., 1995). The current situation is no doubt even greater, and of the remaining systems, 48% are classified as Critically Endangered (CR) (Nel and Driver, 2012). Thus, freshwater ecosystems need to be safeguarded as much as possible from on-going and future development in order to maintain, or even improve the status of existing wetland and river habitats.

Box 11: Gas pipeline development and groundwater

The proposed gas pipelines will be constructed below ground at a depth of about 1 – 2 m from the earth's surface to the top of the pipeline, resulting in overall maximum depth of 4 – 5 m. The relatively shallow placement of the pipeline and associated construction activities are unlikely to significantly impact on ground water and deep aquifers. Since aquatic systems are not driven significantly by ground water resources, and the impacts from gas pipelines will be minor when considering deep ground water flows, groundwater is not considered and assessed in detail as a strategic issue in this SEA.

The presence of shallow and other vulnerable aquifers that could potentially be impacted need to be determined at a site-specific / pipeline route planning stage, avoided as far as possible, appropriate dewatering techniques established if required and any potential impacts mitigated. Shallow aquifers that are less than 5 m below ground could occur in Phase 4 and 1 (Figure 3).

Aspects relevant to potential contamination of groundwater or subsurface drainage are discussed under Aquatic Ecosystems throughout this chapter.

The most common methods involved in pipeline construction spanning water bodies are trenched (wet open-cut and dry open-cut techniques) or trenchless techniques (such as HDD). Trenchless techniques require excavation of pits intermittently along the pipeline route and the assistance of drilling fluids or bentonite based "muds", which in the long term can affect ground water flows.

It is important to note that site specific assessments will be undertaken prior to actual gas pipeline development, and if warranted, Geohydrological and/or Geotechnical Assessments will be commissioned by the Pipeline Developer once a specific pipeline route has been determined.

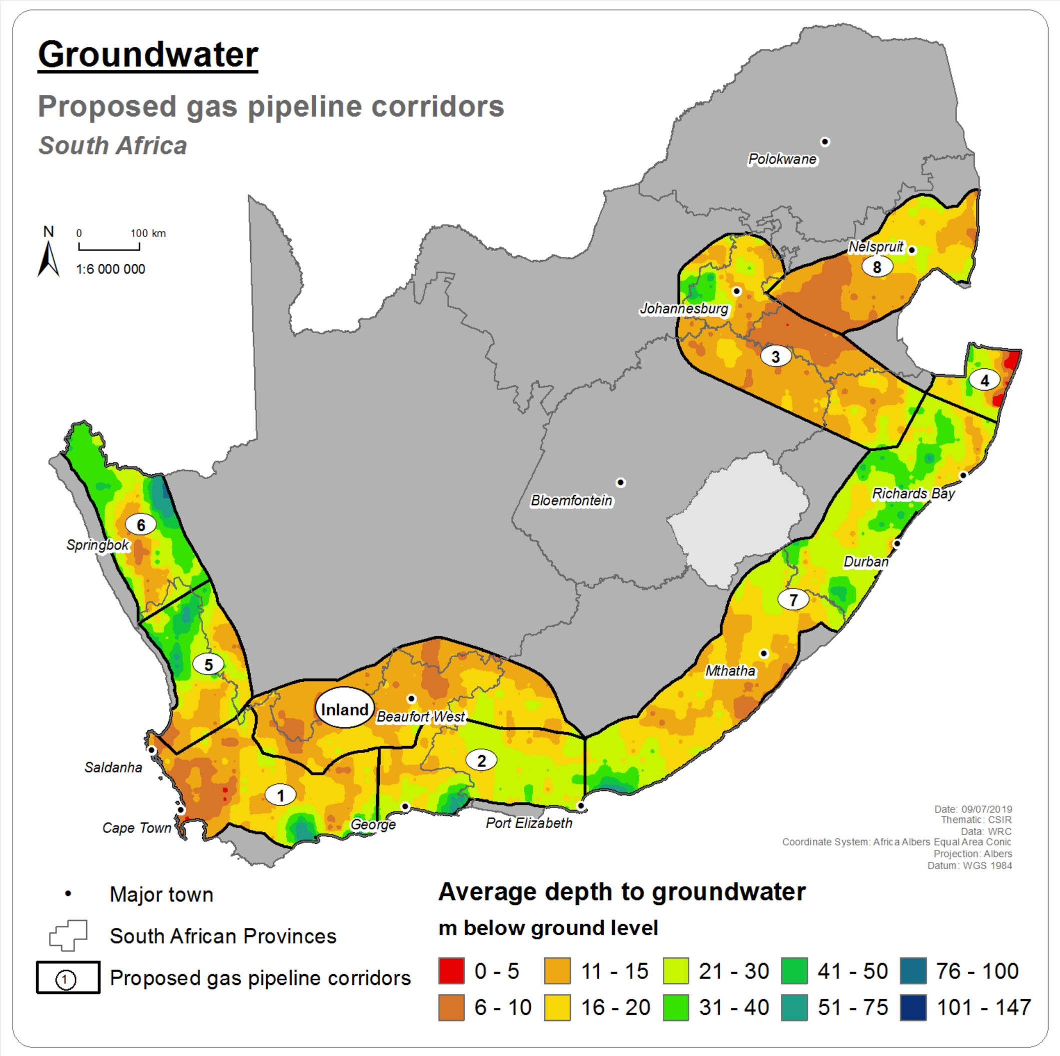


Figure 3: Average depth to groundwater (m below ground level) (WRC, 2012).

Strategic Water Source Areas (SWSAs) are defined as "areas of land that either: (a) supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important; or (b) have high groundwater recharge and where the groundwater forms a nationally important resource; or (c) areas that meet both criteria (a) and (b)" (Le Maitre et al., 2018:1). Changes in the quantity and quality of the water produced by these areas can have adverse effects on economic growth and development in the regions that they support (CSIR, 2017). Thirty-seven groundwater SWSAs have been identified in South Africa and are considered to be strategically important at a national level for water and economic security (Le Maitre et al. 2018). The total area for groundwater SWSAs extends approximately 104 000 km^2, and covers approximately 9% of the land surface of South Africa (Le Maitre et al. 2018). Based on this, the SWSAs have been rated as high sensitivity areas for proposed gas pipeline development.

Groundwater SWSAs are present within the proposed gas pipeline Phases 1, 2, 3, 4, 5 and 7 (Figure 4). The Phase 5 Corridor includes the Sandveld Groundwater SWSA. The Phase 1 corridor includes the West Coast Aquifer, North-Western Cape Ranges, Tulbagh-Ashton Valley, South-Western Cape Ranges, and Cape Peninsula and Cape Flats Groundwater SWSAs. The Phase 2 corridor includes the Coega TMG Aquifer, and George and Outeniqua Groundwater SWSAs. The Phase 7 corridor includes the Transkei Middleveld, Ixopo, KwaDukuza, and the Richards Bay Ground Water Fed Estuary Groundwater SWSAs. The Phase 4 corridor includes the Zululand Coastal Plain Groundwater SWSA. The Phase 3 corridor includes portions of the Richards Bay Ground Water Fed Estuary, Zululand Coastal Plain, Far West Karst Region, West Rand Karst Belt, Eastern Karst Belt and

Ventersdorp/Schnoonspruit Karst Belt Groundwater SWSAs. Extremely small areas of the Rompco Pipeline Corridor (Phase 8) and Inland Corridor contain Groundwater SWSAs. No Groundwater SWSAs are located within the Phase 6 Corridor.

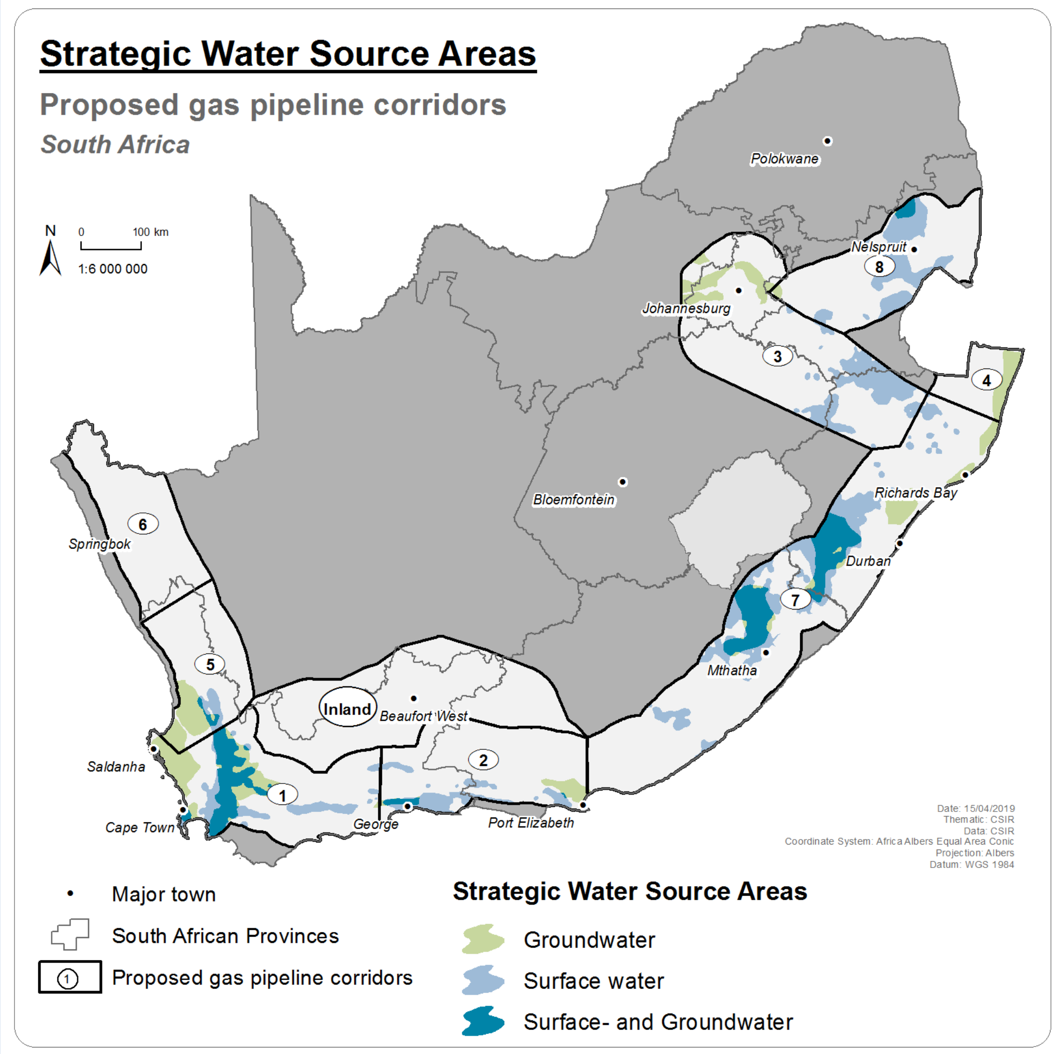


Figure 4: Strategic Water Source Areas of South Africa (CSIR, 2017).

4.1.3 Estuaries

An estuary is defined as "a partially enclosed permanent water body, either continuously or periodically open to the sea on decadal time scales, extending as far as the upper limit of tidal action, back-flooding or salinity penetration. During floods an estuary can become a river mouth with no seawater entering the formerly estuarine area, and when there is little or no fluvial input, an estuary can be isolated from the sea by a sandbar and become a lagoon or lake which may become fresh or hypersaline" (Van Niekerk and Turpie, 2012:29).

South African estuaries differ considerably in terms of their physicochemical and biotic characteristics (Colloty et al., 2002; Vorwerk et al., 2008). Despite their differences, proactive planning and effective management of estuaries require an understanding of changing estuarine patterns, processes and responses to global change pressures (i.e. those that arise directly from anthropogenic activities as well as climate change). As human population pressures escalate, the need for strategic management becomes increasingly evident (Boehm et al., 2017; Borja et al., 2017). Reactive planning of resource allocation in these systems on an estuary-by-estuary basis is costly, time consuming and not feasible. Proactive planning requires a strategic assessment of change at a range of scales to ensure optimum resource use.

Estuaries and adjacent ecosystems form an interrelated network of life-support systems that includes neighbouring terrestrial and marine habitats. Many estuarine species are dependent on different habitats in order to complete their life cycles (Whitfield, 1998). Estuarine ecosystems are, therefore, not independent and isolated from other ecosystems. Rather, estuaries form part of regional, national and global ecosystems, directly through connections via water flows (e.g. the transport of nutrients and detritus) and indirectly via the movement of estuarine fauna (e.g. Gillanders, 2005; Ray, 2005). Linkages between individual estuaries and other ecosystems span scales ranging from a few hundred metres to thousands of kilometres. Therefore, impacts to a specific estuarine ecosystem may affect ecosystems seemingly remote from that estuary, and have ramifications for ecosystem goods and services that people rely on from areas distant over large spatial scales. The closure of Lake St Lucia for example, resulted in declines and eventual closure of a prawn fishery on the Thukela Banks over 100 km to the south.

South Africa has nearly 300 relatively small estuaries, the majority (>70%) of which are <50 ha in size. These estuaries fall into three biogeographical regions which characterise the South African coast; namely the Cool Temperate west coast, the Warm Temperate southern and south-east coast, and the Subtropical east coast (Emanuel et al., 1992; Harrison, 2002; Turpie et al., 2002) (Figure 5). In addition to obvious sea temperature differences, rainfall patterns in these regions vary significantly (Davies and Day, 1998; Lynch, 2004; Schulze and Lynch, 2007; Schulze and Maharaj, 2007). Annual runoff of South African rivers is highly variable and unpredictable in comparison with larger Northern Hemisphere systems, fluctuating between floods and extremely low (to zero) flows (Poff and Ward, 1989; Dettinger and Diaz, 2000; Jones et al., 2014). Estuary catchment sizes range from very small (<1 km^2) to very large (>10 000 km^2), with those in the Cool Temperate region tending to be larger than those in the Warm Temperate and Subtropical regions (Jezewski et al., 1984; Reddering and Rust, 1990).

Strong wave action and high sediment availability results in more than 90% of South African estuaries having restricted inlets (or mouths). More than 75% of estuaries close for varying periods of time due to sand bar formation across the mouth (Whitfield, 1992; Cooper, 2001; Taljaard et al., 2009; Whitfield and Elliott, 2011). Most estuaries are highly dynamic with an average water depth of 1-5 m. The tidal range around the whole coast is microtidal (<2 m) but high wave energy, makes it a wave-dominated coast (Cooper, 2001).

Estuaries exhibit a high spatial heterogeneity, with each system characterised by its own unique geomorphology and physicochemical processes. Individual systems can be highly variable temporally and the full spatial extent (i.e. tidal limit or back-flooding mark) of many systems remains unknown. This makes it difficult to delineate the dynamic spatial area where estuarine processes occur within each system, the so-called Estuary Functional Zones (EFZ). In South Africa the EFZ is generally defined by the +5 m topographical contour (as indicative of 5 m above mean sea level) and includes all the estuarine open water area; estuarine habitats (sand and mudflats, rock and plant communities) and adjacent floodplain area whether developed or undeveloped. It therefore encompasses not only the estuary water-body but also all the habitats that support physical and biological processes that characterise an estuarine system.

For the purposes of this study, and as is typical in estuarine assessment in a South African context, all permanent coastal water bodies (i.e. not ephemeral water bodies) sporadically or permanently linked to the sea were regarded as estuarine systems. Using existing estuarine vegetation and fish data sets, published and unpublished literature, as well as anecdotal information, all systems were evaluated by an expert panel and their health evaluated (Van Niekerk and Turpie, 2012).

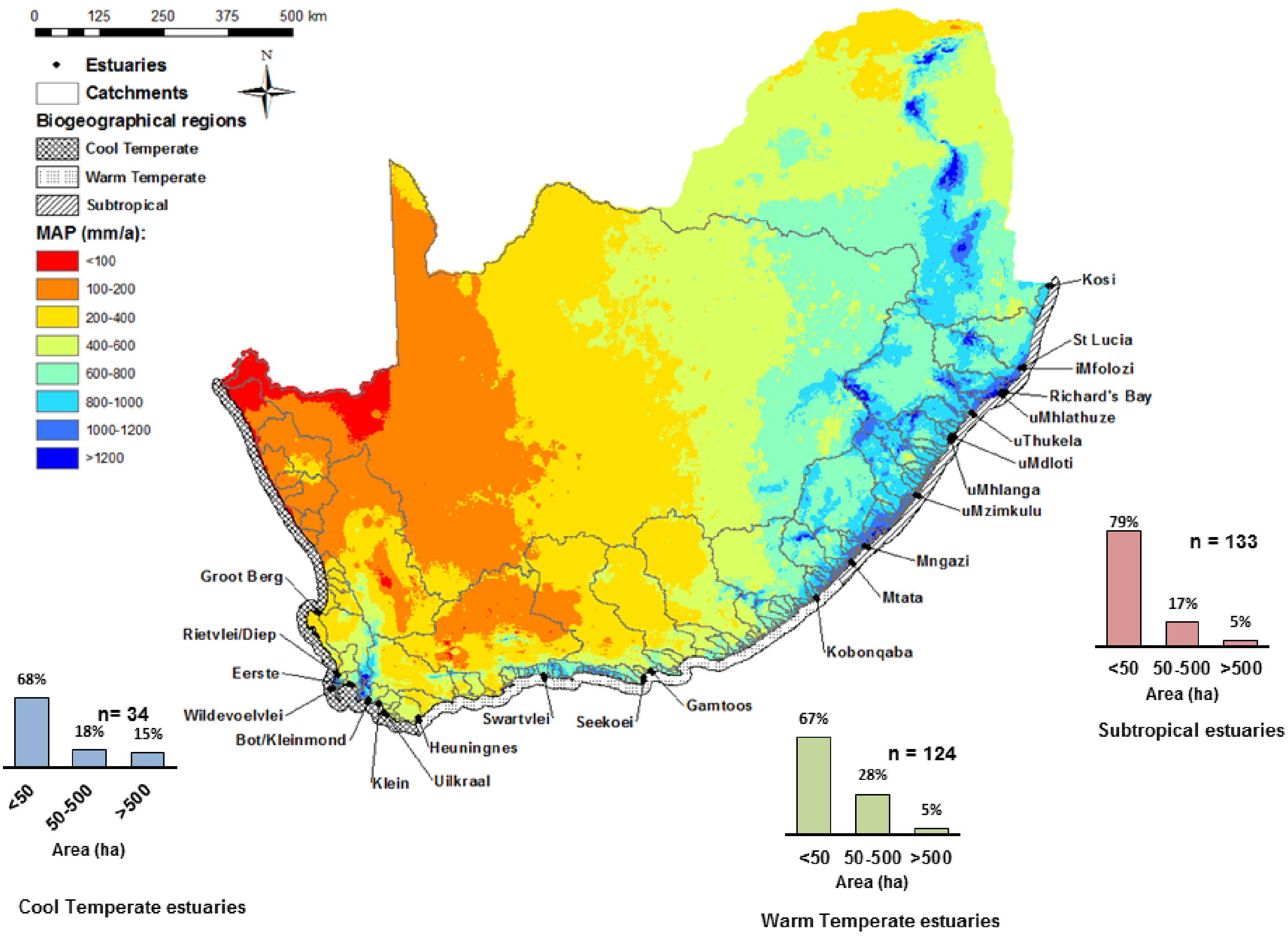


Figure 5: Map showing the three biogeographical regions, relative catchment size, mean annual precipitation (MAP) (in mm/a) and estuary size distribution (in ha) for South Africa (van Niekerk et al. 2013).

4.1.3.1 Sedimentary processes of importance

Estuaries are complex water bodies and differ considerably from fluvial systems. In estuaries the flow reverses due to tidal inflows being stronger than freshwater outflows. Water quality charges in an estuary are also complex due to both upstream and downstream sources.

Estuaries also have two sources of sediment; that from the river (delivered primarily during floods) and a supply of marine sediment from the ocean delivered by littoral drift and transported by tidal currents into the estuary. Within estuaries, tidal sediment transport is a result of the interaction of both currents and waves. This is especially dynamic in the mouth region of estuaries and further up the system wave action is rapidly reduced. Wave-current interaction considerably complicates sediment transport predictions. During neap tides, maximum water velocities in the estuary are low with little sediment transport, while both velocities and transport increase towards spring tides. Significantly, in some estuaries over this neap to spring period, there is a net upstream sediment transport, e.g. in the Goukou (Beck et al., 2004). If there is a long-term net ingress of marine sediment (which is often the case), then the only plausible way for a long-term equilibrium to be established is for occasional large river floods to flush out this accumulated sediment.

Floods therefore, are the most important natural processes which erode and transport sediments out of estuaries. Large volumes of sediments can be removed in a very short time during major floods with a return period of 1 in 50 years and more. Smaller floods with return periods of 1-2 years can sometimes also have a significant influence. Floods of various scales therefore play a major role in the equilibrium between sedimentation and erosion in estuaries (Beck et al., 2004).

This is an important consideration because sedimentation of South African estuaries has created several environmental and social problems. Sediment transport imbalances are caused by changes in the river inflow (especially floods), increased catchment sediment yields and hard structures in estuaries that change flow velocities. Reduced sediment transport capacities within estuaries and decreased flushing efficiencies cause increased sedimentation and in the long-term this may lead to the complete closure of estuaries.

Estuary channel formation is also highly dynamic on decadal time scales. During low flow periods shallow tidal flows can meander several sand banks in the EFZ. During floods rapid changes in estuarine morphology occur over very short time frames. The system can be completely reset and channels can be scoured by meters, only to be filled in over time again by catchment and marine sediment. These types of changes can be illustrated using the Thukela Estuary as an example (Figure 6). Scouring during flooding can be significant with numerical modelling studies indicating possible scour depths on larger river systems of between 20 and 30 m (Basson et al., 2017).

These dynamic processes are an integral part of the natural functioning of South African estuaries and need to be accounted for in proposals to develop within EFZs. In the context of the present work, proposed crossings of estuaries by pipelines need to be assessed with the knowledge that estuary channel formation can occur anywhere in the EFZ and that scouring during floods (with a return period of 1:10 years) is significantly deeper than the observed estuary bed levels under typical (non-flood) conditions.

a) b)

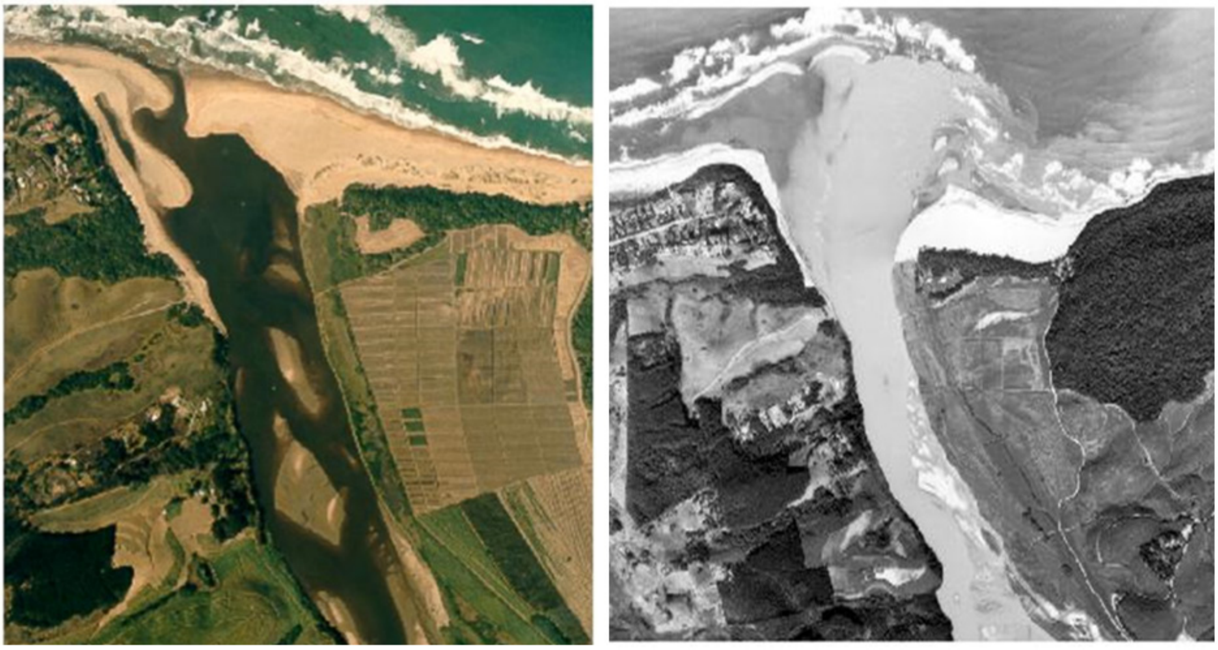


Figure 6: a) Thukela Estuary under low flow conditions with a stable channel meandering between sand banks; and b) under resetting flood conditions with high volumes of sediment being eroded from the system.

4.1.3.2 Habitat of importance

Estuaries are generally made up of a high diversity of habitat types, which include open water areas, un-vegetated sand-, mudflats and rock areas, and vegetated areas (plant communities). Plant community types can be subdivided into submerged macrophytes, salt marsh, mangroves, reeds and sedges (Adams et al., 2018).

- **Open water area:** Un-vegetated basin and channel waters which are measured as the water surface area. The primary producers are the phytoplankton consisting of flagellates, dinoflagellates, diatoms and blue-green algae which occur in a wide range of salinity ranging from freshwater to marine conditions.

- **Sand / mudflats / rock:** Soft (mobile) substrates (sand and mud) and hard (non-mobile) substrates (rocks) and shorelines areas. Habitat mapping from aerial photographs cannot distinguish between sand and mud habitats and therefore in databases used for the purposes of this study are presented as a single area. The dominant primary producers of these habitats are the benthic microalgae.
- **Macroalgae:** Macroalgae may be intertidal (intermittently exposed) or subtidal (submerged at all times), and attached or free floating. Filamentous macroalgae often form algal mats and increase in response to nutrient enrichment or calm sheltered conditions when the mouth of an estuary is closed. Typical genera include *Enteromorpha* and *Cladophora*. Many marine species can get washed into an estuary and providing that the salinity is high enough, can proliferate. These include *Codium*, *Caulerpa*, *Gracilaria* and *Polysiphonia*.
- **Submerged macrophytes:** Submerged macrophytes are plants that are rooted in the substrate with their leaves and stems completely submersed (e.g. *Stukenia pectinata* and *Ruppia cirrhosa*) or exposed on each low tide (e.g. the seagrass *Zostera capensis*). *Zostera capensis* occupies the intertidal zone of most permanently open Cape estuaries whereas *Ruppia cirrhosa* is common in temporarily open/closed estuaries. *Stukenia pectinata* occurs in closed systems or in the upper reaches of open estuaries where the salinity is less than 10 ppt.
- **Salt marsh:** Salt marsh plants show distinct zonation patterns along tidal inundation and salinity gradients. Zonation is well developed in estuaries with a large tidal range e.g. Berg, Knysna and Swartkops estuaries. Common genera are *Sarcocornia*, *Salicornia*, *Triglochin*, *Limonium* and *Juncus*. Halophytic grasses such as *Sporobolus virginicus* and *Paspalum* spp. are also present. Intertidal salt marsh occurs below mean high water spring and supratidal salt marsh above this. *Sarcocornia pillansii* is common in the supratidal zone and large stands can occur in estuaries such as the Olifants.
- **Reeds and sedges:** Reeds, sedges and rushes are important in the freshwater and brackish zones of estuaries. Because they are often associated with freshwater input they can be used to identify freshwater seepage sites along estuaries. The dominant species are the common reed *Phragmites australis*, *Schoenoplectus scirpoides* and *Bolboschoenus maritimus* (sea club-rush).
- **Mangroves:** Mangroves are trees that establish in the intertidal zone in permanently open estuaries along the east coast of South Africa, north of East London where water temperature is usually above 20°C. The white mangrove *Avicennia marina* is the most widespread, followed by *Bruguiera gymnorrhiza* and then *Rhizophora mucronata*. *Lumnitzera racemosa*, *Ceriops tagal* and *Xylocarpus granatum* only occur in the Kosi Estuary.
- **Swamp forest:** Swamp forests, unlike mangroves are freshwater habitats associated with estuaries in KwaZulu-Natal. Common species include *Syzygium cordatum*, *Barringtonia racemosa* and *Ficus trichopoda*. It is often difficult to distinguish this habitat from coastal forest in aerial photographs.

Box 12: Estuarine Species of Conservation Concern

Plants

Some macrophyte species (mangroves and eelgrass) have only recently been reassessed in the Red Data List and freshwater mangrove *Barringtonia racemosa* was only added in 2016 (IUCN, 2012). If categorised as a species of special concern the data provided for each assessment was tabulated. Further research on these species was also captured. If categorised as 'Least Concern' details pertaining to the state of the population was not captured unless noted in a particular study. While the spatial location of all species of special concern is not known for South Africa's estuaries, what is still clear is all estuaries support estuarine habitat of concern and should be deemed as highly sensitive.

Interference (harvesting, clearing, removal) of mangrove and swamp forest is regulated under the National Forests Act 84 of 1998 and destruction or harvesting of indigenous trees requires a licence. All mangrove trees and swamp forests are protected under this act. The taxonomy of some salt marsh species is under currently under review; which makes it difficult to determine their population sizes, report on their threat status or set targets for protection. However according to the National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008, as amended), all coastal wetlands, which include salt marshes and mangroves, form part of the coastal protection zone. The purpose of establishing this zone is to restrict and regulate activities in order to achieve the aims as set out in the Act. Other laws pertaining to species in these areas: National Environmental Management Act 1998, Marine and Living Resources Act 1998, The National Environmental Management: Biodiversity Act 2004, and National Forestry Act 1998.

Fish
The IUCN Red List of Threatened Species includes many fish that occur in estuaries in South Africa (ICUN, 2018). By far the majority of these fish are categorised as species of Least Concern. The IUCN Red List categories and criteria (IUCN, 2012) are designed to be applied to the entire (global) range of a species and fish listed in the Least Concern category here range from those which are actually quite common and (still) abundant in South African systems (e.g. *Rhabdosargus sarba*) to species which are uncommon, rare and in a national sense could be considered as endangered (e.g. *Microphis brachyurus*). A species of special concern, in the process of being IUCN red listed, is *Argyrosomus japonicus* (Dusky Kob), a species with South African populations at critically low levels (Griffiths, 1997, Mirimin et al., 2016). Predominant threats faced by the listed species include development (urban, commercial, recreational and industrial), agriculture, mining, resource use (fishing and harvesting of aquatic resources), modification of natural systems (flow modification and other), pollution, and climate change (ICUN, 2018). **All estuaries in the corridors function as nurseries for Critically Endangered or Endangered fish species of high recreational or conservation importance.**

4.2 Description of the proposed gas pipeline corridors

Due to the vast extent of the proposed gas pipeline corridors, all of the biomes of South Africa are potentially affected[2] (Table 8). Note that proposed gas pipeline corridor Phases 3, 8 and Inland and 6 do not border the coastline, as such, estuaries are not directly affected by these corridors.

Table 8: Extent of the biomes within each of the proposed gas pipeline corridors.

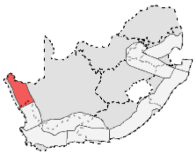
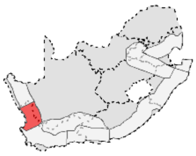
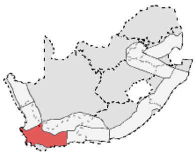
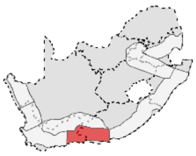
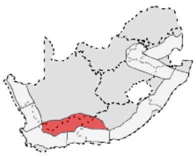
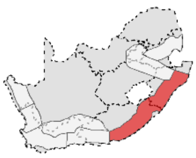
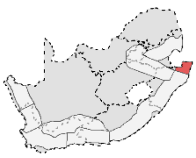
Biome	Extent (% of each proposed gas pipeline corridor)								
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8	Inland Phase
Succulent Karoo	15	10			56	65			16
Nama-Karoo	1	15				21	1		62
Fynbos	79	36			38	2	1		7
Azonal Vegetation	2	4	< 1	2	4	1	1	< 1	8
Albany Thicket	4	33					11		4
Grassland		1	86	2			46	62	3
Indian Ocean Coastal Belt				16			7		
Savanna			14	73			31	38	
Desert						12			
*Forests**	*< 1*	*1*	*< 1*	*5*	*< 1*		*2*	*< 1*	

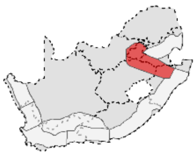
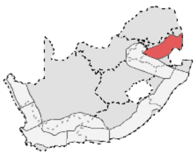
**The Forest biome presents and engineering constraint for gas pipeline development and also contains sensitive and rare environments. Therefore it is assumed that it will be avoided and not considered for regulatory streamlining.*

The ecological and biodiversity environmental description for the proposed gas pipeline phases have been grouped according to biomes. The sequence of the descriptions are arranged from arid/winter rainfall areas to higher rainfall areas (Table 9).

[2] Not all the corridors will eventually be developed. The development of the phased gas pipeline network is based on a viable business case, market demand, and finding a gas source. It is likely that only one of the corridors will be developed, depending on where natural gas is imported or exploited locally.

Table 9: Summary of key environmental features in each of the proposed gas pipeline phases, arranged in the sequence in which they are described in this Section.

Proposed gas pipeline corridor	Brief description	
Phase 6 	• This proposed gas pipeline corridor is situated within Desert, Fynbos, Succulent Karoo, Nama Karoo vegetation types in the Northern Cape and Western Cape Provinces. • Mostly arid environment, with prominent protected areas that include the Richtersveld and Namaqua National Parks (NPs), with extensive areas earmarked as potential NPAES focus areas. • Relatively untransformed when compared to the other proposed gas pipeline corridors.	Arid / winter rainfall
Phase 5 	• This proposed gas pipeline corridor is situated within Fynbos, Succulent Karoo vegetation types in the Northern Cape and Western Cape Provinces. • Notable protected environments include the Cederberg and Winterhoek Mountains. • Relatively transformed by settlements and cultivation.	
Phase 1 	• This proposed gas pipeline corridor is situated within Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket vegetation types in the Western Cape Province. • Extensively transformed by settlements and cultivation, as such many of the remaining ecosystems are of conservation importance and currently protected.	
Phase 2 	• This proposed gas pipeline corridor is situated within Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket, Grassland vegetation types in the Western Cape and Eastern Cape Provinces. • Extensively transformed around major towns (Mossel Bay, George, Port Elizabeth) due to urban settlement and agriculture.	
Inland 	• This proposed gas pipeline corridor is situated within Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket, Grassland vegetation types in the Western Cape, Northern Cape and Eastern Cape Provinces. • Relatively untransformed when compared to the other proposed gas pipeline corridors.	
Phase 7 	• This proposed gas pipeline corridor is situated within Fynbos, Nama Karoo, Albany Thicket, Savanna, Grassland, Indian Ocean Coastal Belt vegetation types in the Eastern Cape and KwaZulu-Natal Provinces. • Transformed by urban settlement and agriculture, especially between Durban and Richards Bay in the KwaZulu-Natal Province. • Many aquatic systems (rivers, wetlands and estuaries) present.	
Phase 4 	• This proposed gas pipeline corridor is situated within Savanna, Indian Ocean Coastal Belt vegetation types in the KwaZulu-Natal Province. • Relatively untransformed when compared to the other proposed gas pipeline corridors, with many protected areas associated with large wetlands present.	

Proposed gas pipeline corridor	Brief description	
Phase 3 	• This proposed gas pipeline corridor is situated within Savanna, Grassland vegetation types in the KwaZulu-Natal, Free State, Mpumalanga, Gauteng, and North-West Provinces. • Extensively transformed by settlements, agriculture and mining.	Higher / summer rainfall
Phase 8 	• This proposed gas pipeline corridor is situated within Savanna, Grassland vegetation types in the Mpumalanga Province. • Extensively transformed by settlements, agriculture and mining, with the Kruger NP occupying the eastern part of the corridor. • Kruger NP occupies most of the eastern corner of this corridor.	

4.2.1 Phase 6

The proposed Phase 6 gas pipeline corridor is located from the Namibian border to the northern most part of the Western Cape Province (Figure 1) predominantly within Fynbos, Succulent Karoo and Nama Karoo vegetation types.

The annual rainfall ranges from <50 mm in the Orange River valley to 100-200 mm over the lowlands and more than 400 mm in the Kamiesberg and is supplemented by fog along the coast. The rain falls mainly in the winter months. The summers are hot and dry. The temperatures are moderated by the typically strong winds but these winds also have a drying effect, creating harsh conditions for plants and animals.

The dominant features of the Phase 6 corridor are the large Protected Areas present in the northern section of the corridor, which includes the Richtersveld National Park and the Richtersveld World Heritage Site, as well as the Orange River Mouth and the Nababieps Provincial Nature Reserves (Figure 7).The central section of the corridor is characterised by several Protected Areas including the Goegap Provincial Nature Reserve and the Namakwa National Park. Other sensitive areas include the Kamiesberg Mountains which are considered largely unsuitable for pipeline construction due to the rugged terrain as well as diversity of this area. Also, elements of sensitive ecosystems can be found in this corridor as isolated fragments located mostly on mountain tops in the Kamiesberg (central), Richtersveld (north) and Bokkeveld (south), or on the coastal plain (west). The Knersvlakte Nature Reserve is an important Protected Area located in the southern section of the corridor.

4.2.1.1 Succulent Karoo, Nama Karoo and Desert

This arid environment is typified by Desert and Karoo vegetation rich in succulents with a high level of species richness and endemism, many of which are of conservation concern such as the Endangered Giant Quiver tree (*Aloidendron pillansii*) and the 'halfmens' (*Pachypodium namaquanum*). The abundance of fauna of cons ervation concern in this corridor is also quite high, with numerous locally-endemic gecko species present along the mountains of the Orange River valley. Along the coast, there are also several fauna of concern including the Namib Web-footed Gecko and Grant's Golden Mole.

In general, this Phase of the pipeline corridor is considered generally fairly high sensitivity due to the diversity of the underlying Succulent Karoo and Desert vegetation, and the high abundance of features and fauna of conservation concern within this area (Figures 6 and 8). In the north, along the Orange River, as well as in the west, along the coast, there is little scope for avoidance of very high and high sensitivity areas. Also, both the Namaqualand Hardeveld and the Namaqualand Sandveld, as well the Knersvlakte in the south are considered areas of conservation concern. However, some areas in a southerly direction along the centre of the corridor have a medium sensitivity due to the presence of extensive degraded rangeland. The far eastern section of the corridor located within Bushmanland is typified by Nama Karoo vegetation with very few species of conservation concern (SCC) and are thus generally considered to be of low sensitivity.

Although there are these low sensitivity areas situated in the far eastern parts of the corridor, within Bushmanland, it is not likely that this area can be easily accessed by the pipeline route given that the Bushmanland plains are situated on the inland plateau, which are separated from the western section of the corridor by the escarpment. Also, it is recommended that this Gas Corridor is extended westwards towards the coast as there are some less sensitive as well as transformed areas located in the Sandveld along the coast where the topography and soils are also far more conducive for pipeline construction than through the rugged mountains within the current corridor alignment.

4.2.1.2 Fynbos

The Fynbos Biome in the corridor comprises four vegetation types: Namaqualand Granite Renosterveld, Kamiesberg Granite Fynbos, Namaqualand Sand Fynbos, Stinkfonteinberge Quartzite Fynbos (Rebelo et al., 2006). No Azonal vegetation types occur in the areas of the Fynbos vegetation types in the corridor.

Namaqualand Granite Renosterveld and Kamiesberg Granite Fynbos are found on the upper slopes and peaks of Kamiesberg Mountains with the latter confined to the highest peaks in the area. Stinkfonteinberge Quartzite Fynbos is only found on the upper slopes and peaks of some of the Vandersterrberg range in the Richtersveld. They are all endemic to the corridor. Namaqualand Sand Fynbos is found on the leached, deep sands on the coastal plain where the patches are embedded in and grade into the Strandveld vegetation types, which are part of the Succulent Karoo Biome. Most of this vegetation lies to west of the corridor with small portions extending into it.

None of these vegetation types were considered threatened in the 2011 National Biodiversity Assessment (Driver et al., 2012). Many of the plant species are endemic to these vegetation types, especially in the Kamiesberg and Richtersveld (Rebelo et al., 2006). In the 2016 Northern Cape Critical Biodiversity Area (CBA) plan, the Kamiesberg Granite Fynbos is considered a CBA1 (Figure 7) because of its extreme rarity and endemism (with less than 5000 ha of the original area remaining) and because it is confined to the Northern Cape province (Holness and Oosthuysen, 2016). Most of the Namaqualand Granite Renosterveld and Namaqualand Sand Fynbos fall into areas which are CBA1 or CBA2. None of the Namaqualand Sand Fynbos in the Western Cape extends into the corridor.

The northern section of the Stinkfonteinberge Quartzite Fynbos falls within the Richtersveld National Park (NP) and the southern portion within the Richtersveld World Heritage Site. There are no protected areas in the Namaqualand Granite Renosterveld, Kamiesberg Granite Fynbos or the portions of Namaqualand Sand Fynbos that fall into the corridor. The Richtersveld NP and World Heritage site form an extensive protected area in the north (Figure 7), and the Namaqualand NP forms a link between the coast and the Namaqua Highlands. Linking this park to the Kamiesberg is seen as a very high conservation priority.

4.2.1.3 Birds and bats

Bat species of Conservation Importance likely to be encountered in the proposed Phase 6 gas corridor include:

- Angolan hairy bat
- Namibian long-eared bat

Table 10 presents red data species that occur in the biomes present in the proposed Phase 6 gas pipeline corridor.

Table 10: Red Data bird species likely to be encountered in the proposed Phase 6 gas corridor.

Species	Status	Biome				
		Fynbos	Succulent Karoo	Nama Karoo	Desert	Azonal
African Marsh-Harrier	EN	✓				✓
Barlow's Lark	VU		✓		✓	
Black Harrier	EN	✓	✓	✓	✓	
Black Stork	VU	✓	✓	✓	✓	✓
Blue Crane	NT	✓	✓			✓
Burchell's Courser	VU		✓	✓	✓	✓
Caspian Tern	VU					✓
Chestnut-banded Plover	NT					✓
Great White Pelican	VU					✓
Greater Flamingo	NT	✓	✓	✓	✓	✓
Karoo Korhaan	NT	✓	✓	✓	✓	
Kori Bustard	NT		✓			
Lanner Falcon	VU	✓	✓	✓	✓	✓
Lesser Flamingo	NT	✓	✓	✓	✓	✓
Ludwig's Bustard	EN	✓	✓	✓	✓	
Maccoa Duck	NT					✓
Martial Eagle	EN	✓	✓	✓	✓	
Red Lark	VU		✓	✓		
Sclater's Lark	NT		✓			
Secretarybird	NT	✓	✓	✓		
Southern Black Korhaan	VU	✓	✓			
Verreaux's Eagle	VU	✓	✓	✓	✓	
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened						

4.2.1.4 Freshwater ecosystems

Rivers within the proposed Phase 6 gas pipeline corridor are all non-perennial/ephemeral in character with exception of the Gariep (Orange) River (Figure 8), which receives most of its flow from its headwaters in Lesotho and the Vaal River. Most of the river habitats fall within the Namaqua Highland Ecoregion, while a smaller number of systems occur within the Nama Karoo and the Orange River Gorge. Only 5% of the river habitat is considered to be Threatened (i.e. EN and VU). The Present Ecological State (PES) of rivers is generally good, with 30% of the rivers assessed to be in fair condition, while a very small proportion (1%) are in a poor state.

Wetland habitats occupy a very low proportion of the corridor (<1%) owing to the xeric climatic conditions of the Succulent Karoo. Nevertheless, the area supports up to 44 wetland types, dominated by floodplain wetland habitat along the lower Gariep River and channelled-valley bottom wetlands within the Namaqualand Hardeveld region. One Ramsar wetland occurs within the corridor, and is located at the mouth of the Gariep River. A moderate proportion (17%) of the wetlands in the corridor are characterised as NFEPA wetland, which predominantly include floodplain wetland along the Gariep River and seeps within the Namaqualand Hardeveld region. A small proportion (12%) of the wetland habitats are associated with the Endangered Gariep Desert wetland vegetation group.

Approximately 98% of the proposed Phase 6 gas pipeline corridor comprises land that is largely natural, thus only a very small proportion is transformed through urbanisation, agricultural and mining developments. Impacts on freshwater ecosystems from associated land use activities of the transformed landscape are relatively localised within the corridor context. More widespread impacts to freshwater systems tend to be linked to livestock farming practices and infestation of IAPs. The combined effect of anthropogenic pressures results in both localised and widespread impacts that affect functioning and integrity of freshwater ecosystems.

The Kamiesberg is an important water source area at the local level but not at the national level.

Box 13: Red Data aquatic biota likely to be encountered in Phase 6

There are no known occurrences of Red Listed Odonata and fish in the proposed Phase 6 gas pipeline corridor. Three Red Listed amphibians are known to occur in the corridor, namely Breviceps macrops (Near Threatened), which inhabits sandy habitats along Namaqualand coast, *Capensibufo deceptus* (Data Deficient) which occurs in shallow temporary pools with emergent sedge-like plants in Mountain Fynbos or Grassy Fynbos in the Fynbos Biome (IUCN, 2017) and *Breviceps branchi* (Data Deficient), which is only known from a single specimen collected near the Holgat River. One Critically Endangered reptile, *Pachydactylus rangei*, inhabits dry river beds and surrounding dunes/sanding environments in the north western corner of the corridor. One Red Listed mammal occurs within the corridor, namely the Near Threatened *Otomys auratus*. This corridor supports a low diversity of (up to 6) Red Listed plants. Of these, two are Vulnerable (i.e. *Isoetes eludens* and *Oxalis dines*), while four are Near Threatened.

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 6 pipeline corridor include:

- Pollution from application of fertilizers, herbicides and pesticides, as well as point-source discharges from urban centres (e.g. Springbok and Vioolsdrif);
- Grazing by livestock, particularly high/concentrated levels of along watercourses, causing overgrazing and trampling within and adjacent to river and wetland systems, which in turn leads to increased erosion and changes in vegetation structure (notably, the loss of riparian habitat);
- Increases in woody vegetation along rivers, in particular by *Acacia karoo*, as well as infestations of invasive alien species (e.g. *Tamarix* spp. and *Prosopis glandulosa*). These deep-rooted species are able to readily consume groundwater. Heavily infested areas have a significant impact on the hydrology of catchments, as well as outcompeting indigenous species;
- More localised, yet severe impacts, linked to sand mining and other mining activities (e.g. alluvial diamond mining at the mouth of the Gariep River and along the west coast);
- Groundwater utilisation both for domestic and agricultural uses;
- Construction of weirs and dams along river systems, which alters the natural hydrological flows, which is most notable for the Gariep River as a consequence of numerous, large dams/impoundments in the catchment; and
- Road crossings, which cause concentration of surface runoff and localised sheet and gulley erosion in proximity to rivers and wetlands.

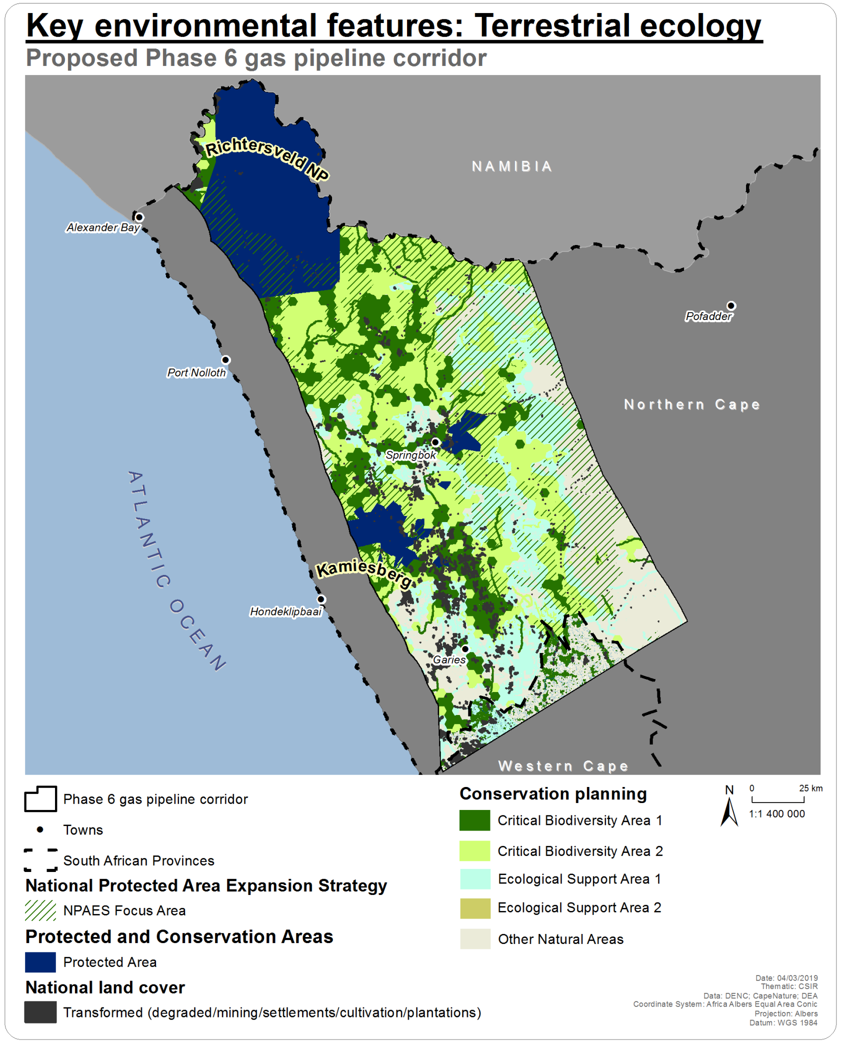


Figure 7: Key environmental features of the proposed Phase 6 gas pipeline corridor.

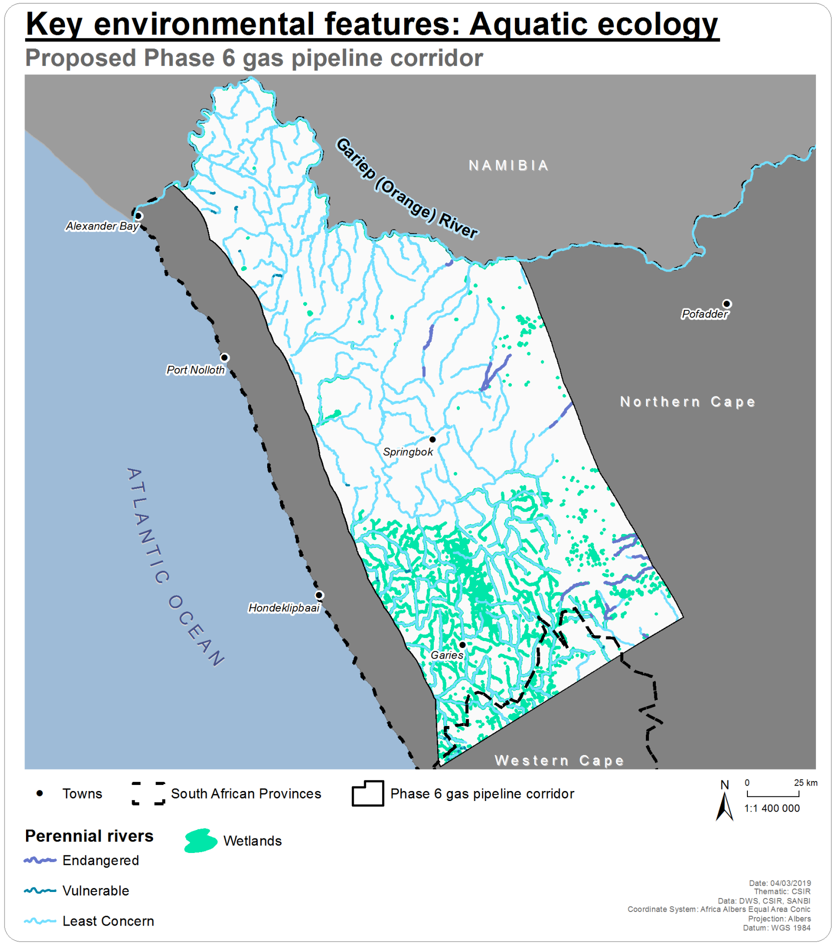


Figure 8: Key aquatic ecosystem features of the proposed Phase 6 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extents.

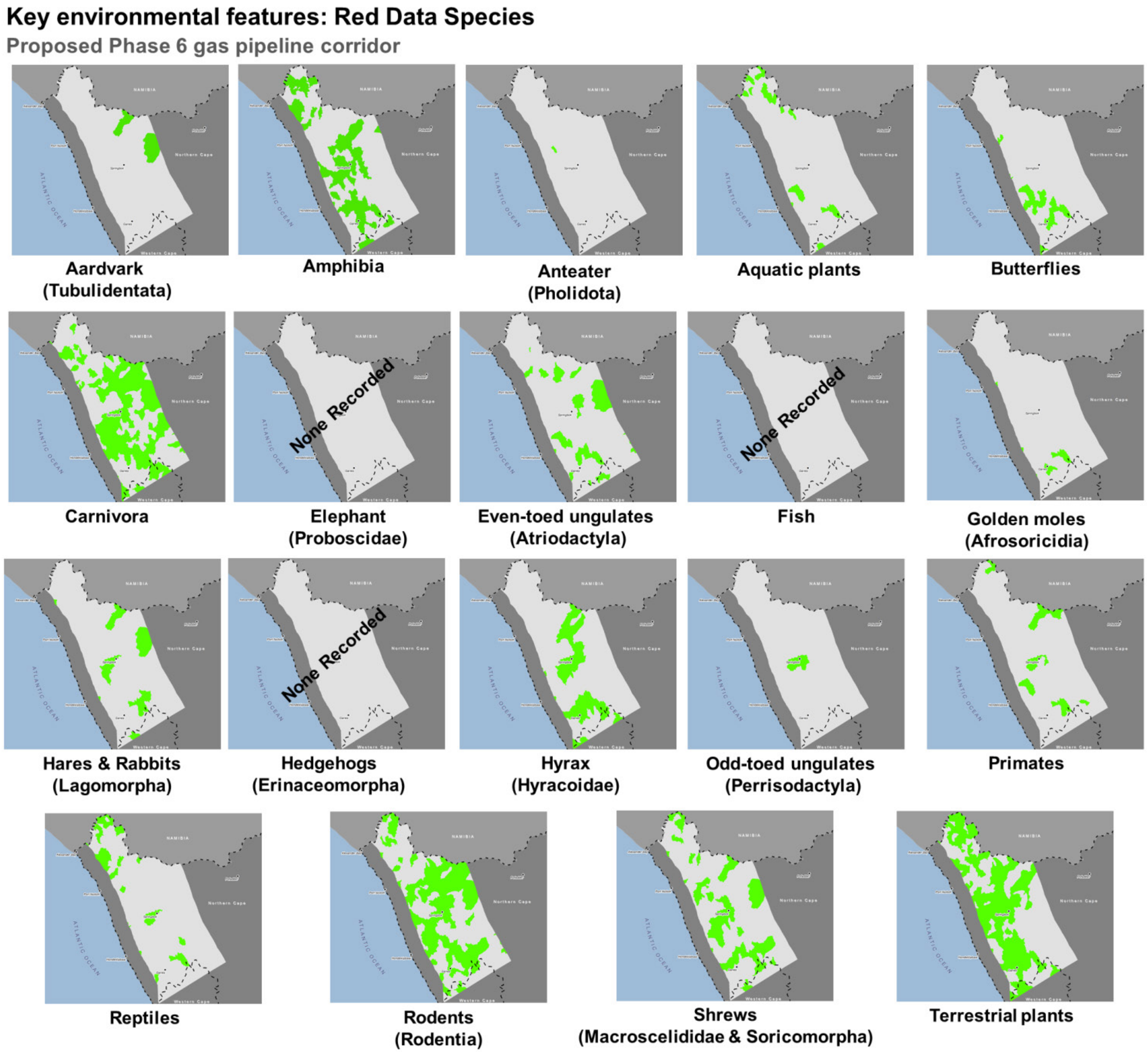


Figure 9: Distribution of recorded Red Data species in the proposed Phase 6 gas pipeline corridor (at quinary catchment scale).

4.2.2 Phase 5

The proposed Phase 5 gas pipeline corridor is located from the northern part of the Western Cape Province towards Piketberg (Figure 1) predominantly within Fynbos and Succulent Karoo vegetation types.

The rainfall falls mainly in the winter months and the summers are hot and dry with strong, drying winds. The rainfall decreases from about 400 mm on the coastal lowlands in the south to 200 mm in the north, and reaches about 800-1 000 mm on the Piketberg, Piekenierskloof and Cedarberg mountains.

4.2.2.1 Fynbos

The northern and inland parts of the corridor fall primarily into the Succulent Karoo Biome and the south-western and southern part in the Fynbos biome. Fires occur at intervals of 8-15 years in the mountain Fynbos but at longer intervals in the Renosterveld and sand plain Fynbos of the lowlands. The rainfall is too low for cultivation in the north and the vegetation is fairly intact and used as rangelands. The extent of the cultivated dryland areas increases south of Vredendal as do cultivated areas on the Nieuwoudtville plateau and the Gifberg (Figure 10). Almost all of the Swartland is under cultivation. Areas under irrigation are found along the Olifants River, in the Sandveld and along the Berg River southwards to Hopefield.

The extent of vegetation transformation has resulted in 11 of the 14 Fynbos vegetation types in this part of the corridor being classified as threatened (6 Vulnerable (VU), 4 Endangered (EN), 1 Critically Rare) due to habitat loss in the Western Cape Biodiversity Spatial Plan (Pool-Stanvliet et al., 2017). All of these are lowland vegetation types with the Swartland Shale Renosterveld (CR) having only 6.3% of its original extent remaining and every remnant classified as a CBA 1. The high degree of transformation means that every remnant that can form part of a corridor is a CBA 1, resulting in a nearly continuous CBA 1 from the coast to the inland mountains north of the Piketberg (Figure 10). The Nieuwoudtville-Gifberg plateau in the Northern Cape also is an extensive area where all natural vegetation is categorised as CBA 1 (Figure 10). At the scale of this map many of the small CBA 1s in highly transformed areas like the Swartland are not visible but minimising impacts on them will be critical at the route planning stage. The main pinch point is from the Piketberg through the Sandveld to Graafwater. The route westwards into the Olifants River valley also is through high sensitivity areas and difficult terrain.

The extensive Azonal vegetation types are primarily salt marshes and wetlands associated with estuaries (e.g. The Berg and Olifants Rivers) and river floodplains.

The Cape mountains are important water sources for the rivers and streams that flow into the adjacent lowland with the Cederberg, Piekenierskloof and Kouebokkeveld forming part of the Groot Winterhoek Strategic Water Source Areas (SWSA) (Nel et al., 2013; 2017). There are also extensive SWSAs for groundwater in this area and in the inland valleys.

4.2.2.2 Succulent Karoo

The proposed Phase 5 gas pipeline corridor includes the transition from the arid Knersvlakte in the north to the wetter Swartland and Cedarberg Mountains in the south (Figure 10). Significant features include the various parts of the Knersvlakte Nature Reserve, as well as the Bokkeveld Escarpment. The Knersvlakte is considered especially sensitive due to the exceptional levels of endemism which characterise this area as well as its arid nature and associated difficulty in effectively rehabilitating disturbed areas.

4.2.2.3 Birds and bats

The Namibian long-eared bat is the only bat species of Conservation Importance occurring in the proposed Phase 5 gas pipeline, whilst several red data bird species may be present (Table 11).

Table 11: Red Data bird species likely to be encountered in the proposed Phase 5 gas corridor.

Species	Status	Biome		
		Fynbos	Succulent Karoo	Azonal
African Marsh-Harrier	EN	✓		✓
Black Harrier	EN	✓	✓	
Black Stork	VU	✓	✓	✓
Blue Crane	NT	✓	✓	✓
Burchell's Courser	VU		✓	✓
Burchell's Courser	VU		✓	✓
Cape Rock-jumper	NT	✓		
Caspian Tern	VU			✓
Chestnut-banded Plover	NT			✓
Eurasian Curlew	NT			✓
European Roller	NT	✓		
Great White Pelican	VU			✓
Greater Flamingo	NT	✓	✓	✓
Karoo Korhaan	NT	✓	✓	
Lanner Falcon	VU	✓	✓	✓
Lesser Flamingo	NT	✓	✓	✓
Ludwig's Bustard	EN	✓	✓	
Maccoa Duck	NT			✓
Martial Eagle	EN	✓	✓	
Protea Seedeater	NT	✓		
Red Lark	VU		✓	
Secretary bird	NT	✓	✓	
Southern Black Korhaan	VU	✓	✓	
Verreaux's Eagle	VU	✓	✓	
Yellow-billed Stork	EN			✓
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened				

4.2.2.4 Freshwater ecosystems

Rivers within the proposed Phase 5 gas pipeline corridor are mostly ephemeral/non-perennial (approximately 61%), while around 39% are considered to be perennial/permanently-flowing. These rivers drain a number of ecoregions, such as the South Western Coastal Belt, Western Folded Mountains and the Great Karoo. Major river systems include the Doring, Olifant and Sout (Figure 11). Less than 25% of the rivers are considered to be Threatened (i.e. CR, EN and VU). More than 60% of the rivers are in a natural/good condition, 8% are in a fair condition, while 30% are in a poor/very poor condition.

Wetland habitats occupy a small proportion of the corridor (~3%) comprising up to 90 different wetland types, dominated by channelled-valley bottom wetlands, particularly within the Northwest Sand Fynbos region. The corridor contains a single Ramsar wetland, namely Verlorenvlei (Figure 11), which is approximately 1,500 ha. A moderate proportion (~23%) of the wetlands in the corridor are characterised as NFEPA wetlands. Almost all of the wetland habitats within the corridor are associated with Least Threatened (LT) wetland vegetation groups (e.g. the Knersvlakte and Trans-Escarpment Succulent Karoo).

A large portion (81%) of the proposed Phase 5 gas pipeline corridor comprises land that is largely natural, with a fairly small proportion (8%) of the corridor protected by a number of conservation areas (e.g. Cederberg Wilderness Area, Moedverloren Nature Reserve and Tankwa Karoo National Park). The remaining area is mostly transformed by cultivation (~19%), with <1% attributed to plantations, urbanisation (e.g. Citrusdal and Vredendal) and mining.

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 5 pipeline corridor include:

- Pollution from application of fertilizers, herbicides and pesticides, as well as point-source discharges from urban centres (e.g. Bitterfontein);
- Grazing by livestock, particularly high/concentrated levels of along watercourses, causing overgrazing and trampling within and adjacent to river and wetland systems, which in turn leads to increased erosion and changes in vegetation structure (notably, the loss of riparian habitat);
- Increases in woody vegetation along rivers, in particular by *Acacia karoo*, as well as infestations of invasive alien species (e.g. *Tamarix spp.* and *Prosopis glandulosa*). These deep-rooted species are able to readily consume groundwater. Heavily infested areas have a significant impact on the hydrology of catchments, as well as outcompeting indigenous species;
- More localised, yet severe impacts, linked to sand mining and other mining activities (e.g. alluvial diamond mining at the mouth of the Gariep River and along the west coast);
- Groundwater utilisation both for domestic and agricultural uses;
- Construction of weirs and dams along river systems, which alters the natural hydrological flows, which is most notable for the Gariep River as a consequence of numerous, large dams/impoundments in the catchment; and
- Road crossings, which cause concentration of surface runoff and localised sheet and gulley erosion in proximity to rivers and wetlands.

4.2.2.5 Estuaries

Three estuaries are situated within the Phase 5 corridor; the Olifants, Verlorenvlei and the Groot Berg (Figure 11). They have a combined estuarine habitat area of 8 600 ha and are amongst the longest of South Africa's estuaries with the Groot Berg Estuary nearly 70 km and the Olifants Estuary about 40 km long. The Groot Berg roughly extends about 40 km into the Phase 5 corridor. Their health statuses vary between C and D Categories on the Department of Water and Sanitation (DWS) scale ("A" being near natural and "F" being extremely degraded) (Van Niekerk et al., 2018, in progress).

All three estuaries are national conservation priorities as identified in the national estuaries biodiversity plan (Turpie et al., 2012). The Olifants and Groot Berg are of very high biodiversity Importance, ranking in the top five estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). These systems are also important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). From a habitat diversity and abundance perspective the Olifants and Groot Berg are also considered highly important as they support large areas of sensitive estuarine habitats such as intertidal and supratidal saltmarsh.

Box 14: Red Data aquatic biota likely to be encountered in Phase 5

Two species of Odonata that are listed as Vulnerable (i.e. *Syncordulia gracilis* and *S. legator*) occur in the corridor, along with two species that are Near Threatened. Of the 14 Red Listed fish species that occur within the corridor, three are listed as Critically Endangered (i.e. *Pseudobarbus burchelli, P. erubescens* and *P.* sp. Nov. 'doring'), while six are considered Endangered, four are Near Threatened, and one is Data Deficient. The only Red Listed amphibian that occurs within the corridor includes the Near Threatened *Breviceps gibbosus*. There is also only one Red Listed reptile that occurs within the corridor, namely the Vulnerable *Bradypodion pumilum*. The Critically Endangered Riverine Rabbit *Bunolagus monticularis* occurs in a few, isolated localities within the corridor. The only other Red Listed mammals include two that are Near Threatened. This corridor supports a moderate diversity of Red Listed plants of up to 25 species, including two that are Critically Endangered (i.e. *Pilularia bokkeveldensis* and *Senecio cadiscus*), while ten are Endangered, nine are Vulnerable and four are Near Threatened.

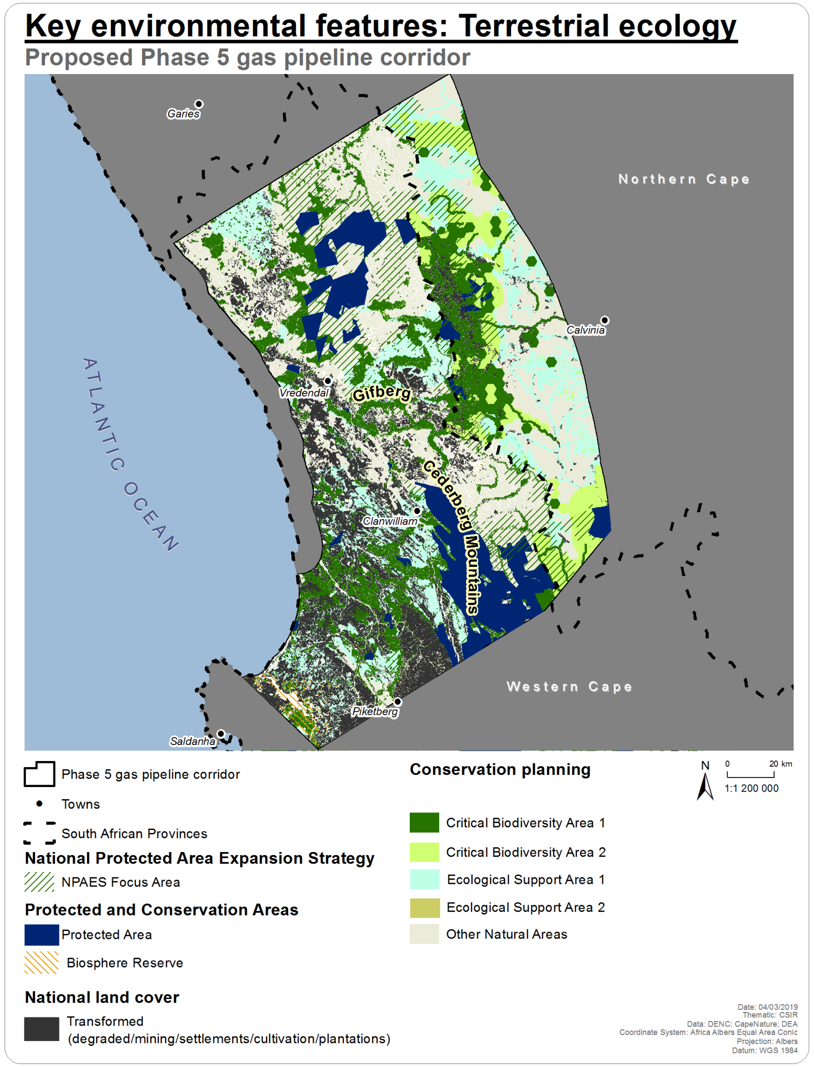


Figure 10: Key environmental features of the proposed Phase 5 gas pipeline corridor.

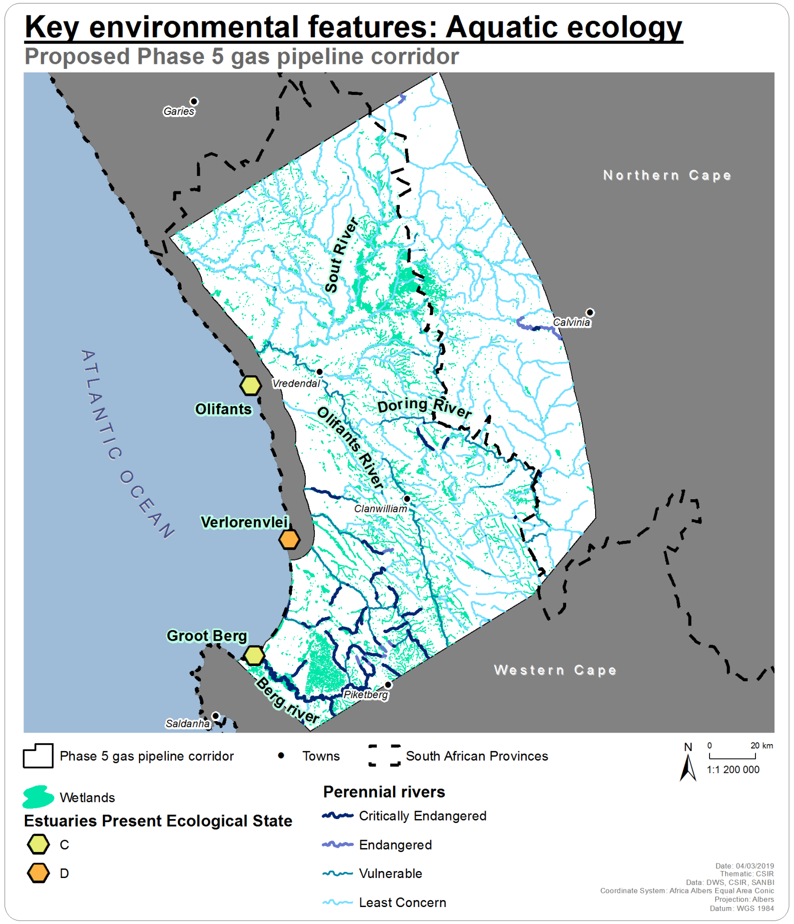


Figure 11: Key aquatic ecosystem features of the proposed Phase 5 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent.

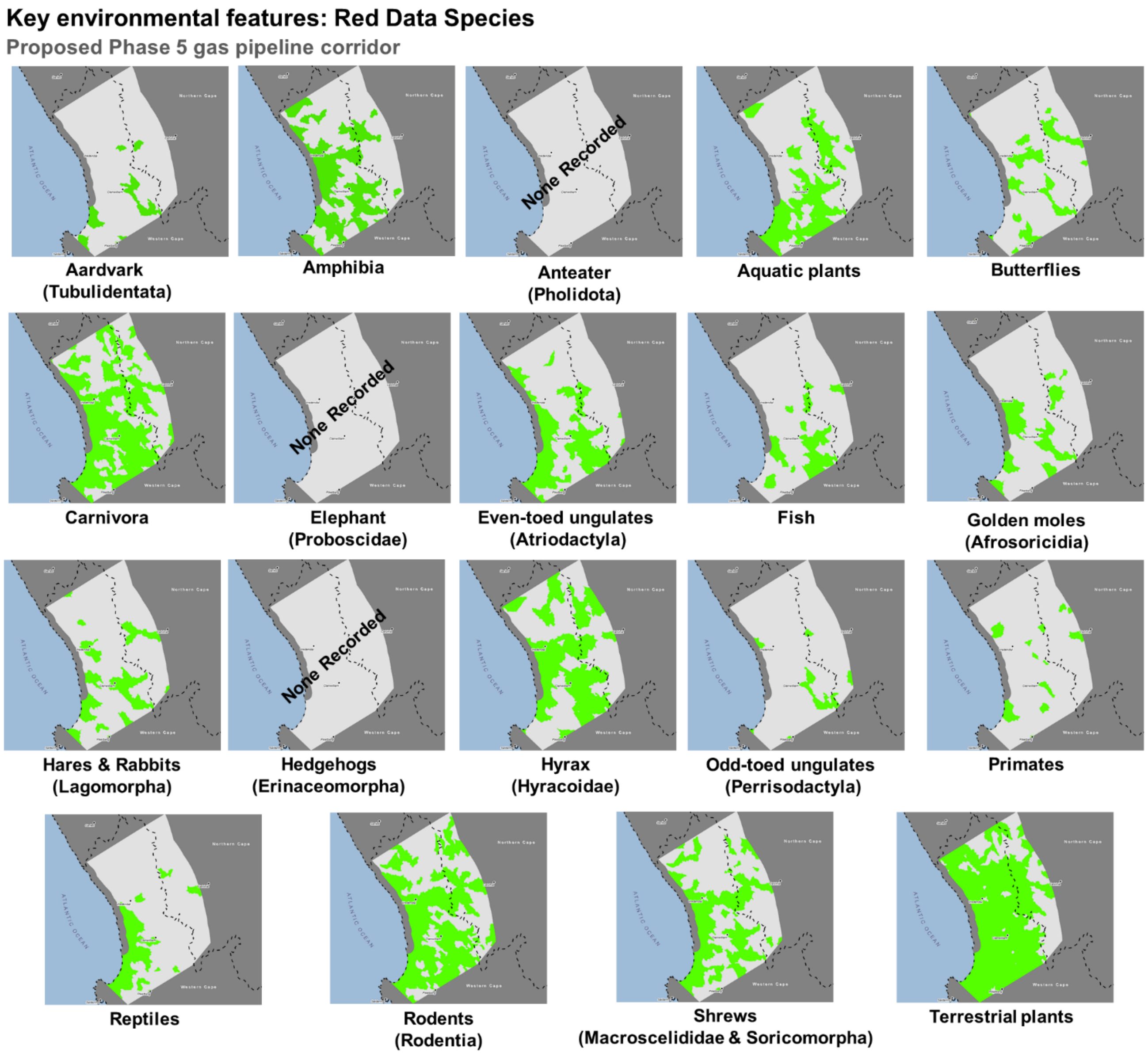


Figure 12: Distribution of recorded Red Data species in the proposed Phase 5 gas pipeline corridor (at quinary catchment scale).

4.2.3 Phase 1

The proposed Phase 1 gas pipeline corridor is located approximately from Saldanha to Mossel Bay (Figure 1), predominantly within the Fynbos and Succulent Karoo vegetation types. The lowlands to the south of the cape Fold Mountains are extensively transformed by settlements and agriculture.

A prominent feature of this corridor is the rugged Cape Folded Belt mountains extending roughly north-south from the northern Cederberg to Cape Hangklip, the Kouebokkeveld and Hex inland, and the Riviersonderend, Langeberg, and Swartberg which run more or less east-west. The rainfall falls primarily in winter in the west and centre but becomes bimodal with spring and ranges from about 400 mm in the northwest to over 2 500 mm in the Boland mountains. The summers are warm and dry, with strong, desiccating south-easterly winds. The rainfall is lower on the inland mountains and east-west ranges but exceeds 1 000 mm in the central Langeberg. These mountain ranges are important water sources for the rivers and streams that flow into the adjacent lowland and nationally significant SWSAs (Nel et al., 2013; 2017).

The western part of this corridor is dominated by the sandy plains and granite and shale hills of the West Coast and the Swartland with sandstone inselbergs. The West Coast NP and adjacent CBAs form a block that extends right across the corridor at this point, forming a pinchpoint. The coastal mountain chain is almost unbroken from Piekenierskloof in the north to Hangklip in the south, with only a narrow gap formed by the Klein Berg River valley (Nuwekloof Pass). These ranges are either in Nature Reserves, Mountain Catchment Areas or Informal Protected Areas. The inland mountain chain from the Cederberg to the Langeberg is also only broken by narrow river valleys. The remaining natural vegetation adjoining these protected areas is all in CBAs or ESAs. The Hex River Mountains extend inland from this mountain chain to the inland boundary of this corridor. There is a pinch point near Robertson and routes over the north-south oriented river systems between Swellendam and Mosselbay (e.g. GouKou, Duiwenhoks, Gouritz) will have to be chosen with care as these are also climate change adaptation corridors.

4.2.3.1 Fynbos

This corridor covers the core area of the Fynbos Biome, as well as some of the most transformed portions, and so includes a large number of threatened ecosystems and a high proportion of the threatened species in the biome. The entire corridor falls within the biome except for the areas of the Succulent Karoo in the drier inland valleys, islands of Afromontane Forest, and some small areas of Albany Thicket in river valleys both on the coastal lowlands and in inland valleys. The corridor overlaps with a total of 113 vegetation types, including 86 from the Fynbos Biome. Of these, 18 are rated CR, 14 EN and 15 VU, making a total of 54 threatened. All of the Sand Fynbos, 78 of the Renosterveld, 50 of the Strandveld and 44 of the other Fynbos vegetation types are considered threatened. Threatened flora and the full range of threatened terrestrial fauna are found in the CBA areas within the corridor, especially in the lowlands.

These findings clearly highlight the extensive transformation of the lowland vegetation types and that all their natural remnants are considered highly or very highly sensitive. So, even if the lowlands look like the best options for a route, some careful routing will be needed to minimise impacts.

4.2.3.2 Succulent Karoo and Nama Karoo

Important features present in the proposed Phase 1 gas pipeline corridor include the Tankwa Karoo, which includes the Tankwa Karoo National Park as well as several areas where the Riverine Rabbit is known to occur (Figure 13). The Riverine Rabbit is also known to occur more widely within the corridor, from Touws River, through to the Robertson area and Sanbona Private Nature Reserve and northwards towards Anysberg Nature Reserve. The Worcester-Robertson Succulent Karoo region is also considered to be an area of high plant diversity and endemism and the vegetation in this area is considered fairly high sensitivity. In the east the corridor also includes the area around Calitzdorp as well as the open plains between Laingsburg and Prince Albert, where the major features are the larger drainage systems present including the Dwyka, Gamka, Groot and Touws Rivers. The mountains in this area are generally important areas for the Grey Rhebok, as well as potential habitat for the Cape Mountain Zebra and Cape Leopard.

4.2.3.3 Albany thicket

The Albany Thicket vegetation in the proposed Phase 1 gas pipeline corridor is highly diverse with at least four distinct vegetation biomes forming a mosaic with Albany Thicket mostly in river valleys. Albany Thicket is restricted to deep, well-drained, fertile sandy loams with the densest thickets occurring on the deepest soils (Cowling, 1983). Soil moisture is another important limiting factor. The vegetation is adapted to grow in hot, dry river valleys where soil moisture is limited for extended periods. Soil moisture decreases towards the west, resulting in thickets that are more dense, succulent and thorny.

According to Mucina and Rutherford (2006), overall 60% of this biome has been severely degraded, with only 11% still in pristine condition, and around 7.3% totally lost. The mesic thicket, which has the highest levels of endemism and species richness within the Thicket biome, is under the greatest pressure.

A more detailed analysis by Lloyd et al. (2002) and Vlok & Euston-Brown (2002b) provides figures on levels of severely degraded and moderately degraded thicket for each vegetation sub-class. This analysis shows that except for the Mainland Montane Solid (Thicket) and Coastal Dune Solid Thicket, all the vegetation units described show high levels of severe and moderate degradation.

Forms of thicket vegetation that have been especially ravaged by overgrazing in the past century, are those rich in spekboom or igwanishe, *Portulacaria afra*. There is evidence that even in the short space of a decade, heavy browsing, especially by mohair-producing angora goats, can convert dense shrubland into a desert-like state (Vlok & Euston-Brown, 2002a). Of some 16,000 km^2 formerly covered in spekboom-rich thicket, some 46 has undergone severe degradation and 34 moderate disturbance. This is predominantly from overgrazing, although clearing for crop cultivation is another major threat to the Thicket vegetation. Land has been cleared along the rivers, and lucerne and other crops are grown under irrigation. Land has also been cleared for orange orchards in the Addo region (Vlok & Euston-Brown, 2002b).

The role that indigenous herbivores may have played in determining vegetation boundaries, as do domestic livestock today under certain management regimes has been the subject of much speculation (Hoffman & Cowling, 1990). Several studies have shown that African elephant (*Loxodonta Africana*) has a substantial impact on subtropical thicket composition (Stuart-Hill, 1992), however, these animals as well as black rhinoceros (*Diceros bicornis)*, even under exceptionally high population density (unlike goats) do not convert solid thicket into a mosaic savannah, as Thicket types are probably much more resilient to the impacts of indigenous herbivores. Overgrazing by domestic livestock, in particular goats, has caused dramatic changes in thicket vegetation, with Nama-Karoo shrub like elements invading Arid Thicket types, and subtropical grasses massively increasing in cover in some Valley Thickets, creating savanna-like vegetation that burns at regular intervals, further eliminating succulents and fire-sensitive shrubs (Hoffman & Cowling, 1990).

Unfortunately, removing livestock and resting the veld does not lead to natural recovery of the vegetation, as seedling establishment is constrained by the exposed soil's temperature extremes and reduced water-holding capacity. Essentially, to restore this thicket type requires active interventions (Vlok & Euston-Brown, 2002a).

The Albany Centre is a major centre of botanical diversity and endemism for succulents of karroid affinity, especially in the Mesembryanthemeceae, Euphorbiaceae and Crassulaceae, as well as a centre for certain bulb groups.

Subtropical thicket is renowned for its high plants species richness and levels of endemism (i.e. species that grow nowhere else). Vlok & Euston-Brown (2002a) provide a tally of 1 588 subtropical thicket species for the planning domain, 322 (20 of which are endemic). Most of these endemics are succulents associated with the vygie, euphorbia, crassula, aloe and stapeliad plant groups (Vlok & Euston-Brown, 2002a).

The subtropical thicket is associated with two globally recognised centres of succulent plant endemism, namely the Little Karoo Centre of the Succulent Karoo in the west and the Albany Centre in the east (van Wyk & Smith, 2001). The Albany Centre encompasses elements of the Cape and Succulent Karoo regions.

4.2.3.4 Birds and bats

The Namibian long-eared bat is the only bat species of Conservation Importance occurring in the proposed Phase 1 gas pipeline, whilst several red data bird species may be present (Table 12).

Table 12: Red Data bird species likely to be encountered in the proposed Phase 1 gas corridor.

Species	Status	Biome					
		Fynbos	Succulent Karoo	Nama Karoo	Albany Thicket	Forest	Azonal
Abdim's Stork	NT						
African Crowned Eagle	VU					✓	
African Marsh-Harrier	EN	✓					✓
African Rock Pipit	NT	✓	✓	✓			
Agulhas Long-billed Lark	NT	✓					
Black Harrier	EN	✓	✓	✓			
Black Stork	VU	✓	✓	✓			✓
Black-winged Pratincole	NT	Vagrant					
Blue Crane	NT	✓	✓				✓
Burchell's Courser	VU						
Burchell's Courser	VU		✓	✓			✓
Cape Rock-jumper	NT	✓					
Cape Vulture	EN	✓					
Caspian Tern	VU						x
Chestnut-banded Plover	NT						✓
Damara Tern	CR						✓
Denham's Bustard	VU	✓					
Eurasian Curlew	NT						✓
European Roller	NT	✓			✓		
Great White Pelican	VU						✓
Greater Flamingo	NT	✓	✓	✓			x
Greater Painted-snipe	NT						✓
Half-collared Kingfisher	NT						✓
Hottentot Buttonquail	EN	✓					
Karoo Korhaan	NT	✓	✓	✓			
Knysna Warbler	VU				✓	✓	
Knysna Woodpecker	NT				✓	✓	
Kori Bustard	NT		✓	✓			
Lanner Falcon	VU	✓	✓	✓	✓	✓	✓
Lesser Flamingo	NT	✓	✓	✓			✓
Ludwig's Bustard	EN	✓	✓	✓			
Maccoa Duck	NT						x
Marabou Stork	NT	Vagrant					
Martial Eagle	EN	✓	✓	✓	✓		
Protea Seedeater	NT	✓					
Red-footed Falcon	NT						
Sclater's Lark	NT						

Species	Status	Biome					
		Fynbos	Succulent Karoo	Nama Karoo	Albany Thicket	Forest	Azonal
Secretarybird	NT	✓	✓	✓			
Southern Black Korhaan	VU	✓	✓				
Striped Flufftail	VU	✓					
Tawny Eagle	EN						
Verreaux's Eagle	VU	✓	✓	✓			
Yellow-billed Stork	EN						
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened							

4.2.3.5 Freshwater ecosystems

Rivers within the proposed Phase 1 gas pipeline corridor are either perennial/permanently-flowing (approximately 55%) or ephemeral/non-perennial (approximately 45%), and are characteristic of the South Western Coastal Belt, Western Folded Mountains, Southern Folded Mountains and the Southern Coastal Belt ecoregions. Major river systems include the Berg, Bree, Gourits and Doring Rivers (Figure 14). Most (approximately 65%) of the river habitat in the corridor is currently Threatened (i.e. CR, EN and VU). The rivers are generally in a poor condition – 30% of rivers are in a natural/good condition, 20% are in a fair condition, 44% are in a poor condition, and 6% are either very poor/critical condition.

Wetland habitats within this corridor occupy a fair proportion of the corridor (~7%) comprising up to 221 different wetland types, dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the East Coast Shale Renosterveld region. The corridor boasts five Ramsar wetlands, namely Langebaan, False Bay Nature Reserve, Bot-Kleinmond Estuarine System, De Mond (Heuningnes Estuary) and De Hoop Vlei. A moderate proportion (~18%) of the wetlands in the corridor are characterised as NFEPA wetlands. Most notable is that 50% of the wetlands of the corridor are associated with the CR wetland groups: East Coast Shale Renosterveld (20%), Rainshadow Valley Karoo (15%), West Coast Shale Renosterveld (9%) and Western Fynbos-Renosterveld Shale Renosterveld (6%).

The Cape Mountains are important water sources for the rivers and streams that flow into the adjacent lowlands. The ranges from the Cederberg to the Langeberg and south to Cape Hangklip, and Table Mountain all being SWSAs (Nel et al., 2013; 2017). There are also extensive SWSAs for groundwater in this area including the West Coast aquifer and the Sandveld aquifer, as well as in the inland valleys.

Box 15: Red Data aquatic biota likely to be encountered in Phase 1

Three Endangered Odonata (*Proischnura polychromatica, Orthetrum rubens* and *Spesbona angusta*), as well as four Vulnerable and three Near Threatened species. *Orthetrum rubens* is a restricted species that is only known from the mountains of the Western Cape: since 2016 the only known extant population is in the Hottenstots-Holland Mountains, at Victoria Peak. *Spesbona angusta* is also restricted to a wetland at the base of Franschhoek pass, and thus careful conservation planning and improvement of wetland in terms of water depth and density of pools is required for this species (Veldtman et al., 2017). *Proischnura polychromatica* has also only been recently recorded near Ceres, and also at the base of Franschhoek Pass, and are only known from sites where alien invasive trees have been removed (Veldtman et al., 2017).

The corridor supports an exceptionally high number of Red Listed fish (up to 22 species) of which four are Critically Endangered: *Pseudobarbus burchelli*, which is found in the Breede and Tradouw river systems, Pseudobarbus erubescens (endemic to the Twee River Catchment within Olifants system), *Pseudobarbus* sp. nov. 'doring' (Breekkrans and Driehoeks Tributaries of the Doring river, Olifants system), and *Pseudobarbus* sp. nov. 'heuningnes' (Heuningnes River System). In addition, 10 fish species are Endangered, three are Vulnerable, four are Near Threated and one is Data Deficient. The corridor also supports a high number of Red Listed amphibians (up to 16 species) of which five are Critically Endangered (*Arthroleptella rugosa, A. subvoce, Capensibufo rosei, Heleophryne rosei* and *Microbatrachella capensis*), two are Endangered, six are Near Threated and three are Data Deficient. *Arthroleptella rugosa* (Rough Moss frog) is a highly restricted species occurring only on the Klein Swartberg Mountain near Caledon, A. subvoce's status may be changed to a more threatened category (Turner and de Villiers, 2017); *Capensibufo rosei* is only found to occur on the Cape Peninsula, in two or three remaining populations; *Heleophryne rosei* is restricted to four streams on Table mountain area, and *Microbatrachella capensis* is a vital indicator of a unique and threatened ecosystem: coastal lowland blackwater wetlands. There is only one Red Listed reptile that occurs within the corridor, namely the Vulnerable *Bradypodion pumilum*. The Phase 1 Corridor supports known occurrences of the Critically Endangered Riverine Rabbit *Bunolagus monticularis*, which is restricted to the semi-arid Karoo, with an estimated extent of occurrence (EOO) of 54,227 km^2 and area of occupancy (AOO) 2,943 km^2 (2016 Mammal Red List *Bunolagus monticularis* CR). The Riverine Rabbit inhabits dense, discontinuous scrub vegetation along seasonal river beds and is dependent on soft, deep alluvial spoils along these river courses, for constructing burrows in order to breed. Other Red Listed mammals include the Vulnerable *Dasymys capensis*, as well as three species that are Near Threatened. This corridor supports the highest diversity of Red Listed plants with up to 75 species. Of this diversity, 16 are Critically Endangered, 23 are Endangered, 22 are Vulnerable, six are Near Threatened, four are Data Deficient and four are rare.

Approximately 67% of the Phase 1 Corridor comprises land that is largely natural with a small proportion (~1%) degraded. A significant proportion (20%) of the corridor is protected by over 100 different conservation areas (e.g. Koue Bokkeveld Mountain Catchment Area, Matroosberg Mountain Catchment Area, Langeberg Mountain Catchment Area). The remaining area is largely transformed by cultivation (~29%), but also urbanisation in and around Cape Town (2%) and plantations (1%). Impacts on freshwater ecosystems caused by land use activities vary across the corridor, however, combined effect has had a significant effect on freshwater ecosystem functioning and integrity.

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 1 pipeline corridor include:

- There has been rapid population growth within the Western Cape, and thus urbanization has increased, particularly since 2009. Informal settlements in particular have expanded and reactive spatial planning has led to poor or even absent basic service infrastructure. The result is unsustainable practices including increased illegal dumping and waste disposal in rivers, contributing to water pollution. The greatest instances of transformation are reported to be in Cape Town itself and other coastal nodes.

- Very high (unacceptable) faecal contamination in the Berg, Bree, Diep, Gouritz and Kuils River systems. Inland water is generally considered not fit even for agricultural or industrial use.
- Alien invasive species, which reduce both surface and ground water availability, increase fire risk and compete with indigenous species, which result in habitat loss and degradation. Alien invasive plants are a large problem, as are invasive fish species within rivers – 17 in total.
- Agriculture, also reported to be increasing in the Western Cape region, contributes to the pollution of freshwater resources, as a result of run-off of pesticides and fertilizers. In addition, over-abstraction of water for both agriculture and urban use forms a major problem in many areas.
- Damage to river beds, wetlands and floodplains (channel modification) as a result of agricultural practices is also considered to be a major threat to freshwater ecosystems in this region.
- Other pressures which impact on these systems include overgrazing and illegal harvesting of species.
- Further to this, within the Western Cape, water has been identified as a provincial risk, based on increased urbanization, climate change, failing infrastructure and consumer behaviour.

4.2.3.6 Estuaries

In total 25 estuaries are situated within the Phase 1 corridor, with a combined estuarine habitat area of 3 100 ha (Figure 14). Most are not particularly long and extend less than 10 km into the proposed Gas Pipeline corridor. Exceptions are the Breede (<30 km), Gourits (<25 km), Duiwenhoks (<15 km), Goukou (<15 km), Sand (<10 km), Sout (Wes) (<10 km) and Rietvlei/Diep (<10 km).

The Langebaan, Wildevoëlvlei, Breë, Duiwenhoks and Goukou estuaries are of very high biodiversity importance, ranking in the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). In addition, the Rietvlei/Diep, Sand, Palmiet, Gourits estuaries are also rated as important from a biodiversity perspective.

Only eight estuaries in this corridor are in excellent or good conditions (Categories A to B). These systems have a high sensitivity to change as they will degrade from their near pristine state relatively easily.

Eleven estuaries in the corridor are identified as national conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012), most of which are identified as important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). From a habitat diversity and abundance perspective the Langebaan, Rietvlei/Diep, Wildevoëlvlei, Sand, Palmiet, Breë, Duiwenhoks, Goukou and Gourits estuaries are also considered important for habitat diversity and abundance, as they support sensitive estuarine habitats such as intertidal and supratidal saltmarsh.

See Addendum 1 to this chapter for a complete list of estuaries present in the proposed Phase 1 gas pipeline corridor.

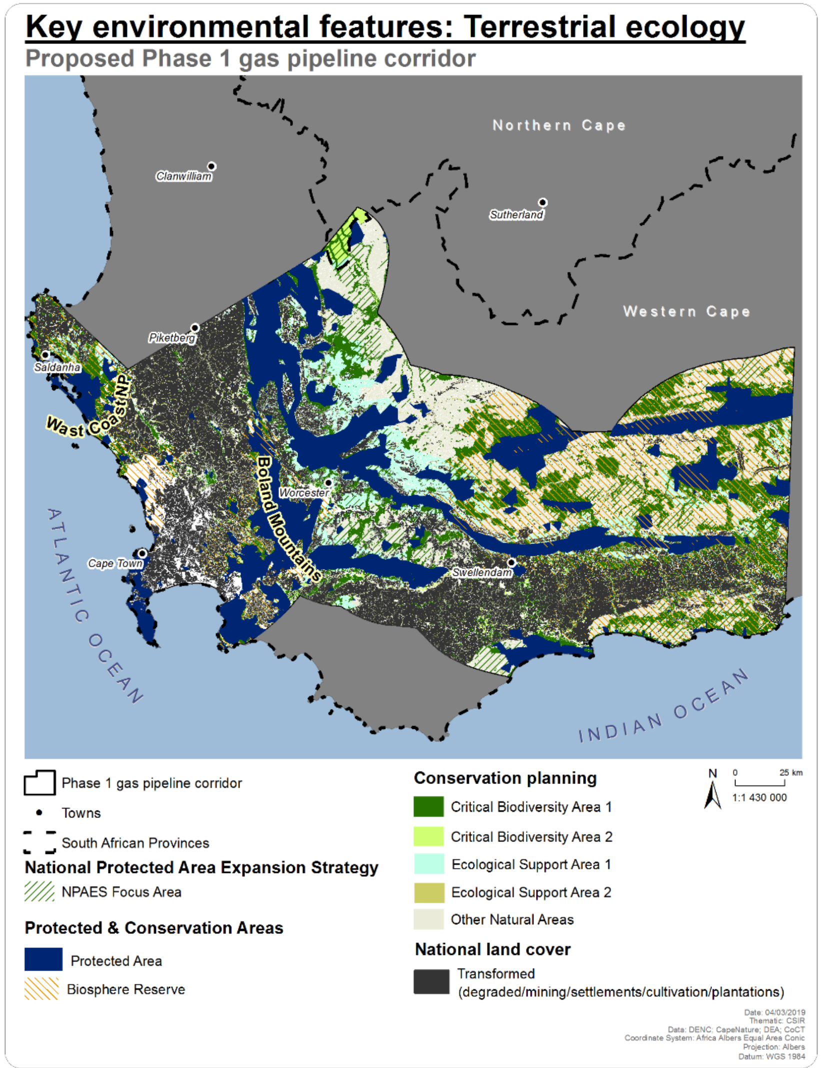


Figure 13: Key environmental features of the proposed Phase 1 gas pipeline corridor.

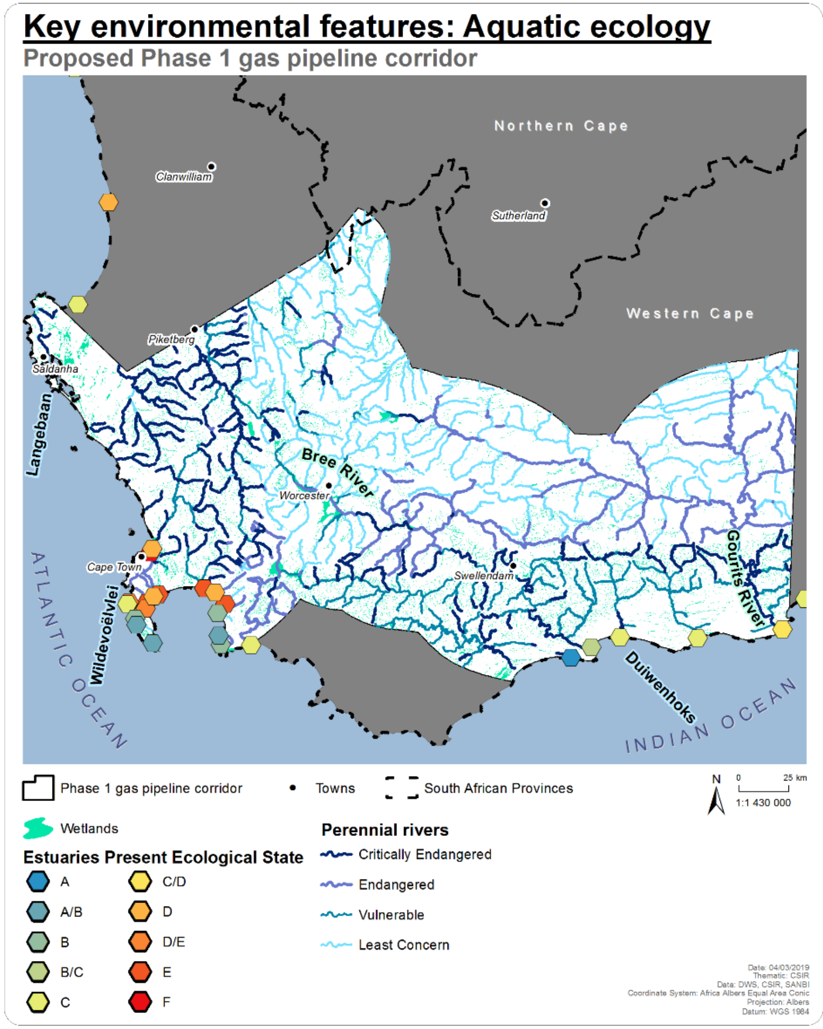


Figure 14: Key aquatic ecosystem features of the proposed Phase 1 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent.

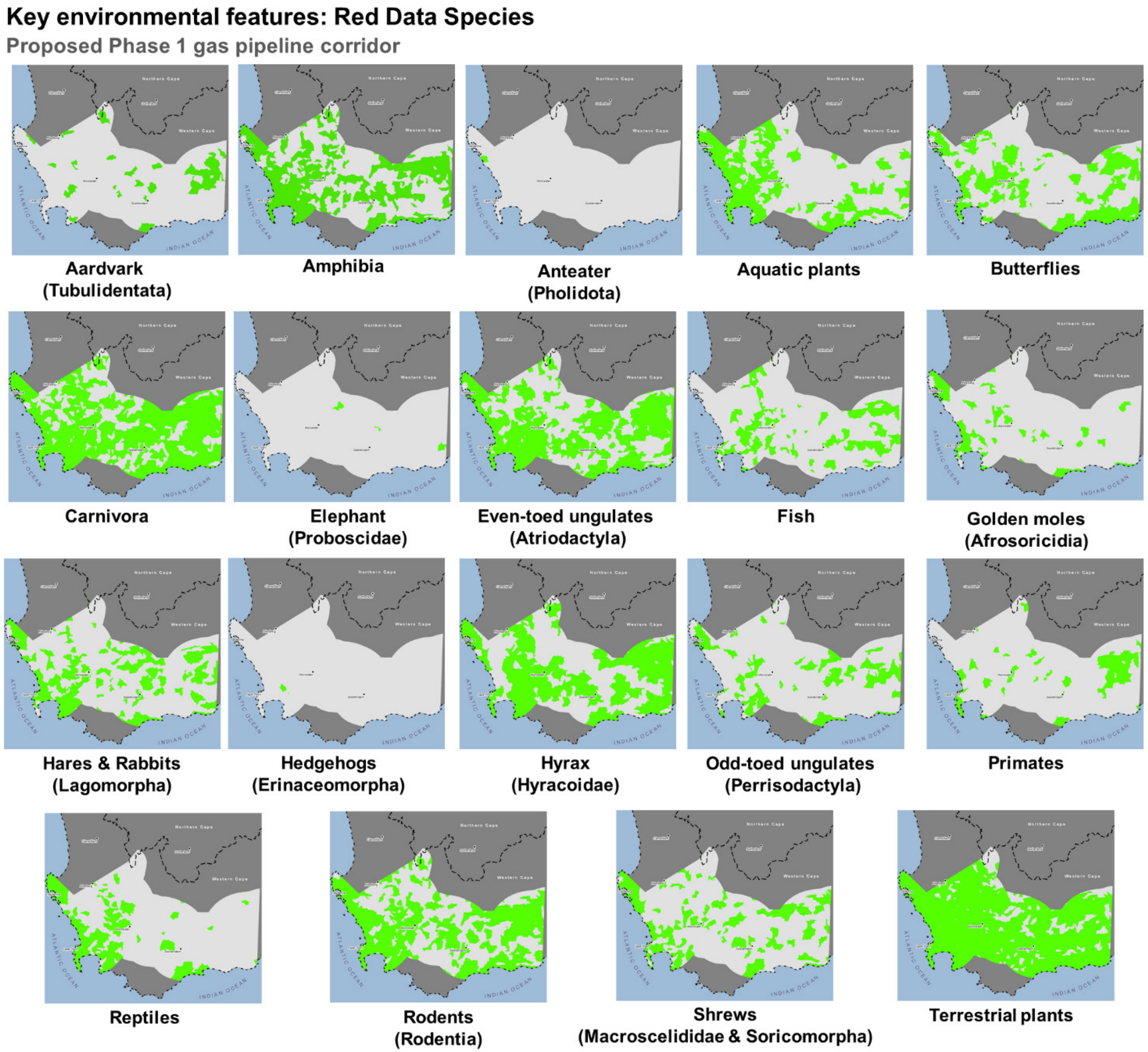


Figure 15: Distribution of recorded Red Data species in the proposed Phase 1 gas pipeline corridor (at quinary catchment scale).

4.2.4 Phase 2

The proposed Phase 2 gas pipeline corridor is located approximately from to Mossel Bay to Port Elizabeth (Figure 1). Transformation has occurred around major towns (Mossel Bay, George, Port Elizabeth) due to urban settlement and agriculture.

The climate is characterised by mild temperatures, except in the interior valleys, and evenly distributed rainfall with spring and autumn peaks. Berg winds are common in the winter and are often associated with fires in the Fynbos biome (Geldenhuys, 1994; Kraaij et al., 2013a).

4.2.4.1 Fynbos

A prominent feature is the east-west mountain ranges, with the Huisrivier-Outeniqua-Tsitsikamma-Kouga-Baviaanskloof in the south and the Swartberg, Groot and Klein Winterhoekberge-Suurberg inland in the north. The Kammanassie Mountains in the western part of the corridor form a link between the inland and the coastal ranges at the eastern end of the Little Karoo. The mountain ranges with their protected areas have extensive ESA and CBA areas adjoining them (Figure 16). The intensively farmed and developed coastal lowlands from Mosselbay to Plettenberg Bay have a fine-scale mosaic of CBAs including the remnants of these coastal vegetation. The same applies to the Langkloof and the Humansdorp Plains. The complicated mosaic of Fynbos and Forest in the area between Wilderness and Plettenberg Bay will have to be treated as special a unit in the routing assessment should the construction be authorised. The best option is probably the inland through the Little Karoo and Langkloof but the pinch points at the feasible passes from the coast inland are a problem. There are also pinch points between about Joubertina and Kareedouw and between there and the Gamtoos River valley. Another option is to avoid the Langkloof and go via Uniondale, Willowmore and, Steytlerville to Coega.

In the Western Cape portion, the corridor includes 50 vegetation types with 34 of these being Fynbos, 4 Forest, 4 Succulent Karoo and 7 Azonal. Thirteen (38) of the Fynbos vegetation types are threatened based on the WCBSP data. Based on the 2011 Threatened Ecosystems listing, there are six threatened (two CR) Fynbos vegetation types in the Eastern Cape which is 15 of the vegetation types; five of these extend into the Western Cape. Most of these threatened vegetation types are found on the intensively developed coastal lowlands between Mosselbay in the west and Humansdorp in the east. The full range of threatened terrestrial fauna can be found in the CBA areas.

The Cape Mountains are important water sources for the rivers and streams that flow into the adjacent lowland with the Huisrivier-Outeniqua-Tsitsikamma-Kouga and Swartberg all being SWSAs (Nel et al., 2013; 2017). There are also extensive SWSAs for groundwater in this area, including the West Coast aquifer and the Sandveld aquifer, as well as in the inland valleys.

4.2.4.2 Succulent Karoo and Nama Karoo

The arid sections of the propose Phase 2 gas pipeline corridor are bounded by various mountain ranges in the south such as the Swartberg and Baviaanskloof. The arid Karoo plains from Prince Albert in the west to Steytlerville and Jansenville in the east are generally of moderate sensitivity, but there are occasional high to very high sensitivity areas present including the major features such as the Kariega, Sout and Groot Rivers, as well as the transition areas between the plains of the Nama Karoo and the thicket communities present on the slopes and hills of the area. Only few fauna of conservation concern are present across this area, apart from the Black-footed Cat which occurs at a low density across this area as well as the South African Hedgehog, which is known from the eastern margin of this corridor. The mountains are also home to the Near-Threatened Mountain Reedbuck and Grey Rhebok.

4.2.4.3 Albany Thicket

The Albany Thicket in the proposed Phase 2 gas pipeline corridor is rich in high value biodiversity areas and is characterised by a large number of Protected Areas and CBAs. It contains the Baviaanskloof PA, part of the Cape Floral regions World Heritage serial sites, as well as a number of CR vegetation types including, Sundays Spekboomveld and Sundays Noorsveld, and comprises the south-western sector of the Maputaland-Pondoland hotspot and the Albany Centre of Endemism (Van Wyk & Smith, 2001) (Figure 16).

4.2.4.4 Grassland

Grassland has a very limited extent in the proposed Phase 2 gas pipeline corridor, with small patches Karoo Escarpment Grassland in the Karoo National Park (north-west of Beaufort West), together with Bedford Dry Grassland towards the eastern side of the corridor.

4.2.4.5 Birds and bats

No bat species of Conservation Importance occur in the proposed Phase 2 gas pipeline corridor. Table 13 presents red data species that occur in the biomes present in the proposed Phase 2 gas pipeline corridor.

Table 13: Red Data bird species likely to be encountered in the proposed Phase 2 gas corridor.

Species	Status	Biome						
		Fynbos	Succulent Karoo	Nama Karoo	Albany Thicket	Grassland	Forest	Azonal
African Crowned Eagle	VU						✓	
African Finfoot	VU							✓
African Grass-Owl	VU	✓				✓		
African Marsh-Harrier	EN	✓				✓		✓
African Rock Pipit	NT	✓	✓	✓	✓			
Agulhas Long-billed Lark	NT	✓						
Black Harrier	EN	✓	✓	✓		✓		
Black Stork	VU	✓	✓	✓	✓			✓
Black-winged Pratincole	NT	Vagrant						
Blue Crane	NT	✓	✓	✓		✓		✓
Burchell's Courser	VU		✓	✓				✓
Cape Rock-jumper	NT	✓						
Cape Vulture	EN	✓						
Caspian Tern	VU							✓
Chestnut-banded Plover	NT							✓
Damara Tern	CR							✓
Denham's Bustard	VU	✓				✓		
Eurasian Curlew	NT							✓
European Roller	NT	✓			✓			
Great White Pelican	VU							✓
Greater Flamingo	NT	✓	✓	✓				✓
Greater Painted-snipe	NT							✓
Grey Crowned Crane	EN					✓		✓
Half-collared Kingfisher	NT							✓
Hottentot Buttonquail	EN	✓						
Karoo Korhaan	NT	✓	✓	✓				
Knysna Warbler	VU				✓		✓	
Knysna Woodpecker	NT				✓		✓	
Kori Bustard	NT		✓	✓		✓		

Species	Status	Biome						
		Fynbos	Succulent Karoo	Nama Karoo	Albany Thicket	Grassland	Forest	Azonal
Lanner Falcon	VU	✓	✓	✓	✓	✓	✓	✓
Lesser Flamingo	NT	✓	✓	✓				✓
Ludwig's Bustard	EN		✓	✓				
Maccoa Duck	NT							✓
Martial Eagle	EN	✓	✓	✓	✓	✓		
Pallid Harrier	NT					✓		
Protea Seedeater	NT	✓						
Red-footed Falcon	NT			✓		✓		
Sclater's Lark	NT		✓	✓				
Secretary bird	NT	✓	✓	✓		✓		
Southern Black Korhaan	VU	✓	✓					
Striped Flufftail	VU	✓						
Verreaux's Eagle	VU	✓	✓	✓				
White-bellied Korhaan	VU	✓				✓		
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened								

4.2.4.6 Freshwater ecosystems

Rivers within the proposed Phase 2 gas pipeline corridor are either perennial/permanently-flowing (approximately 45%) or ephemeral/non-perennial (approximately 55%), and are largely characteristic of the Southern Folded Mountains ecoregion, as well as the Great Karoo and the Southern Eastern Coastal Belt ecoregions. Major river systems include the Olifants, Kouga, Doring and Sondags Rivers (Figure 17). A moderate proportion (approximately 41%) of the river habitat in the corridor is currently Threatened (i.e. CR, EN and VU). The rivers are generally in either a natural/good (44%) or fair (38%) condition, while 17% of the rivers are in either a poor, very poor or critical state.

Wetland habitats within this corridor occupy a fair proportion of the corridor (~8%) comprising up to 133 different wetland types, dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the Albany Thicket and Eastern Fynbos-Renosterveld Sandstone Fynbos regions. The corridor contains one Ramsar wetland, the Wilderness Lakes, which cover 1 300 ha. A small proportion (~5%) of the wetlands in the corridor are characterised as NFEPA wetland. Most notable is that more than 60% of the wetlands of the corridor are associated with the Critically Endangered wetland groups: Albany Thicket Valley (34%), and Lower Nama Karoo (29%).

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 2 pipeline corridor include:

- Urbanization, particularly in towns and cities within the coastal zone, resulting in increased pressure on infrastructure;
- Flow alteration caused by impoundments (e.g. Kouga, Clanwilliam, Darlington), affect downstream aquatic systems (e.g. channel characteristics, riparian vegetation, and instream and floodplain habitats) as well as river continuity
- Increased agriculture and cultivation in this area has caused increased pressure on aquatic ecosystem, through processes such as channel modification, over abstraction of water for irrigation, river bank alteration and contamination of groundwater and rivers through the run-off of fertilizers, pesticides and herbicides. The abstraction of water for the irrigation of crops such as potatoes, grapes, deciduous and citrus fruits within the Olifants catchment, has resulted in extreme pressure on the flow of this system;

- Plantations of alien invasive species have also caused increased pressure on aquatic systems as a result of the decreased flow and lowering of the groundwater table. Kouga and Baviaanskloof form the source of many of the freshwater systems in the Eastern Cape, including a large proportion of the catchments of the Gamtoos, Krom and Seekoei rivers. Invasive alien Acacia, Hakea and Pinus trees pose a serious threat to the conservation of water (the uptake of water of these species is high) and natural vegetation in these mountains;
- Alien trees are also known to accelerate riverbank erosion and reduce in-stream flow. They are also responsible for changes in fire regime and alteration of plant community composition. This is particularly relevant in this region, which experiences high levels of water stress, drought and associated increased fire risk.

Box 16: Red Data aquatic biota likely to be encountered in Phase 2

One Endangered species of Odonata (i.e. *Metacnemis valida*) which occurs in the corridor (status threatened by habitat loss and now only known from two sites on the Kubusi River in the vicinity of Stutterheim) (IUCN, 2017); as well as two Vulnerable and two Near Threatened species. In addition, there are three vulnerable species, and two near-threatened species of Odonata supported in this corridor. The corridor also supports one Critically Endangered fish (i.e. *Pseudobarbus senticeps*: a narrow range endemic species which is restricted to the Krom River system (IUCN, 2017), along with three Endangered, one Vulnerable, one Near Threated and one Data Deficient species. The only Red Listed amphibians that occur within the corridor include the Endangered *Afrixalus knysnae* and *Heleophryne hewitti*. *Afrixalus knysnae* is known from around five locations at low altitudes, on either side of the border between the Eastern Cape and Western Cape Provinces and its EOO is 816 km2, and its AOO is 27 km. (IUCN, 2017) The ghost frog occurring in the Kammanassie Mountains may be Hewitt's ghost frog (*Heleophryne hewitti*), but at this stage this still needs to be confirmed and thus the status updates (Turner and de Villiers, 2017) There are no Red Listed reptiles that are known to occur within the corridor. The corridor supports a reasonable diversity of Red Listed mammals, including the Critically Endangered Riverine Rabbit *Bunolagus monticularis* (see info on status above), as well as one Vulnerable and four Near Threated species.

This corridor supports a low diversity of (up to 7) Red Listed plants. Nevertheless, one is listed as Critically Endangered (i.e. *Cotula myriophylloides*) and another is Endangered (i.e. *Felicia westae*). The other species comprise of two Vulnerable, one Near Threatened, one Data Deficient, and one rare species.

4.2.4.7 Estuaries

In total 26 estuaries (Figure 17) are situated within the Phase 2 corridor, with a combined estuarine habitat area of 7 000 ha (note that the Sundays Estuary overlaps with both the Phase 2 and Phase 7 corridor boundaries and is therefore included in both assessments). Most of the estuaries in the region are not particularly long and extend less than 10 km into the corridor, with the exception of the Sundays (<25 km), Swartkops (<15 km), Klein Brak (<10 km), Swartvlei (<10 km), Goukamma (<10 km), Knysna (<10 km), Keurbbooms (<10 km), Gamtoos (<10 km) and Coega (<10 km).

Only seven estuaries in this corridor are in an excellent or good condition (Categories A to B) – these systems are highly sensitive to change as they will degrade from their near pristine state relatively easily.

The Wilderness/Touws, Swartvlei, Knysna, Keurbooms, Gamtoos, and Swartkops estuaries are of very high biodiversity importance, ranking among the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). The Hartenbos, Groot Brak, Goukamma, Piesang, Kabeljous and Sundays estuaries are also rated as important from a biodiversity perspective.

Thirteen estuaries in the corridor are identified as national conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012). In addition, 13 estuaries are identified as important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). From a habitat diversity and abundance perspective the Hartenbos, Klein Brak, Groot Brak, Wilderness, Swartvlei, Goukamma, Knysna, Piesang, Keurbooms, Kabeljous, Gamtoos, Swartkops, Coega and Sundays estuaries are also considered important as they support sensitive estuarine habitats such as intertidal and supratidal saltmarsh.

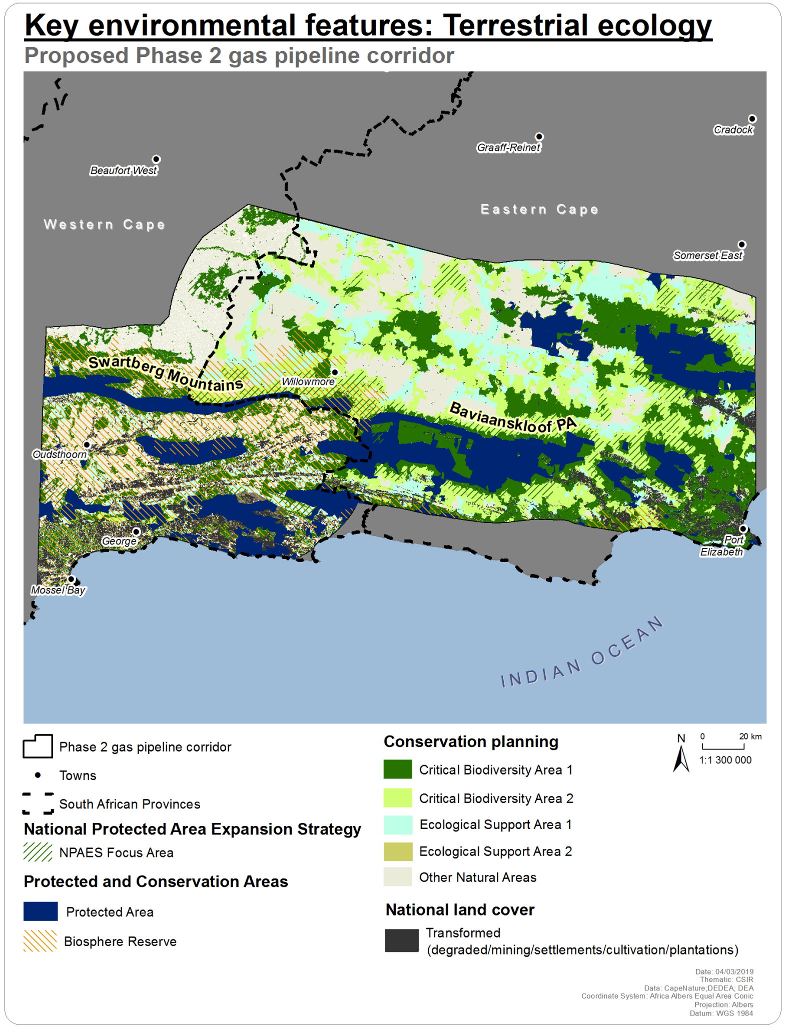


Figure 16: Key environmental features of the proposed Phase 2 gas pipeline corridor.

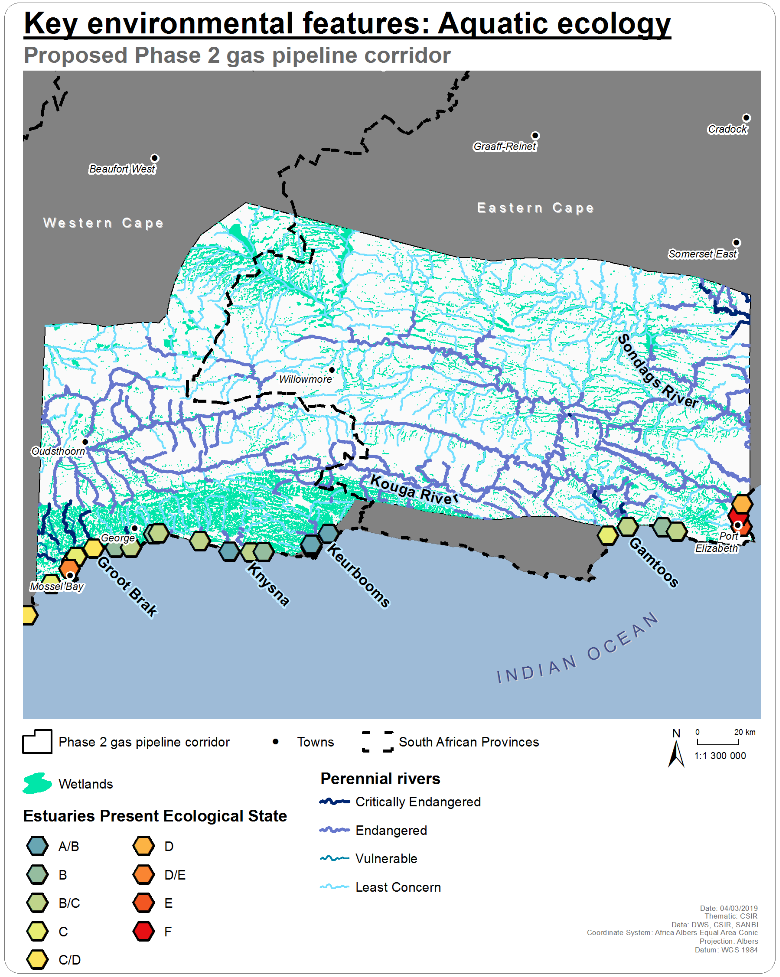


Figure 17: Key aquatic ecosystem features of the proposed Phase 2 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent.

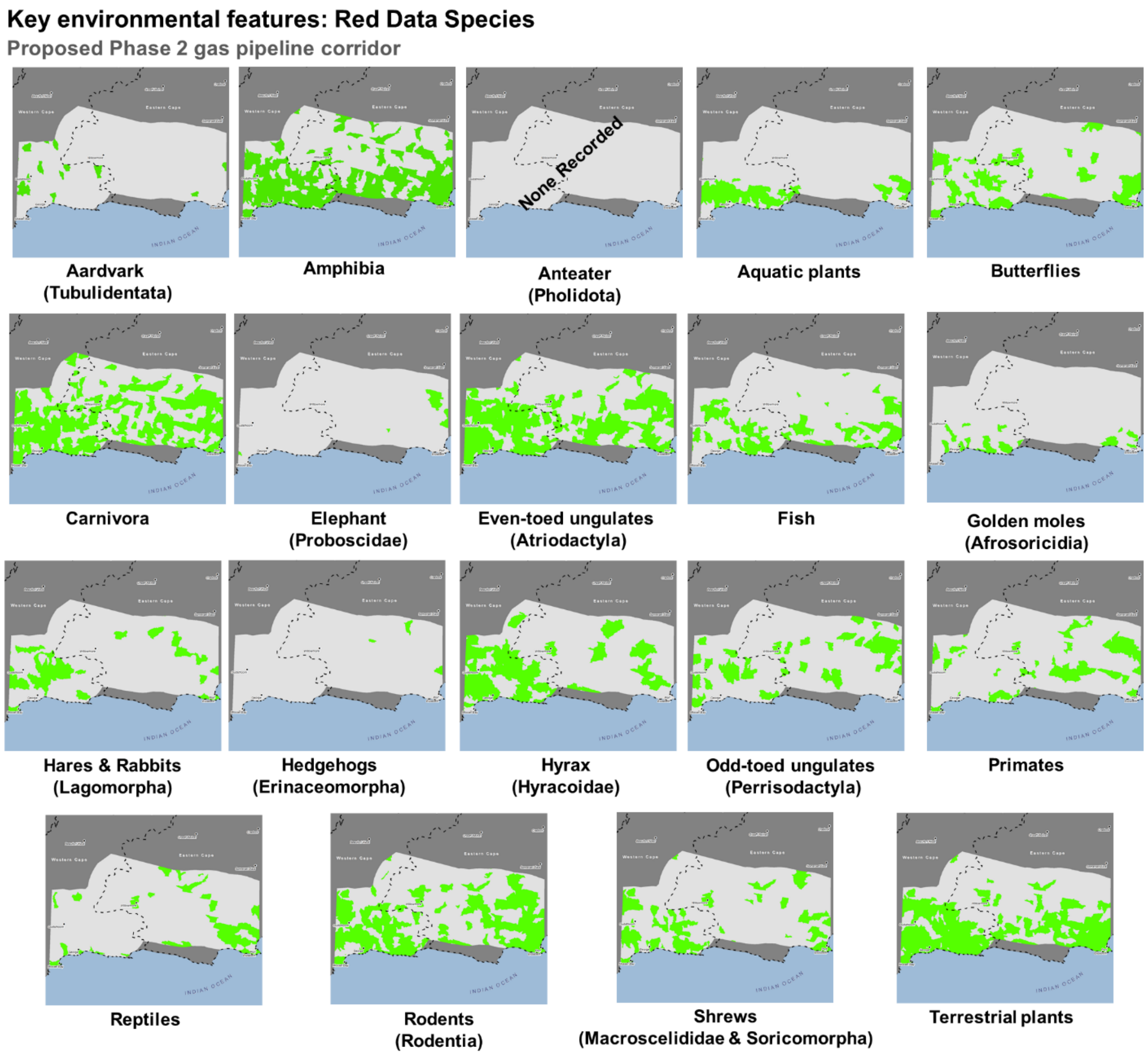


Figure 18: Distribution of recorded Red Data species in the proposed Phase 2 gas pipeline corridor (at quinary catchment scale).

4.2.5 Inland Phase

The proposed Inland Phase gas corridor is situated in the Karoo region from Sutherland to Somerset East (Figure 1). Compared to the other proposed gas pipeline corridors, it is relatively untransformed.

The climate is marked by hot summers and cold winters and the rainfall of about 300-400 mm per year occurs mainly in the winter months.

4.2.5.1 Fynbos

Sixteen Fynbos Biome vegetation types are found in this corridor, with half being Fynbos and half Renosterveld, with one being EN and two VU. About 60 is Roggeveld or Central Mountain or Matjiesfontein Shale Renosterveld. The threatened vegetation types are found mainly in the intensively cultivated Ceres and Kouebokkeveld areas. The Roggeveld escarpment is seen as a key area for the expansion of the Tankwa Karoo NP (Pool-Stanvliet et al., 2017; SANBI, 2009) (Figure 19).

Fires are rare on the Roggeveld Escarpment but more frequent on the northern slopes of the Swartberg and the Bontberg near Touwsriver based on fire occurrence records (Unpublished data, Advanced Fire Information System, Meraka Institute, CSIR).

The diversity and ecology of the Fynbos biome in the Inland Phase corridor is poorly documented and understood. Fires can play a role in regenerating the Renosterveld vegetation (Van der Merwe et al., 2008; van der Merwe and van Rooyen, 2011) but are actively suppressed by the farmers (David Le Maitre, pers. obs.).

The inland mountains, including the Roggeveld are important water source areas at a local scale.

4.2.5.2 Succulent Karoo and Nama Karoo

The inland corridor consists of the plains of the Lower Karoo in the south, which gives way to the Roggeveld and Nuweveld mountain ranges in the north. In general, at a broad level the areas of Lower Karoo are considered less sensitive than the mountains and Upper Karoo in the north. Important features of the Inland Corridor include the Tankwa Karoo National Park in the west, the Roggeveld Mountains which lie within the Roggeveld-Hantam centre of endemism, as well as the Karoo National Park near Beaufort West and the Camdeboo National Park near Graaff-Reinet in the east (Figure 19). Diversity of the rugged northern sections of the inland Corridor is considered high and these areas are considered generally unsuitable for a pipeline. The area from Sutherland across Beaufort West and up towards Loxton and Victoria West is also home to the CR Riverine Rabbit. The open plains to the south of the mountains are however generally of lower diversity with the key biodiversity feature present being the major drainage features such as the Gamka, Buffels, Dwyka, Kariega and Sundays Rivers.

4.2.5.3 Albany Thicket

The proposed Inland Phase gas pipeline corridor area contains many highly sensitive areas due to a number of state Protected Areas including the Camdeboo NP and part of Mountain Zebra NP (Figure 19). It also contains one CR vegetation type, Escarpment Valley Thicket, and part of the Sundays Arid Thicket.

4.2.5.4 Grassland

Grassland has a very limited extent in the proposed Inland Phase gas pipeline corridor, with small patches of Bedford Dry Grassland (Least Threatened) found on the eastern side of the corridor, south of Somerset East.

4.2.5.5 Birds and bats

No bat species of Conservation Importance occur in the proposed Inland Phase gas pipeline corridor. Table 14 presents red data species that occur in the biomes present in the proposed Inland Phase gas pipeline corridor.

Table 14: Red Data bird species likely to be encountered in the proposed Inland Phase gas corridor.

Species	Status	Biome					
		Fynbos	Succulent Karoo	Nama Karoo	Albany Thicket	Grassland	Azonal
Abdim's Stork	NT					✓	
African Finfoot	VU						✓
African Marsh-Harrier	EN	✓				✓	✓
African Rock Pipit	NT	✓	✓	✓		✓	
Black Harrier	EN	✓	✓	✓		✓	
Black Stork	VU		✓	✓			✓
Blue Crane	NT	✓	✓	✓		✓	✓
Burchell's Courser	VU		✓	✓		✓	✓
Cape Rock-jumper	NT	✓					
Caspian Tern	VU						✓
Denham's Bustard	VU					✓	
European Roller	NT				✓	✓	
Greater Flamingo	NT	✓	✓	✓			✓
Half-collared Kingfisher	NT						✓
Karoo Korhaan	NT	✓	✓	✓			
Knysna Woodpecker	NT				✓		
Kori Bustard	NT		✓	✓		✓	
Lanner Falcon	VU	✓	✓	✓	✓	✓	✓
Lesser Flamingo	NT	✓	✓	✓			✓
Ludwig's Bustard	EN	✓	✓	✓		✓	
Maccoa Duck	NT						✓
Marabou Stork	NT	Vagrant					
Martial Eagle	EN		✓	✓	✓	✓	
Protea Seedeater	NT	✓					
Red-footed Falcon	NT			✓		✓	
Sclater's Lark	NT		✓	✓			
Secretary bird	NT	✓	✓	✓		✓	
Southern Black Korhaan	VU	✓	✓				
Tawny Eagle	EN			✓		✓	
Verreaux's Eagle	VU	✓	✓	✓			
Yellow-billed Stork	EN						✓
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened							

4.2.5.6 Freshwater Ecosystems

Rivers within the proposed Inland Phase corridor are mostly ephemeral/non-perennial (95%), and are largely characteristic of the Great Karoo ecoregion, but also form part of the Nama Karoo and Drought Corridor ecoregions. Major river systems include the Dwyka, Kariega and Sondags Rivers (Figure 20). Less than 25% of the river habitat in the corridor is currently Threatened (i.e. CR and EN). The rivers are mostly in a natural/good condition (60%), 34% of rivers are in a fair condition, while 6% are in a poor condition.

Wetland habitats within this corridor occupy a fair proportion of the corridor (~7%), with up to 62 different wetland types dominated by channelled-valley bottom wetlands and depressions that are largely characteristic of the Nama Karoo. There are no Ramsar wetlands within the corridor, and a very small proportion (~1%) of wetlands are classified as NFEPA wetlands. Nevertheless, a significant portion (79%) of the wetlands are associated with CR wetland groups, notably the Lower Nama Karoo (60%) and the Rainshadow Valley Karoo (11%).

Almost the entire (99%) area of the Inland Corridor comprises land that is largely natural, with only a very small proportion transformed by cultivation (1%) and urbanisation (<1%). A very small proportion (3%) of the corridor is protected by a few conservation areas (e.g. Karoo NP and Tankwa Karoo NP). Impacts on freshwater ecosystems from associated land use activities of the transformed landscape are thus relatively localised. More widespread impacts to freshwater systems tend to be linked to livestock farming practices and infestation IAPs. The combined effect of anthropogenic pressures results in both localised and widespread impacts that affect functioning and integrity of freshwater ecosystems.

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Inland Phase pipeline corridor include:

- Weirs and dams (including large water supply dams, e.g. De Hoop, Leeugamka, Vanrynevelspas), which affect instream and riparian habitat continuity, as well as regulate flows downstream;
- Livestock grazing and trampling (including overgrazing, particularly in more rural areas), leading to increased erosion and sedimentation of systems;
- Intensive cultivation immediately adjacent and along the banks of rivers;
- Encroachment and infestation of woody vegetation, including invasive *Tamarix* spp.; and
- Channel incision and headcut erosion, resulting in lowered groundwater table and drying of riparian and wetland habitats.

Box 17: Red Data aquatic biota likely to be encountered in Inland Phase

There are no Red Listed species of Odonata known to occur within the Inland Corridor. Only two Red Listed fish occur within the corridor, namely the Endangered *Pseudobarbus asper*, and the Data Deficient *Sandelia capensis*. There are no Red Listed amphibians and reptiles that are known to occur within the Inland Corridor. The corridor is most notable in terms of supporting significant populations of the Critically Endangered Riverine Rabbit *Bunolagus monticularis*, which is restricted to the semi-arid Karoo, with an estimated EOO of 54,227 km^2 and AOO of 2,943 km^2 (2016 Mammal Red List *Bunolagus monticularis* CR). The Riverine Rabbit inhabits dense, discontinuous scrub vegetation along seasonal river beds and is dependent on soft, deep alluvial spoils along these river courses, for constructing burrows in order to breed. Other Red Listed mammals include the Near Threatened *Serval Leptailurus* and the Near Threatened *Otomys auratus*. This corridor supports the lowest number of Red Listed plants, with only one Vulnerable plant (i.e. *Lachenalia longituba*) and one rare plant (i.e. *Pelargonium denticulatum*) occurring within the corridor.

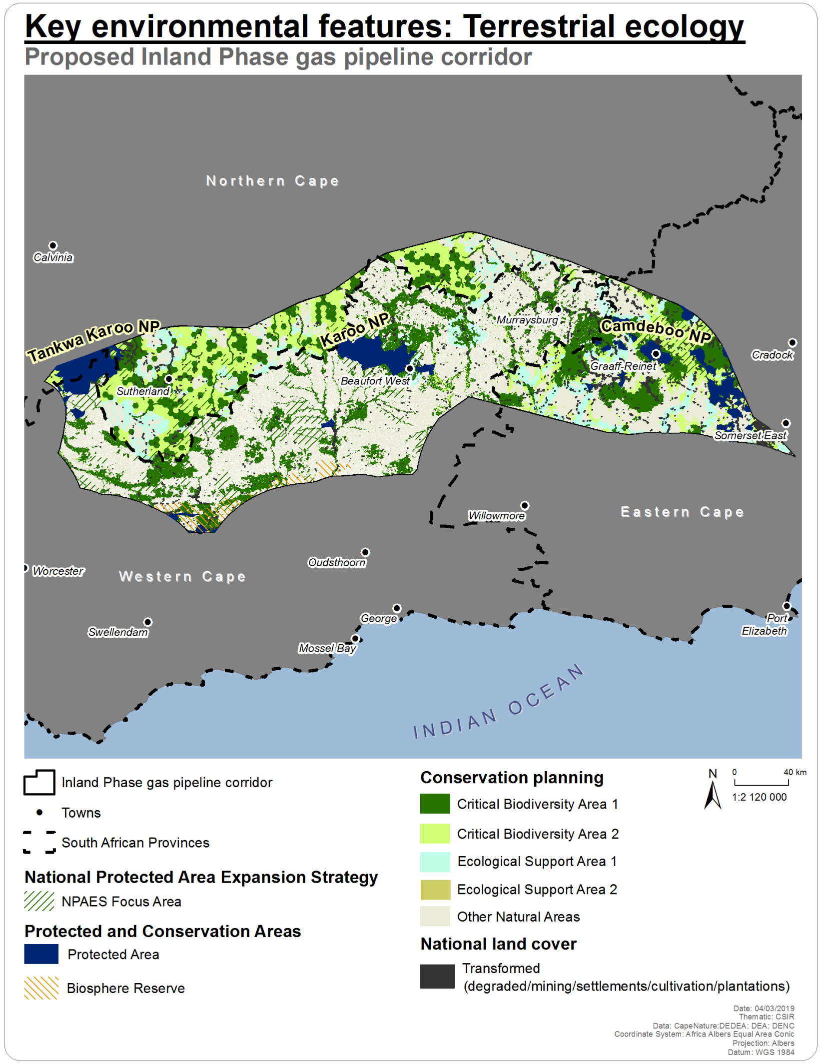


Figure 19: Key environmental features of the proposed Inland Phase gas pipeline corridor.

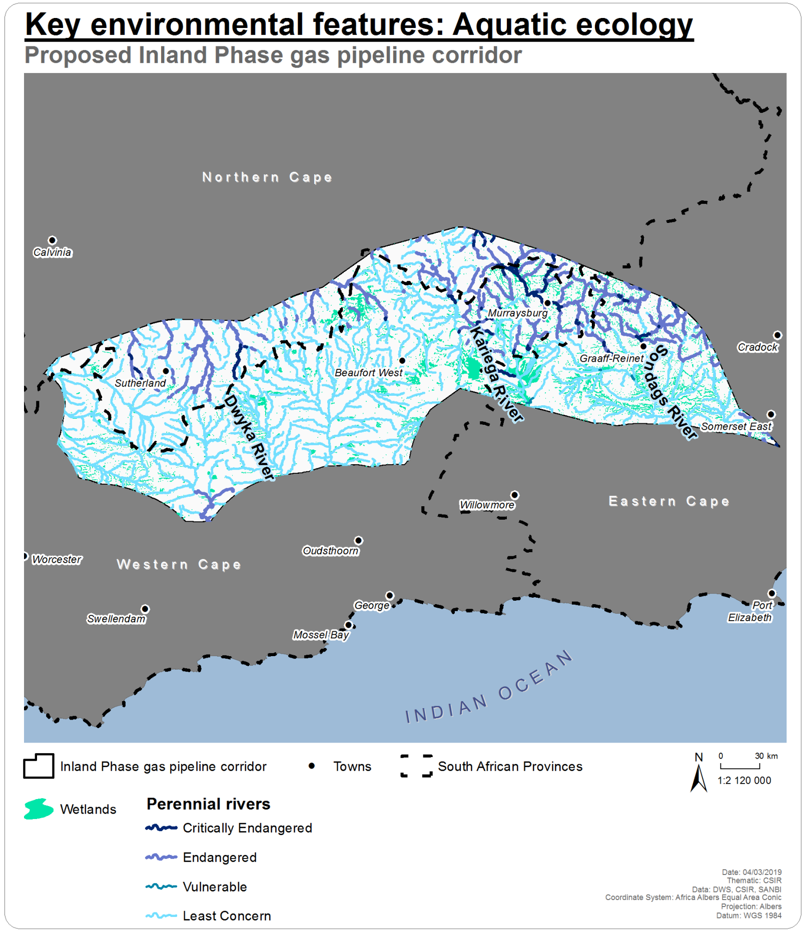


Figure 20: Key aquatic ecosystem features of the proposed Inland Phase gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent

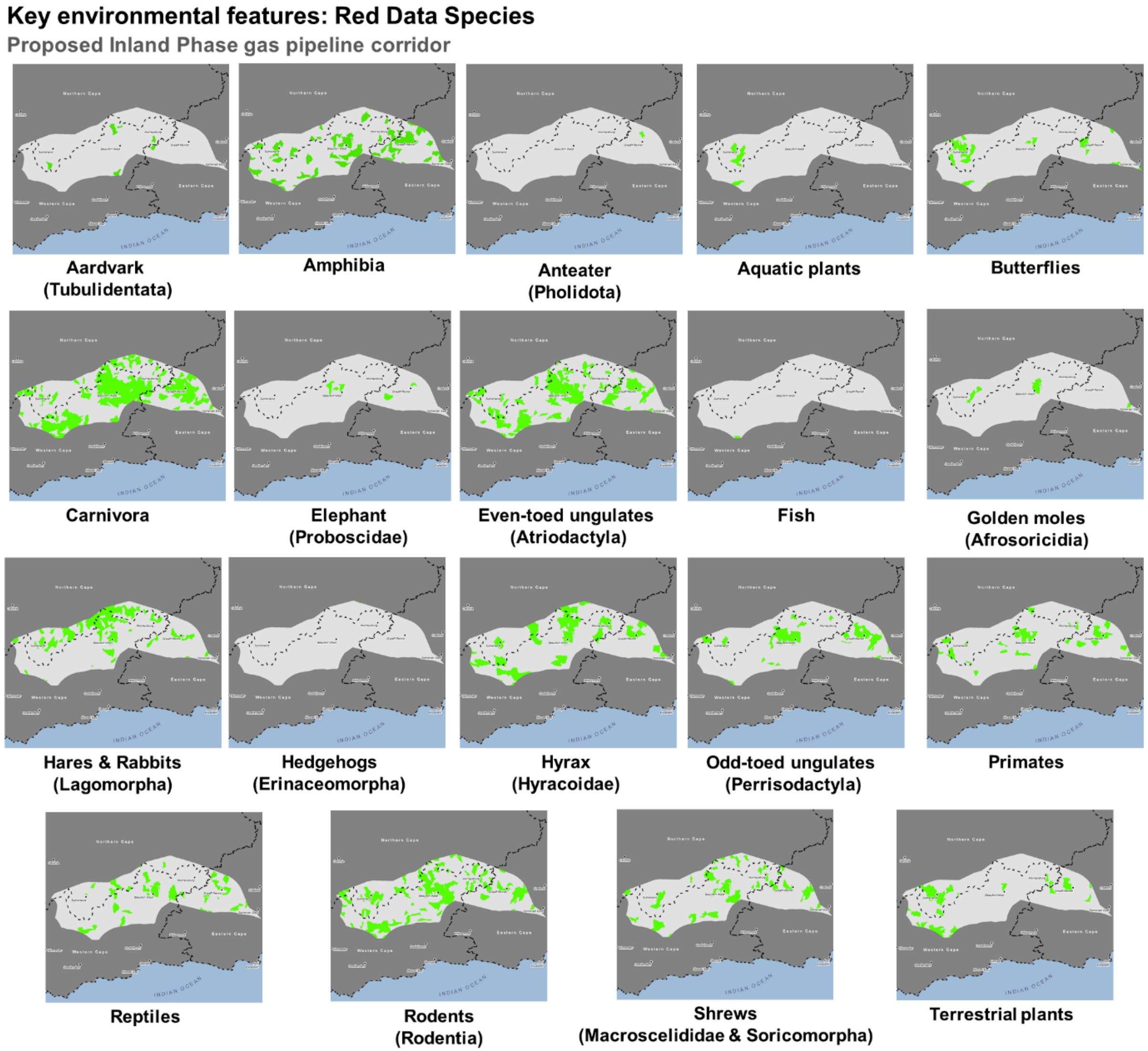


Figure 21: Distribution of recorded Red Data species in the proposed Inland Phase gas pipeline corridor (at quinary catchment scale).

4.2.6 Phase 7

The expansive proposed Phase 7 gas pipeline corridor occupies the eastern coast of South Africa, from Port Elizabeth in the Eastern Cape to Hluhluwe in KwaZulu-Natal (Figure 21 and Figure 23).

The climate of the east coast of southern Africa is controlled by the presence of a high pressure system lying to the east of the sub-continent and intermittently, the area is influenced by low pressure systems arising from the Southern Ocean, particularly during winter. In the late summer, cyclonic systems moving across the Indian Ocean often lead to catastrophic storm events along the coastline (Tinley, 1985).

The northern part of the Eastern Cape tends to be more humid with higher levels of rainfall, with high possibilities of snow in the interior mountain regions during winter. Climate in the KwaZulu-Natal province is subtropical, entailing hot and humid summers and mild winters.

4.2.6.1 Nama Karoo

Only a small patch of Albany Broken Veld in the western section of the proposed Phase 7 gas pipeline corridor. The vegetation type is transitional between the low grassy shrublands of the open plains and the thickets on the slopes of the hills of the area. The majority of species and features of conservation concern within this area are associated with the adjacent areas of thicket, grassland or small pockets of Afromontane forest that occur in moist positions along the mountains of the area.

4.2.6.2 Albany Thicket

The proposed Phase 7 gas pipeline corridor contains a large number of highly sensitive areas mostly due to many state-owned PAs, private nature reserves and game farms. The coastal areas are incised by deep river valleys often with sensitive and endangered vegetation types. It includes important PAs such as Great Fish River and part of Addo Elephant NP, as well as a number of CR vegetation types including Buffels Valley Thicket, Albany Dune, and Albany Thicket, and one EN vegetation type, Sundays Valley Thicket.

4.2.6.3 Grassland and Savanna

The proposed Phase 7 gas pipeline corridor runs through and important Pondoland centre of plant endemism. It has a large number of unique and poorly conserved Grassland and Savanna vegetation types with a large number of endemic species, rare and vulnerable species. Pinch points are not created by conservation areas, but rather by un-conserved or poorly conserved areas of high value and irreplaceable biodiversity.

The nature of the linear structure of the pipeline combined with the altitudinal alignment of vegetation types mean that it may well cut right across almost all areas of a specific vegetation type. This corridor cuts right across three centres of plant endemism.

4.2.6.4 Indian Ocean Coastal Belt

The proposed Phase 7 gas pipeline corridor affects the largest section of the IOCB, which includes a combination of very sensitive unique habitats associated with the Pondoland area and severely degraded and highly urbanised areas such as the greater Durban area.

Between Richards Bay and Hluhluwe, a significant portion of the Isimangaliso Wetland Park associated with Lake St Lucia is located. Outside of this protected area, the landscape is dominated by peri-urban settlement, extensive timber plantations and sugar cane cultivation.

Prominent azonal vegetation includes Swamp Forest (FOa 2) which is largely limited to isolated undisturbed areas in the Richards Bay and St Lucia areas. Extensive Northern Coastal Forests (FOz 7) occur, such as Futululu near Monzi.

Furthermore, the section of the IOCB affected by this corridor includes the lower extent of the Maputaland Coastal Belt (CB 1), the KwaZulu-Natal Coastal Belt (CB 3), Pondoland-Ugu Sandstone Coastal Sourveld (CB 4) and Transkei Coastal Belt (CB 5) major vegetation types. The KwaZulu-Natal south coast and Pondoland area are traversed by a large number of incised coastal and major river systems and undulating valleys. Where not transformed for agricultural purposes, these support Northern Coastal Forest and scarp forest. A prime example is the Umtamvuna River Valley (Umtamvuna Nature Reserve) on the KZN/EC border.

The northern section between Durban and Richards Bay is largely degraded, with the exception of a few pockets of undisturbed and protected habitat, such as the Amatikulu Nature Reserve (Dokodweni/Nyoni area) and The Ongoye Forest, near Mtunzini. The N2 corridor, extensive sugar cane farming and dune mining near Mtunzini are major disturbances within this section of the IOCB.

4.2.6.5 Birds and bats

Bat species of Conservation Importance likely to be encountered in the proposed Phase 7 gas corridor include:

- Short-eared trident bat
- Damara woolly bat
- De Winton's long-eared bat
- Greater long-fingered bat
- Rendall's serotine
- Large-eared free-tailed bat
- Blasius's horseshoe bat
- Swinny's horseshoe bat
- Light-winged lesser house bat
- Schreber's yellow bat

Table 15 presents red data species that occur in the biomes present in the proposed Phase 7 gas pipeline corridor.

Table 15: Red Data bird species likely to be encountered in the proposed Phase 7 gas corridor.

Species	Status	Biome							
		Albany Thicket	Savanna	Grassland	Nama Karoo	Forest	Indian Ocean Coastal Belt	Fynbos	Azonal
Cape Parrot	EN					✓			
Abdim's Stork	NT		✓	✓					✓
Black Harrier	EN			✓	✓			✓	
Black Stork	VU		✓	✓	✓		✓	✓	✓
Blue Crane	NT			✓	✓		✓	✓	✓
Caspian Tern	VU								✓
European Roller	NT		✓				✓		
Greater Flamingo	NT				✓		✓		✓
Black-rumped Buttonquail	VU		✓	✓			✓		
Damara Tern	CR								✓
Karoo Korhaan	NT				✓			✓	
Lanner Falcon	VU	✓	✓	✓	✓		✓	✓	✓

Species	Status	Biome							
		Albany Thicket	Savanna	Grassland	Nama Karoo	Forest	Indian Ocean Coastal Belt	Fynbos	Azonal
Lesser Flamingo	NT				✓		✓		✓
Bush Blackcap	VU					✓			
Maccoa Duck	NT								✓
Martial Eagle	EN	✓	✓	✓	✓		✓	✓	
Red-footed Falcon	NT			✓	✓				
Secretary bird	NT		✓	✓	✓		✓	✓	
Lappet-faced Vulture	EN		✓						
Verreaux's Eagle	VU		✓	✓	✓			✓	
Marabou Stork	NT		✓						✓
Denham's Bustard	VU		✓	✓			✓		
Orange Ground-Thrush	NT					✓			
Pink-backed Pelican	VU						✓		✓
Half-collared Kingfisher	NT								✓
African Rock Pipit	NT				✓				
Eurasian Curlew	NT								✓
Greater Painted-snipe	NT								✓
Knysna Warbler	VU	✓				✓			
Saddle-billed Stork	EN								✓
Short-tailed Pipit	VU			✓					
Southern Bald Ibis	VU			✓					
Burchell's Courser	VU				✓			✓	✓
Cape Vulture	EN		✓	✓					
Chestnut-banded Plover	NT								✓
Southern Ground-Hornbill	EN		✓						
Tawny Eagle	EN		✓						
Wattled Crane	CR			✓					✓
African Grass-Owl	VU			✓			✓		
Grey Crowned Crane	EN			✓			✓		✓
Pallid Harrier	NT			✓					
White-bellied Korhaan	VU		✓	✓				✓	
White-backed Vulture	CR		✓						
Yellow-billed Stork	EN								✓
Yellow-breasted Pipit	VU			✓✓					
Eastern Bronze-naped Pigeon	EN					✓			
Knysna Woodpecker	NT	✓				✓			
African Crowned Eagle	VU					✓			
African Finfoot	VU								✓
African Pygmy-Goose	VU								✓
Bateleur	EN		✓						
Great White Pelican	VU								✓
Kori Bustard	NT		✓		✓				
Lemon-breasted Canary	NT						✓		
Lesser Jacana	VU								✓
Mangrove Kingfisher	EN						✓		✓
Neergaard's Sunbird	VU						✓		
Ludwig's Bustard	EN				✓				
Rosy-throated Longclaw	NT						✓		
Southern Banded Snake-Eagle	CR						✓		
Swamp Nightjar	VU						✓		
White-headed Vulture	CR		✓						
Southern Black Korhaan	VU							✓	

Species	Status	Biome							
		Albany Thicket	Savanna	Grassland	Nama Karoo	Forest	Indian Ocean Coastal Belt	Fynbos	Azonal
Striped Flufftail	VU			✓					
White-backed Night-Heron	VU								✓
African Broadbill	VU					✓			
Bat Hawk	EN		✓						
Bearded Vulture	CR			✓					
Blue Swallow	CR			✓					
Green Barbet	EN					✓			
Mountain Pipit	NT			✓					
Spotted Ground-Thrush	EN					✓			
White-headed Vulture	CR		✓						
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened									

4.2.6.6 Freshwater ecosystems

Rivers within the proposed Phase 7 gas pipeline corridor flow through a number of ecoregions, notably the South Eastern Uplands, but also the Eastern Uplands, North Eastern Coastal Belt and Eastern Coastal Belt. The rivers are predominantly perennial/permanently-flowing (87%), and major river systems include the Groot-Kei, Mbhashe, Mzimvubu, Mzimkhulu, Mkomazi, uMngeni, Thukela, Mhlatuze, and Mfolozi Rivers (Figure 23). Less than 30% of the rivers are considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). More than 60% of the rivers are in a natural/good condition, 8% are in a fair condition, while 30% are in a poor/very poor condition.

Wetland habitats within this corridor occupy a large proportion of the corridor (~12%) comprising up to 155 different wetland types dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the Subescarpment Grassland region. The supports three Ramsar wetlands, including parts of the St. Lucia System, located in the north eastern corner of the corridor, as well as uMgeni Vlei Nature Reserve (958 ha) and Ntsikeni Nature Reserve (9,200 ha). A moderate proportion (~20%) of the wetlands in the corridor are characterised as NFEPA wetland. A very small proportion (3%) of the wetland habitats are associated with the Endangered Lowveld wetland vegetation (Group 10), while 56% occur within the Vulnerable Lowveld wetland vegetation (Group 11).

Approximately 65% of the Phase 7 Corridor, which stretches across most of the Eastern Cape and KwaZulu-Natal, comprises land that is largely natural, with a fairly large area (6%) degraded by existing land management practices. A small proportion (4%) of the area is protected by a number of small conservation areas, but also larger ones (e.g. Addo Elephant National Park, Hluhluwe-Imfolozi Game Reserve and Isimangaliso Wetland Park). The remaining area is transformed by cultivation (19%), urbanisation and rural settlements (5%) and plantations (5%).

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 7 pipeline corridor include:

- Extensive urbanisation causing transformation and degradation of freshwater ecosystems, notably in the greater Durban area, which continues to expand down? along the coast, as well as Pietermaritzburg and a within numerous of coastal towns south of Durban;
- Water quality impacts and pollution associated with urban areas (e.g. domestic and industrial effluents, failing water treatment infrastructure) and agriculture (e.g. pesticides, herbicides and fertiliser applications), all of which are contaminating receiving aquatic environments;

- Very high (unacceptable) faecal contamination in the uMngeni, Mlazi and Mdloti Rivers, as well as numerous rivers draining the eThekwini Metropolitan and Pietermaritzburg;
- Stormwater runoff from hardened surfaces and sewer reticulation in and around urban areas;
- Altered flows and water quality caused by large impoundments (e.g. Midmar, Albert Falls, Inanda, Goedertrouw and Umtata Dams), inter-basin transfers, which severely affect downstream aquatic systems (e.g. channel characteristics, riparian vegetation, thermal regimes, instream and floodplain habitats), as well as upstream/downstream river continuity;
- Illegal sand mining, as well as and other mining activities, particularly along coastal areas;
- Transformation and alteration of watercourses through canals, diversion structures, weirs, road crossings, flood control berms;
- Cultivation of wetlands and floodplains (notably sugarcane), especially along the coastal region;
- Abstraction of water for large-scale irrigation, as well as streamflow reduction associated with extensive plantations;
- Erosion and degradation, especially linked to overgrazing, which is notable in the more rural areas; and
- Excessive infestation of numerous IAPs, particularly along rivers and around wetlands, as well as instream (e.g. Water Hyacinth).

Box 18: Red Data aquatic biota likely to be encountered in Phase 7

Of the ten species of Red Listed Odonata that are known to occur within the corridor, three are listed as Endangered (i.e. *Chlorolestes apricans, Diplacodes pumila* and *Metacnemis valida*), while five are considered Vulnerable and two near threatened. The corridor also supports up to 15 Red Listed fish, of which seven are Endangered and three are Vulnerable, two are near threatened and three are Date Deficient. Of the 9 Red Listed amphibians that occur within the corridor, one is Critically Endangered (i.e. *Vandijkophrynus amatolicus*), while five are Endangered, one is Vulnerable and two are Near Threatened. *Vandijkophrynus amatolicus* has a severely fragmented population and is known only from the Winterberg and Amathole Mountains, centred on Hogsback. The species has a very narrow EOO is 98 km^2, and there is ongoing decline in the extent and quality of habitat (IUCN, 2017) This corridor supports the highest number of Red Listed reptiles, including two Vulnerable, one Near Threatened and one Data Deficient species. The corridor also supports a high diversity of Red Listed mammals (up to 8 species), including three that are Vulnerable and five that are Near Threatened. This corridor supports a high diversity of (up to 39) Red Listed plants. Of these, two are Critically Endangered (i.e. *Isoetes wormaldii* and *Kniphofia leucocephala*), while six are Endangered, 17 are Vulnerable, 11 are Near Threatened, two are Data Deficient and one is rare.

4.2.6.7 Estuaries

In total 155 estuaries are situated within the Phase 7 corridor, with a combined estuarine habitat area of about 55 100 ha (Figure 23 and Figure 25). Most of the estuaries in the region are not particularly long and extend less than 10 km into the corridor, with the exception of St Lucia (< 30km), Sundays (<25 km), Bushmans (<20 km), Keiskamma (<20 km), Kowie (<15 km), Great Fish (<15 km), Tyolomnqa (<15 km), Great Kei (<15 km), Thukela (<15 km), Mhlathuze (<15 km), Mfolozi (<15 km), Coega (<10 km), Kariega, (<10 km), Kleinemond Wes (<10 km), Mgwalana (<10 km), Bira (<10 km), Nahoon (<10 km), Mbashe (<10 km), Mtamvuna (<10 km), Mzimkulu (<10 km), Matigulu/Nyoni (<10 km), Mlalazi (<10 km), Richards Bay(<10 km) and Nhlabane (<10 km).

Seventy-nine estuaries in this corridor are in an excellent or good condition (Categories A to B). These systems vary from very small to large permanently open systems which are highly sensitive to change as they will degrade from their near pristine state relatively easily.

A total of 14 estuaries in this corridor are of very high biodiversity importance, ranking with the top estuaries in South Africa, namely Kariega, Kowie, Great Fish, Mpekweni, Mtati, Mgwalana, Keiskamma, Great Kei, Mbashe, Mngazana, Mlalazi, Mhlathuze, Mfolozi and St Lucia estuaries (Turpie et al., 2002; Turpie and Clark, 2009). In addition, 37 systems are also rated as important from a biodiversity perspective.

Sixty-one estuaries in the corridor are identified as national conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012). In addition, 53 estuaries are identified as important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017).

From a habitat diversity and abundance perspective 96 estuaries are considered important as they support sensitive estuarine habitats such as mangroves, swamp forest or saltmarsh (intertidal and supratidal).

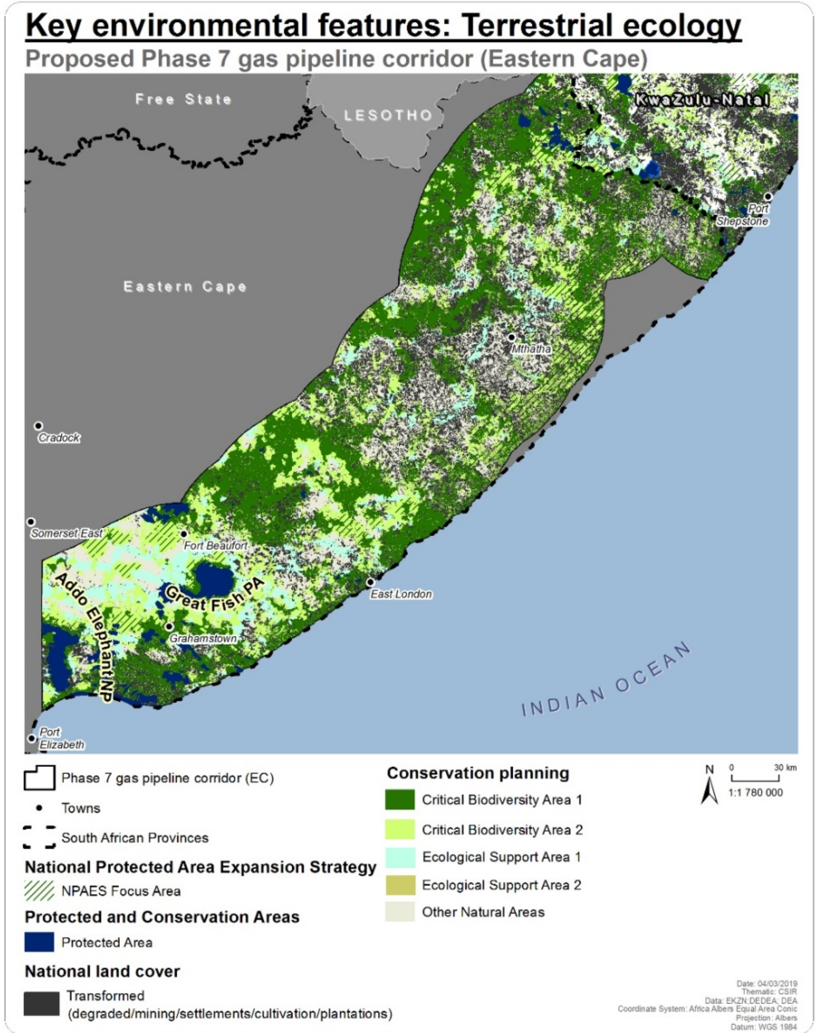


Figure 22: Key environmental features of the proposed Phase 7 gas pipeline corridor (Eastern Cape).

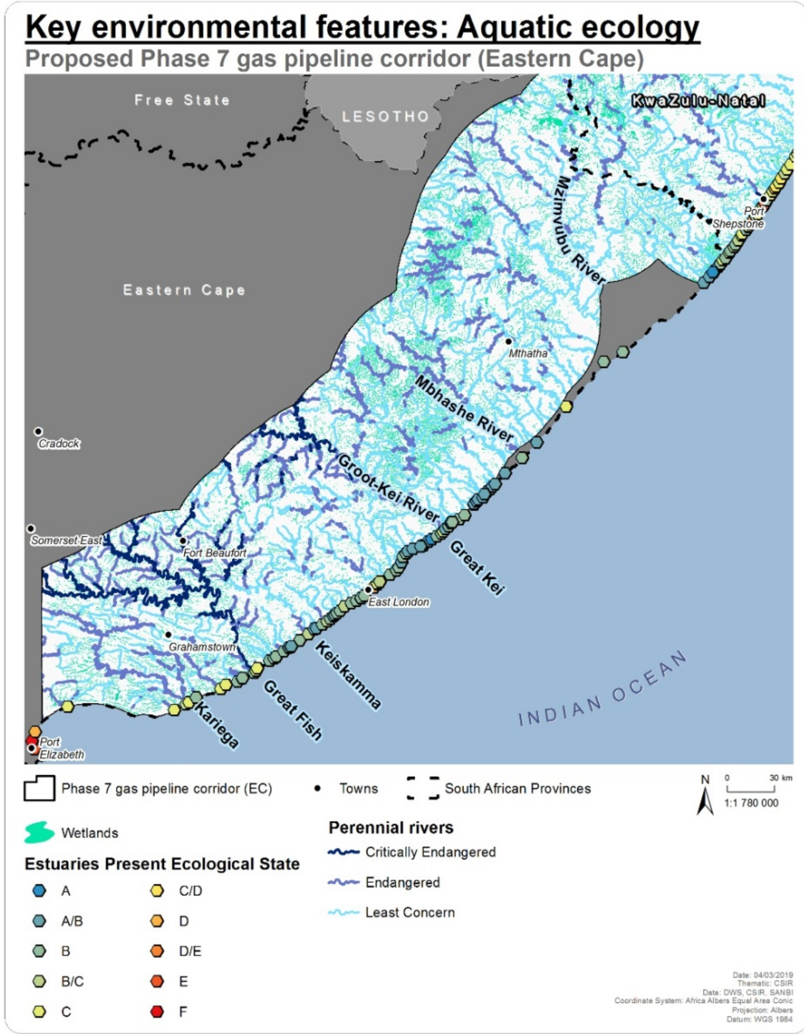


Figure 23: Key aquatic ecosystem features of the proposed Phase 7 gas pipeline corridor (Eastern Cape).

Note: Finer scale features may not be visible at the current map extent

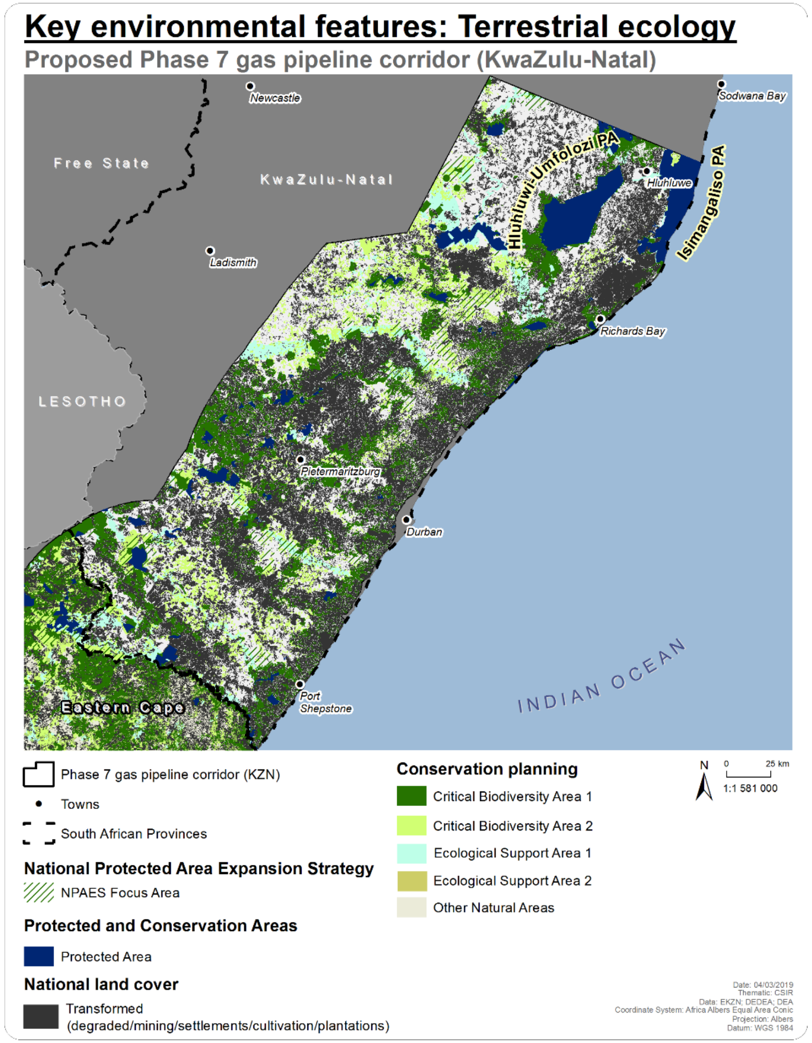


Figure 24: Key environmental features of the proposed Phase 7 gas pipeline corridor (KwaZulu-Natal).

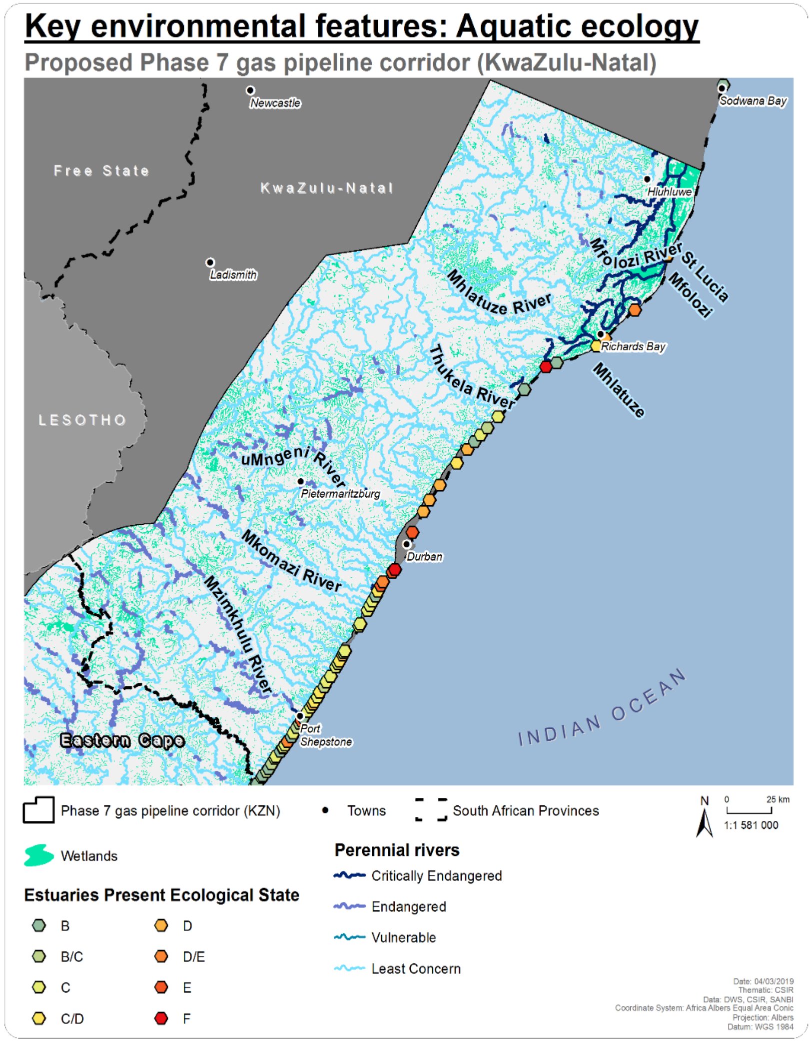


Figure 25: Key aquatic ecosystem features of the proposed Phase 7 gas pipeline corridor (KwaZulu-Natal).

Note: Finer scale features may not be visible at the current map extent

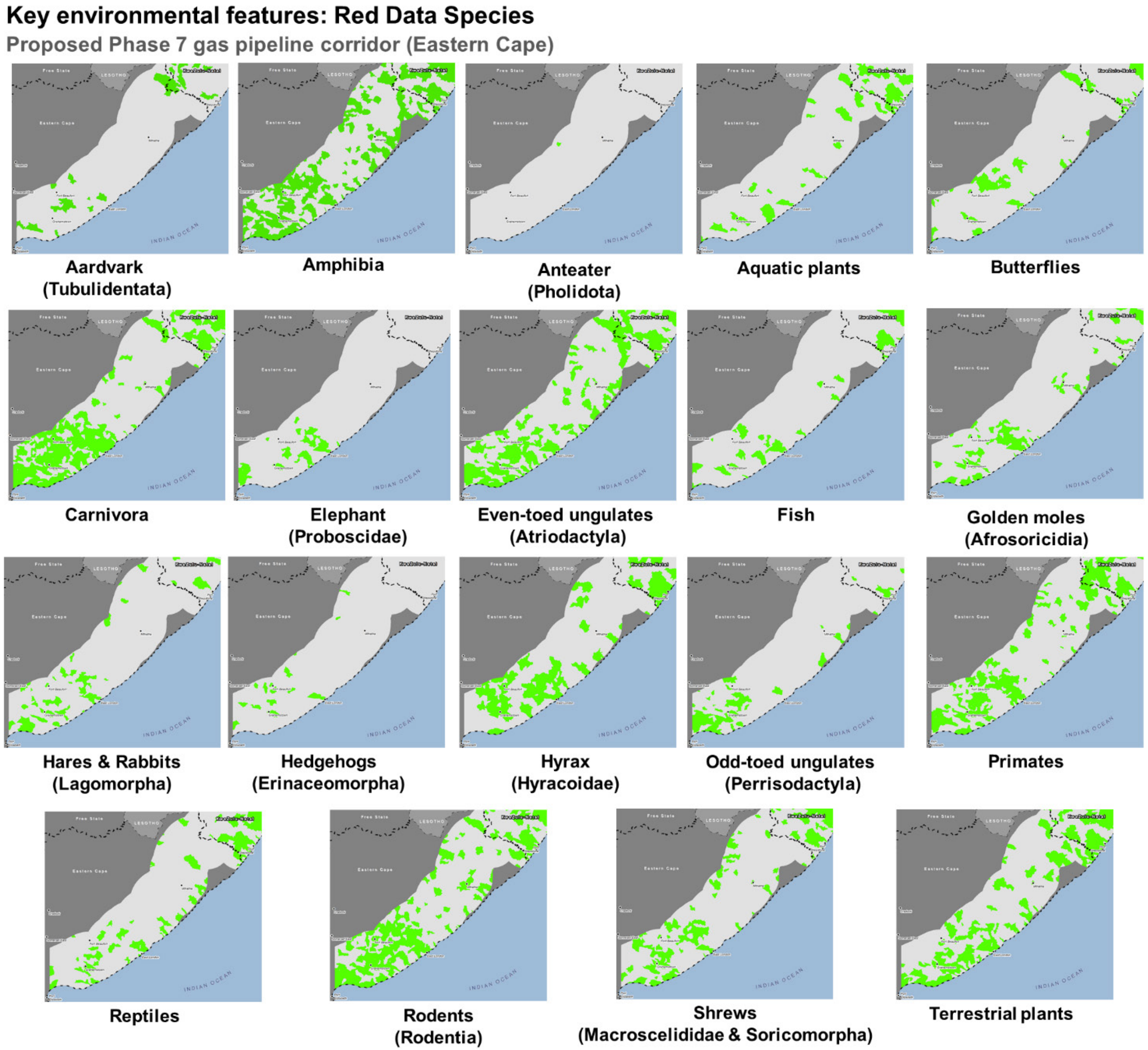


Figure 26: Distribution of recorded Red Data species in the proposed Phase 7 gas pipeline corridor (at quinary catchment scale) (Eastern Cape).

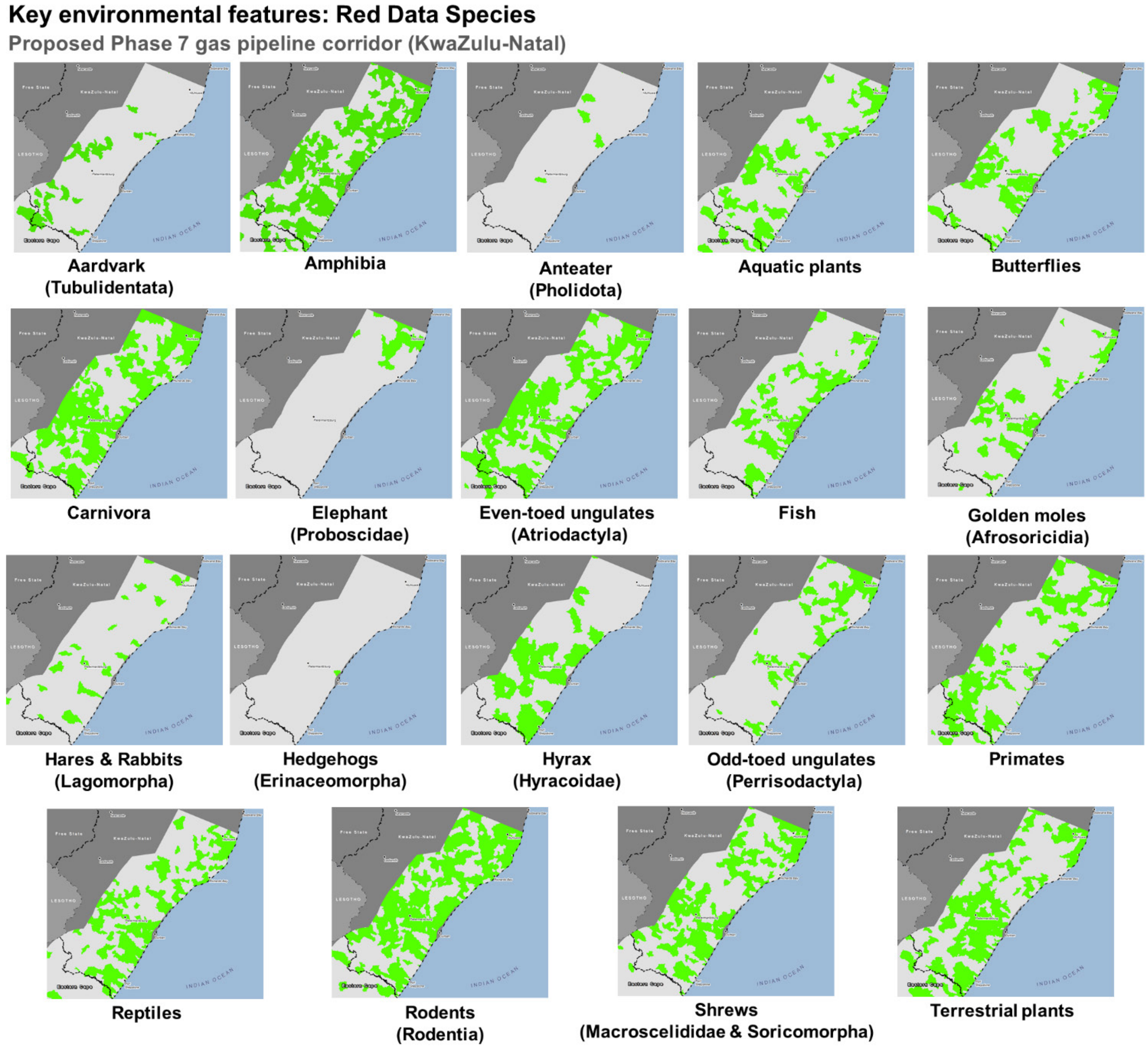


Figure 27: Distribution of recorded Red Data species in the proposed Phase 7 gas pipeline corridor (at quinary catchment scale) (KwaZulu-Natal).

4.2.7 Phase 4

The proposed Phase 4 gas pipeline corridor occupies the eastern coast of South Africa, from Hluhluwe to the Mozambique border (Figure 28).

The climate is subtropical with hot and humid summers and mild winters.

4.2.7.1 Savanna

With the exception of the coastal strip, most of the proposed Phase 4 gas pipeline corridor is Savanna vegetation, and most is in the Maputaland centre of plant endemism. This region has a number of important private and provincial nature reserves that create pinch points. These include Ndumu, Tembe, Mkuzi and the Isimangaliso wetland park (though this is predominantly not Savanna or Grassland).

4.2.7.2 Indian Ocean Coastal Belt

The IOCB within this corridor is made up of the Maputaland Coastal Belt (CB 1) and Maputaland Wooded Grassland (CB 2). Subtropical Freshwater Wetlands and Lowveld Riverine Forest are two significant azonal vegetation types found within this section of the IOCB.

A prominent feature is the Isimangaliso Wetland Park, a significant protected area, Ramsar Site and World Heritage Site. This extends from Maphelane, north of Richards Bay to Kosi Bay and extends inland to the Mkuze Nature Reserve. The bulk of the Isimangaliso Wetland Park, from Lake St. Lucia to Kosi Bay falls within this corridor phase.

4.2.7.3 Birds and bats

Bat species of Conservation Importance likely to be encountered in the proposed Phase 4 gas corridor include:

- Short-eared trident bat
- Damara woolly bat
- Rendall's serotine
- Large-eared free-tailed bat
- Blasius's horseshoe bat
- Swinny's horseshoe bat
- Dent's horseshoe bat
- Light-winged lesser house bat
- Schreber's yellow bat
- Egyptian tomb bat

Table 16 presents red data species that occur in the biomes present in the proposed Phase 4 gas pipeline corridor.

Table 16: Red Data bird species likely to be encountered in the proposed Phase 4 gas corridor.

Species	Status	Biome				
		Savanna	Grassland	Forest	Indian Ocean Coastal Belt	Azonal
Abdim's Stork	NT		✓			✓
African Broadbill	VU			✓		
African Crowned Eagle	VU			✓		
African Finfoot	VU					✓
African Grass-Owl	VU		✓			✓
African Marsh-Harrier	EN	✓	✓		✓	✓
African Pygmy-Goose	VU					✓
African Rock Pipit	NT	✓	✓			
Bateleur	EN	✓				
Black Harrier	EN		✓			
Black Stork	VU	✓	✓		✓	✓
Black-rumped Buttonquail	VU	✓			✓	
Black-winged Pratincole	NT		✓			
Blue Crane	NT		✓		✓	✓
Botha's Lark	EN		✓			
Burchell's Courser	VU		✓			
Bush Blackcap	VU			✓		
Cape Vulture	EN	✓				
Caspian Tern	VU					✓
Chestnut-banded Plover	NT					✓
Denham's Bustard	VU		✓		✓	
Eastern Bronze-naped Pigeon	EN			✓		
Eurasian Curlew	NT					✓
European Roller	NT	✓			✓	
Great White Pelican	VU					✓
Greater Flamingo	NT				✓	✓
Greater Painted-snipe	NT					✓
Grey Crowned Crane	EN		✓		✓	✓
Half-collared Kingfisher	NT					✓
Hooded Vulture	CR	✓				
Lanner Falcon	VU	✓	✓	✓	✓	✓
Lappet-faced Vulture	EN	✓				
Lemon-breasted Canary	NT				✓	
Lesser Flamingo	NT				✓	✓
Lesser Jacana	VU					✓
Maccoa Duck	NT					✓
Mangrove Kingfisher	EN				✓	
Marabou Stork	NT	✓			✓	✓
Martial Eagle	EN	✓	✓		✓	
Neergaard's Sunbird	VU				✓	
Orange Ground-Thrush	NT			✓		
Pallid Harrier	NT		✓		✓	
Pel's Fishing-Owl	EN					✓
Pink-backed Pelican	VU					✓
Red-footed Falcon	NT		✓			

Species	Status	Biome				
		Savanna	Grassland	Forest	Indian Ocean Coastal Belt	Azonal
Rosy-throated Longclaw	NT				✓	
Rudd's Lark	EN		✓			
Saddle-billed Stork	EN					✓
Secretary bird	NT	✓	✓			
Short-tailed Pipit	VU		✓			
Southern Bald Ibis	VU		✓			
Southern Banded Snake-Eagle	CR				✓	
Southern Ground-Hornbill	EN	✓			✓	
Swamp Nightjar	VU				✓	
Tawny Eagle	EN	✓				
Verreaux's Eagle	VU	✓	✓			
Wattled Crane	CR		✓			✓
White-backed Vulture	CR	✓				
White-bellied Korhaan	VU	✓	✓		✓	
White-headed Vulture	CR	✓				
Yellow-billed Stork	EN					✓
Yellow-breasted Pipit	VU		✓			
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened						

4.2.7.4 Freshwater ecosystems

Rivers within the proposed Phase 4 gas pipeline corridor largely form part of the Lowveld and Natal Coastal Plain ecoregions, with a smaller number of river draining off from the Lebombo Uplands. The rivers are either perennial/permanently-flowing (approximately 62%) or ephemeral/non-perennial (approximately 38%). Major river systems include the Phongolo and Mkuze Rivers (Figure 29). Less than 30% of the rivers are considered to be Threatened (i.e. CR, EN and VU). Almost half of the rivers are in a natural/good condition, 36% are in a fair condition, while 16% are in a poor/very poor condition.

Wetland habitats within this corridor occupy a small proportion of the corridor (~4%) comprising up to 47 different wetland types, dominated by floodplain wetlands, particularly within the Indian Ocean Coastal Belt region. The corridor boasts four Ramsar wetlands covering up to 185 000 ha, namely Ndumo Game Reserve, Kosi Bay, Lake Sibaya, and the St. Lucia System. A significant proportion (~51%) of the wetlands in the corridor are characterised as NFEPA wetlands. Most notable is that 65% of the wetland habitats within the corridor are associated with the Endangered Lowveld wetland vegetation (Group 10).

Approximately 72% of the Phase 4 Corridor comprises land that is largely natural, with a significant proportion of the area protected by existing conservation areas (e.g. Isimangaliso Wetland Park, Tembe Elephant Park, Ndumo Game Reserve, Ithala Game Reserve). The remaining area has been largely degraded (~15%) or is transformed by cultivation, plantations, urbanisation and rural settlements. Impacts on freshwater ecosystems caused by land use activities vary across the corridor, however, combined effect has had a significant effect on freshwater ecosystem functioning and integrity.

Box 19: Red Data aquatic biota likely to be encountered in Phase 4

The only Critically Endangered Odonata for South Africa occurs along the Phongolo River in the north-western corner of the Phase 4 Corridor, namely *Chlorocypha consueta*. The Endangered *Diplacodes pumila* also occurs in the corridor along with six species listed as Vulnerable and four species listed as Near Threatened. One Endangered fish, *Silhouettea sibayi* occurs in coastal rivers that flow through the corridor. The corridor also supports two vulnerable species, three Near Threatened and two Data Deficient species of fish. The only Red Listed amphibians that occur within the corridor include the Endangered *Hyperolius pickersgilli* and the Near Threatened *Hemisus guttatus*. The corridor supports two Red Listed reptiles, namely the Hinged Terrapin *Pelusios rhodesianus*, (Vulnerable) which is known from a few water bodies along the coastal region – and *Macrelaps microlepidotus* (Near Threatened), which is found in forests and coastal bush. Up to eight Red Listed mammals occur within the Phase 4 Corridor, including five rodents/shrews, as well as Spotted-necked Otter *Hydrictis maculicollis* (Vulnerable) and Cape Otter *Aonyx capensis* (Near Threatened). This corridor supports a moderate diversity of (up to 24) Red Listed plants, including two that are Endangered (i.e. *Albizia suluensis* and *Mondia whitei*). The majority of the Red Listed plants occurring with the corridor are either Vulnerable (12 species) or Near Threatened (9 species), while one is considered rare.

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 4 pipeline corridor include:

- Extensive urbanisation causing transformation and degradation of freshwater ecosystems, notably in the greater Durban region, which continues to expand up along the coast, as well as Richards Bay;
- Water quality impacts and pollution associated with urban areas (e.g. domestic and industrial effluents, failing water treatment infrastructure) and agriculture (e.g. pesticides, herbicides and fertiliser applications) all of which are contaminating receiving aquatic environments;
- Flow alteration caused by large impoundments (e.g. Pongolapoort Dam), inter-basin transfers, waste water treatment works return flows, and stormwater runoff from hardened surfaces and sewer reticulation, all of which affect downstream aquatic systems (e.g. channel characteristics, riparian vegetation, and instream and floodplain habitats) as well as river continuity;
- Cultivation of wetlands and floodplains (notably sugarcane), especially along the coastal region;
- Illegal sand mining, as well as and other mining activities, particularly in the Richards Bay region;
- Transformation and alteration of watercourses through canals, diversion structures, weirs, road crossings, flood control berms;
- Abstraction of water for irrigation and extensive forestry, which is having a significant impact on groundwater and linked wetlands in the Maputaland region;
- Erosion and degradation, especially linked to overgrazing, which is notable in the more rural areas; and
- Excessive infestation of numerous IAPs, particularly along rivers and around wetlands, as well as instream (e.g. Water Hyacinth).

4.2.7.5 Estuaries

Three estuaries are situated within the Phase 4 corridor, with a combined estuarine habitat area of about 46 200 ha. Note there is overlap with St Lucia lakes system in Phase 7 corridor. Two of the systems in the corridor are very large, with St Lucia extending about 30 km and Kosi extending about 10 km in land (Figure 29). The Mgobezeleni extends less than 10 km inland.

The Mgobezeleni and Kosi estuaries are in an excellent to good condition (Categories A to B). These systems are highly sensitive to change as they will degrade from their near pristine state relatively easily. The St Lucia and Kosi estuarine lake systems are of very high biodiversity importance (Turpie et al., 2002; Turpie and Clark, 2009). All three estuaries in the corridor, St Lucia, Mgobezeleni and Kosi, are identified as national conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012). St Lucia and Kosi are important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). From a habitat diversity and abundance perspective the St Lucia, Mgobezeleni and Kosi estuaries are all considered important as they support sensitive estuarine habitats such as mangroves, swamp forest and saltmarsh.

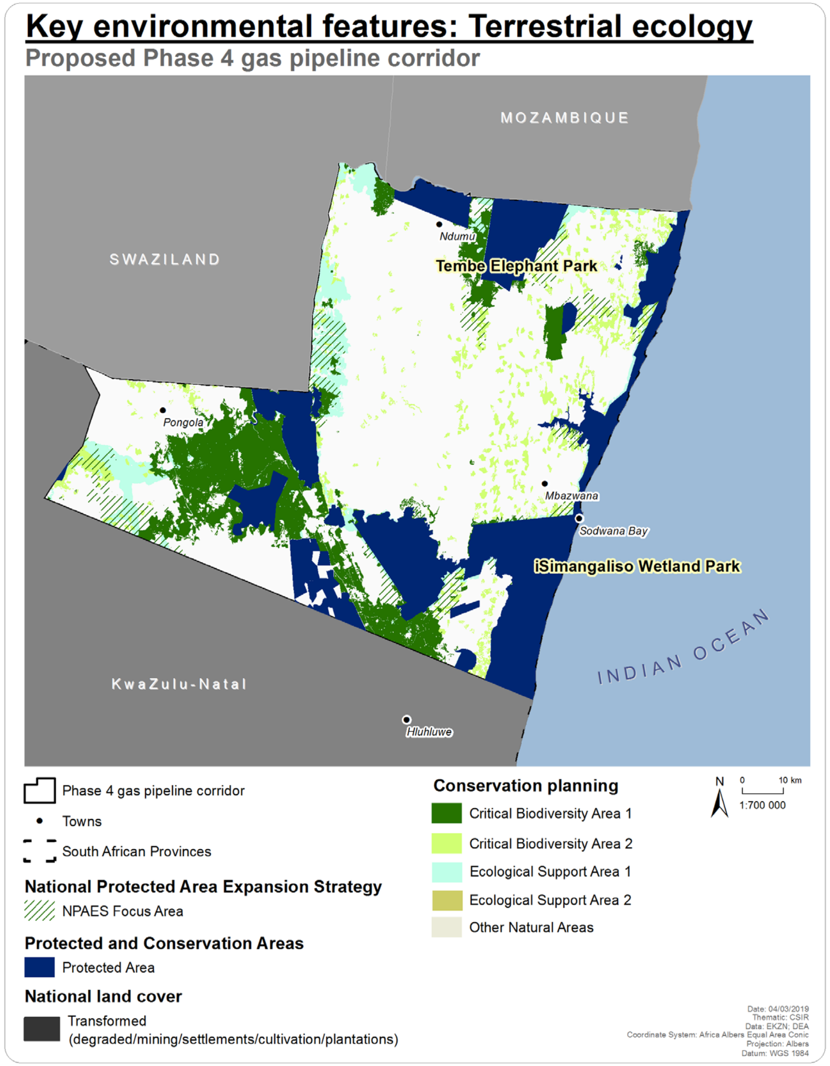


Figure 28: Key environmental features of the proposed Phase 4 gas pipeline corridor.

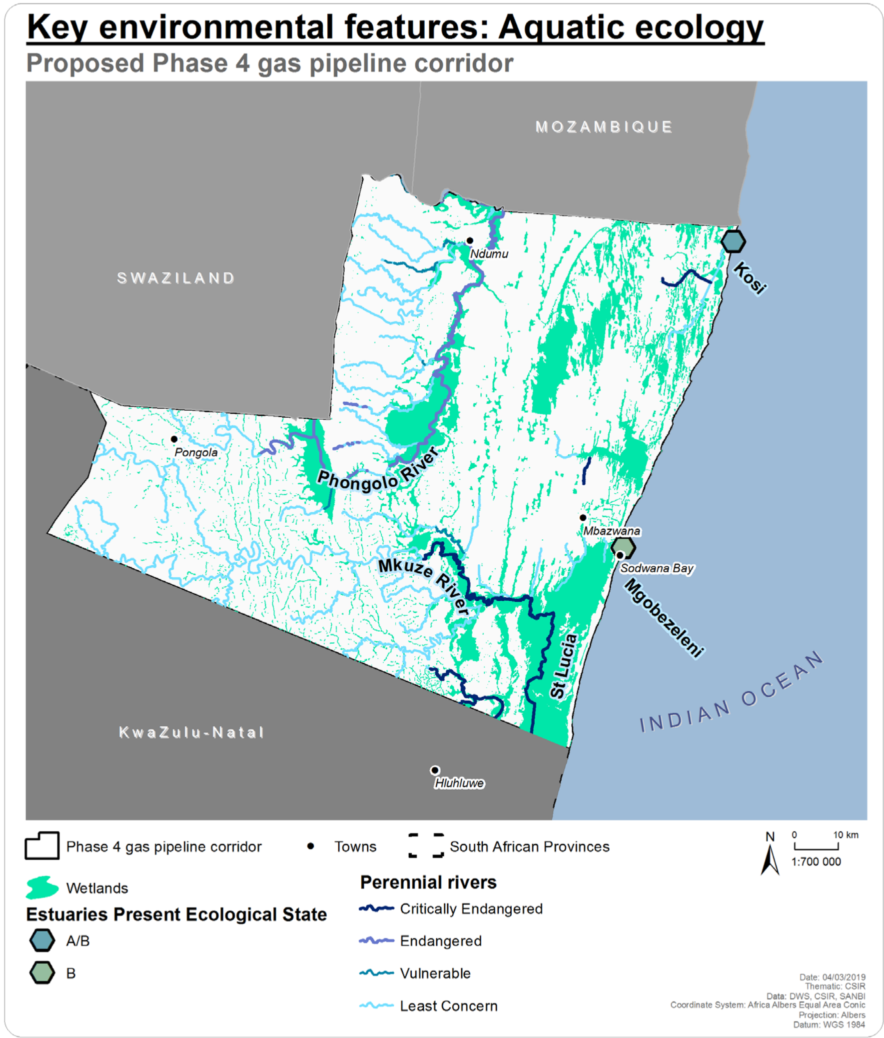


Figure 29: Key aquatic ecosystem features of the proposed Phase 4 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent

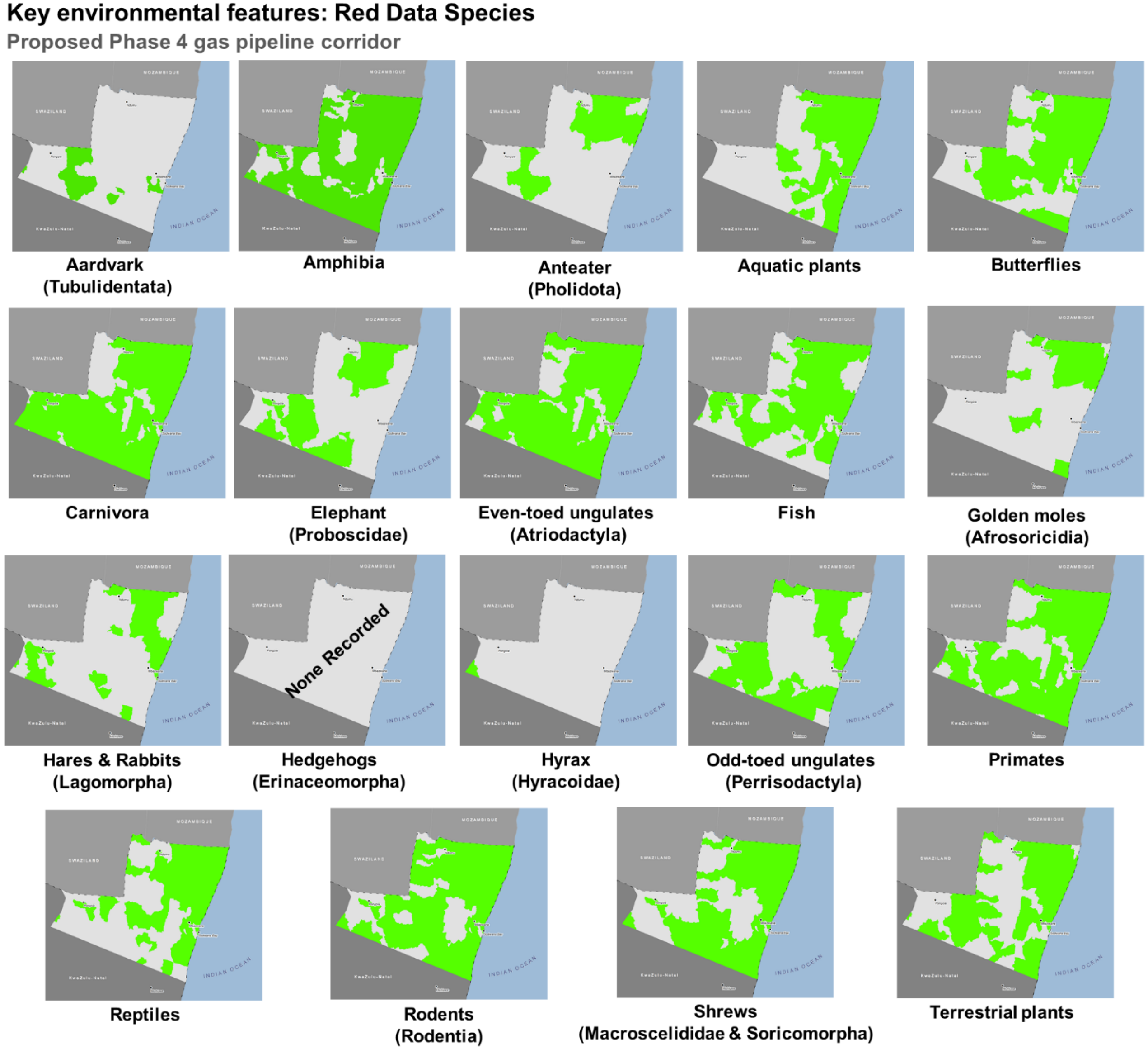


Figure 30: Distribution of recorded Red Data species in the proposed Phase 4 gas pipeline corridor (at quinary catchment scale).

4.2.8 Phase 3

4.2.8.1 *Grassland and Savanna*

With the exception of the coastal strip this corridor falls almost exclusively within Savanna and Grassland regions, with a few embedded forest patches. There are two key pinch points, the one relates to Savanna biodiversity and a string of game reserves centred on the Hluhluwe–Imfolozi Reserve and Nduna reserve in Zululand and the related Maputaland centre of plant endemism. The second is Grassland areas as the corridor cuts through the Drakensberg mountains. In addition, the northern half of Gauteng is a complex area due to parallel mountain ranges, and the area being an ecotone between the Highveld Grasslands and Savanna bushland regions.

4.2.8.2 *Birds and bats*

Bat species of Conservation Importance likely to be encountered in the proposed Phase 3 gas corridor include:

- Short-eared trident bat
- Damara woolly bat
- Rendall's serotine
- Greater long-fingered bat
- Large-eared free-tailed bat
- Blasius's horseshoe bat
- Swinny's horseshoe bat
- Dent's horseshoe bat
- Schreber's yellow bat

Table 17 presents red data species that occur in the biomes present in the proposed Phase 3 gas pipeline corridor.

Table 17: Red Data bird species likely to be encountered in the proposed Phase 3 gas corridor.

Species	Status	Biome			
		Savanna	Grassland	Forest	Azonal
African Marsh-Harrier	EN	✓	✓		✓
Abdim's Stork	NT	✓	✓		✓
Black Harrier	EN		✓		
Black Stork	VU		✓		✓
Blue Crane	NT		✓		✓
Caspian Tern	VU				✓
European Roller	NT	✓			
Greater Flamingo	NT	✓	✓		✓
Black-rumped Buttonquail	VU		✓		
Black-winged Pratincole	NT	✓	✓		✓
Botha's Lark	EN		✓		
Lanner Falcon	VU	✓	✓	✓	✓
Lesser Flamingo	NT	✓	✓		✓
Bush Blackcap	VU			✓	
Maccoa Duck	NT				✓
Martial Eagle	EN	✓	✓	✓	✓
Red-footed Falcon	NT		✓		

Species	Status	Biome			
		Savanna	Grassland	Forest	Azonal
Secretary bird	NT	✓	✓		
Lappet-faced Vulture	EN	✓			
Verreaux's Eagle	VU	✓	✓		
Marabou Stork	NT	✓			✓
Denham's Bustard	VU		✓		
Orange Ground-Thrush	NT			✓	
Pink-backed Pelican	VU				✓
Half-collared Kingfisher	NT				✓
African Rock Pipit	NT	✓	✓		
Eurasian Curlew	NT				✓
Greater Painted-snipe	NT				✓
Rudd's Lark	EN		✓		
Saddle-billed Stork	EN				✓
Short-tailed Pipit	VU		✓		
Southern Bald Ibis	VU		✓		
Burchell's Courser	VU		✓		
Cape Vulture	EN	✓	✓		
Chestnut-banded Plover	NT				✓
Southern Ground-Hornbill	EN	✓			
Tawny Eagle	EN	✓			
Wattled Crane	CR		✓		✓
African Grass-Owl	VU		✓		✓
Grey Crowned Crane	EN		✓		✓
Pallid Harrier	NT		✓		
White-bellied Korhaan	VU	✓	✓		
White-backed Vulture	CR	✓			
Yellow-billed Stork	EN				✓
Yellow-breasted Pipit	VU		✓		
Eastern Bronze-naped Pigeon	EN			✓	
Yellow-throated Sandgrouse	NT	✓	✓		
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened					

4.2.8.3 Freshwater ecosystems

Rivers within the proposed Phase 3 gas pipeline corridor are predominantly perennial/permanently-flowing (81%), and drain a number of ecoregions, notably the Highveld ecoregion. Major river systems include the Vaal, Klip and Buffels Rivers (Figure 32). A significant (approximately 71%) proportion of the rivers that drain the corridor are Critically Endangered. Less than 20% of the rivers are considered to be in a natural/good condition, while 50% are in a fair condition, 23% are in a poor condition and 10% are in either a very poor or critical condition.

Wetland habitats within this corridor occupy a significant proportion of the corridor (~17%) comprising up to 127 different wetland types, dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the Mesic Highveld Grassland and Sub-escarpment Grassland regions. The corridor supports two Ramsar wetlands, namely Seekoeivlei Nature Reserve (4,754 ha) and the Blesbokspruit (1,858 ha). A small proportion (~8%) of the wetlands in the corridor are characterised as NFEPA wetland. Most notable is that more than 50% of the wetland habitats within the corridor are associated with the Critically Endangered Mesic Highveld Grasslands (Groups 2, 3 and 4).

Approximately 62% of the Phase 3 Corridor comprises land that is largely natural with a further 2% degraded. A very small proportion (2%) of the corridor is protected by a number of small conservation areas, but also larger ones such as the Cradle of Humankind World Heritage Site. A significant area has been transformed by cultivation (~29%), urbanisation in and around Johannesburg (5%), plantations (2%), as well as mining (1%).

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 3 pipeline corridor include:

- Very high (unacceptable) faecal pollution in rivers flowing through Gauteng (e.g. the Jukskei River), largely due to discharge of untreated or poorly treated effluent from malfunctioning/overloaded waste water treatment works, as well as surcharging manholes;
- Unsustainable and rapid urbanisation has resulted in the pollution of most river systems within this region. Pollution of the Vaal itself reached crisis point in January 2018 as a result of the acid mine drainage effluent and raw or partially treated sewage being pumped into the system;
- A high concentration of mining and industrial activity in this area places enormous pressure on the aquatic systems and has caused contamination of these systems though chemical leaching;
- Transformation and damage of wetlands e.g. Klip River wetland, through illegal dumping, high levels of urbanization, poor infrastructure and wastewater treatment works, and erosion through the high volumes of wastewater that flow through the wetland;
- Over-abstraction of water, and various impoundments (construction of dams e.g. the Vaal in particular), place huge pressure on the flow of rivers in this region;
- The effects of agriculture are evident and contribute to the pollution of freshwater resources as a result of run-off of pesticides and fertilizers.

Box 20: Red Data aquatic biota likely to be encountered in Phase 3

Only one notable species of Odonata, considered as vulnerable (i.e. *Lestes dissimulans*) occurs in the corridor. Of the 12 Red Listed fish species that occur within the corridor, one is Critically Endangered (i.e. *Pseudobarbus burchelli*), which is found in the Breede and Tradouw river systems, while two are Endangered, two are Vulnerable, five are Near Threatened and two are Data Deficient. The only Red Listed amphibian that occurs within the corridor includes the Near Threatened *Hemisus guttatus*. There are no Red Listed reptiles that are known to occur within the corridor. The corridor supports the highest number of Red Listed mammals (up to 9 species) of which four are Vulnerable and five are Near Threated. This corridor supports a low diversity of (up to 8) Red Listed plants, but which includes two Endangered species (i.e. *Disa zuluensis* and *Kniphofia flammula*). Other Red Listed species include three Vulnerable and three Near Threatened species.

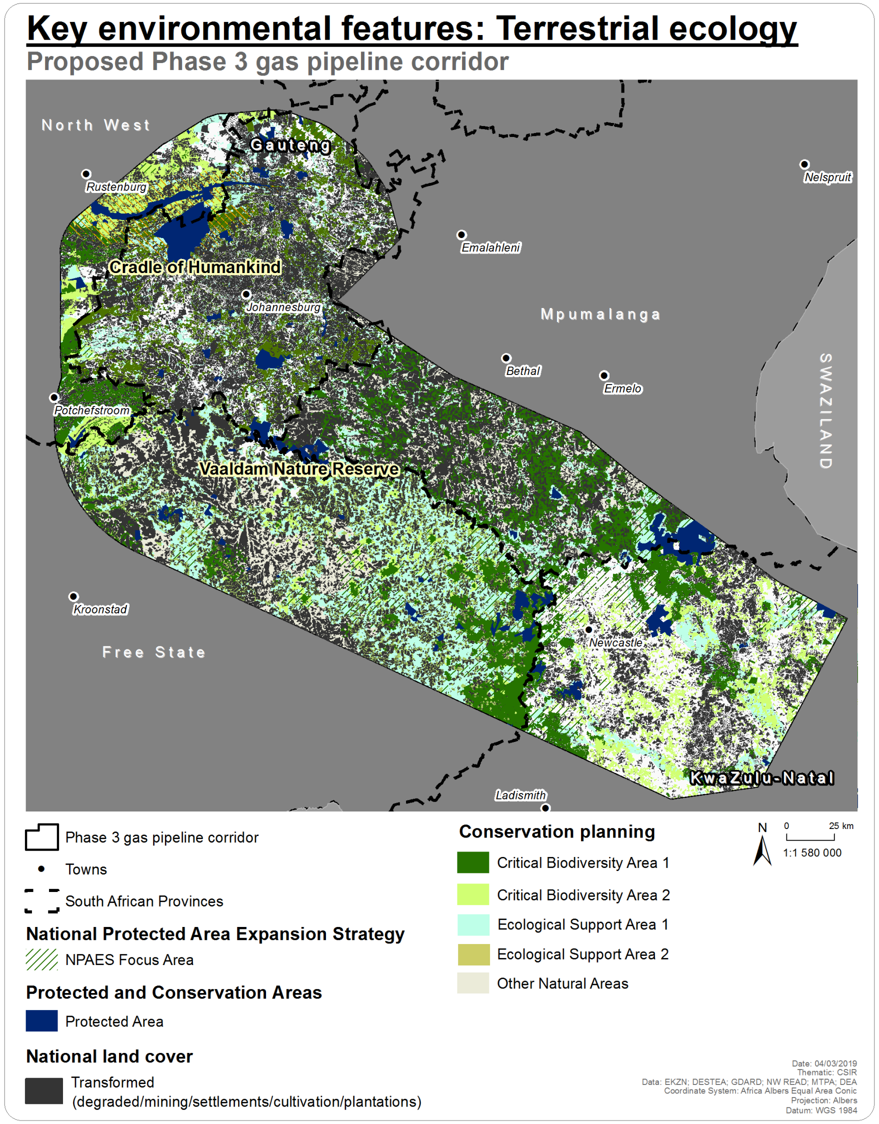


Figure 31: Key environmental features of the proposed Phase 3 gas pipeline corridor.

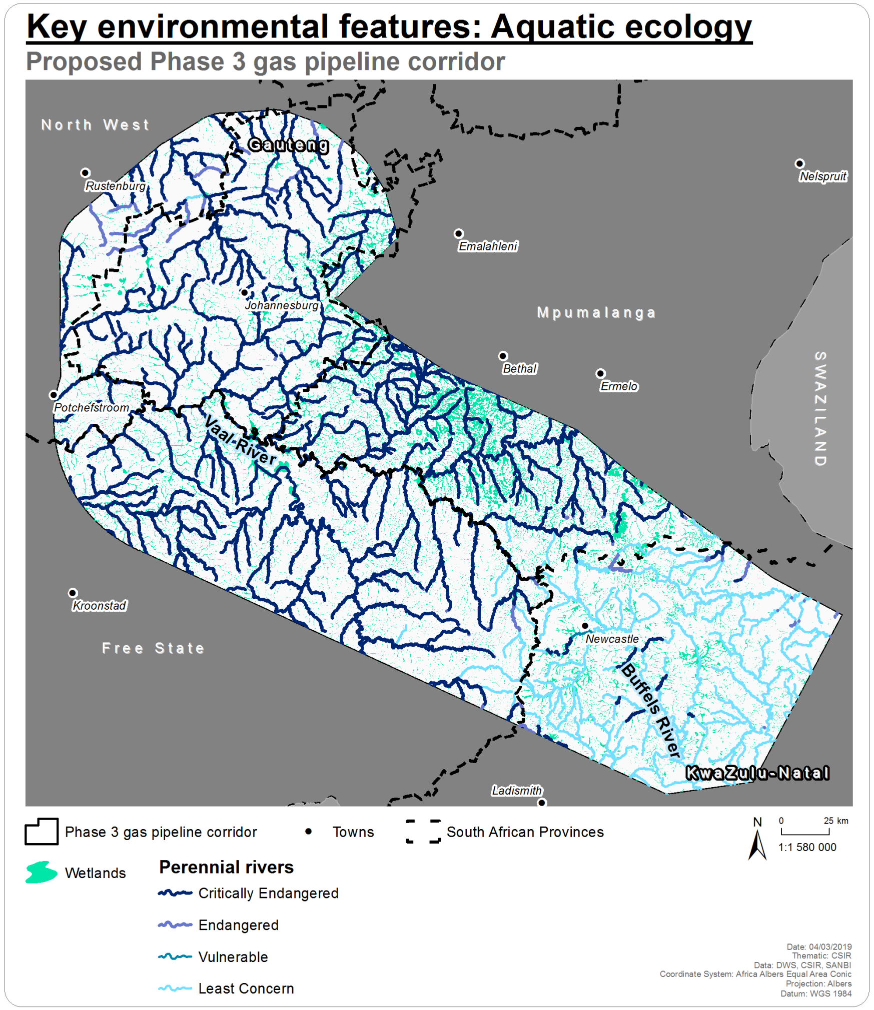


Figure 32: Key aquatic ecosystem features of the proposed Phase 3 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent.

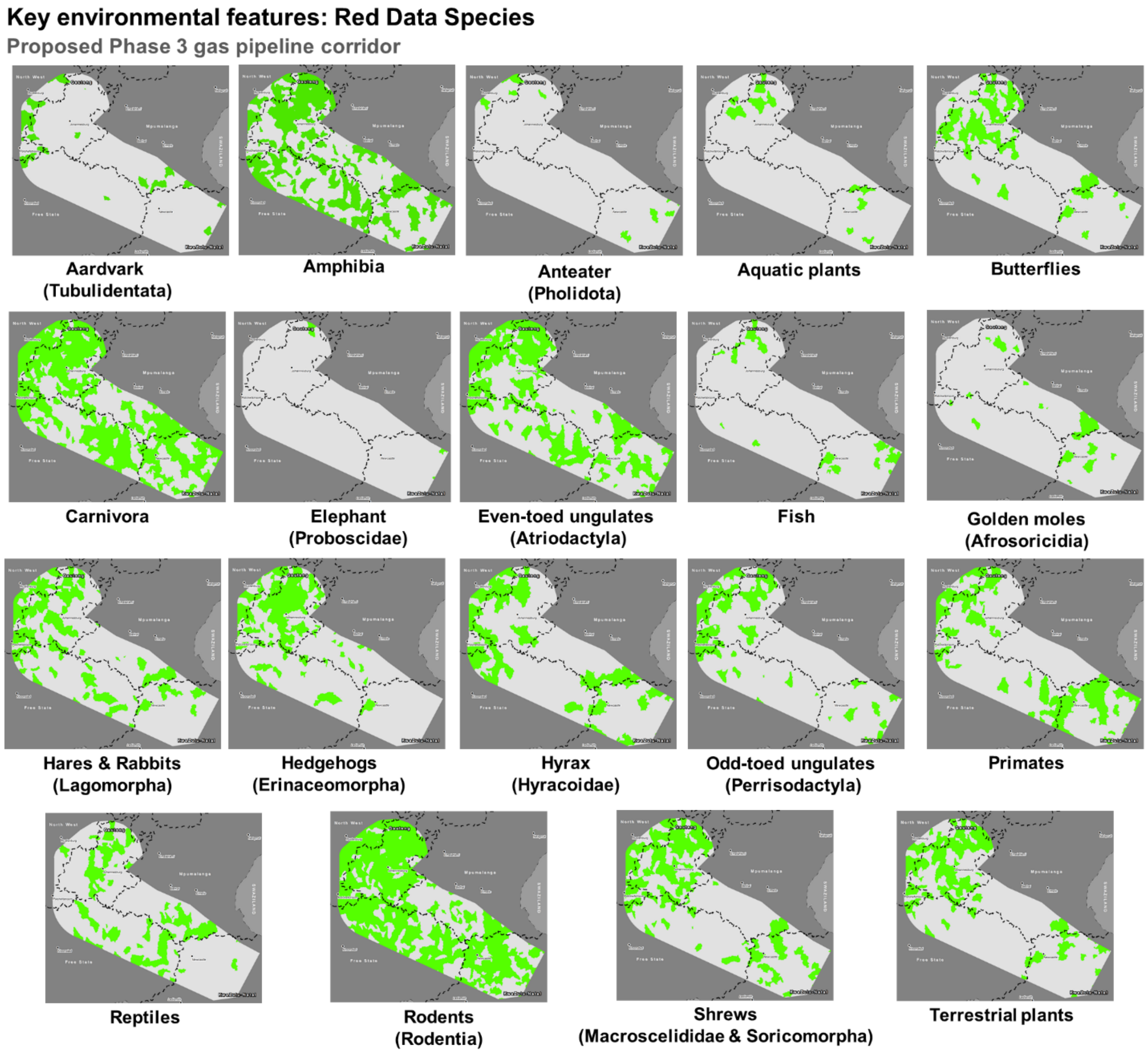


Figure 33: Distribution of recorded Red Data species in the proposed Phase 3 gas pipeline corridor (at quinary catchment scale).

4.2.9 Phase 8

The Kruger National Park can be seen in the north-eastern most corner of the proposed Phase 8 gas pipeline corridor (Figure 33). The number of species records in the KNP indicates that PAs can be expected to be better sampled than surrounding areas (see the Assumptions and Limitations of this assessment in Section 3.1).

4.2.9.1 Grassland & Savanna

This route is almost exclusively through Savanna and Grassland, with a few embedded forest patches. There are a number of critical squeeze points, the first being through the narrow gap below Kruger National Park and associated conservation areas, and the bulge of Swaziland with the Songimvelo and Barberton Nature reserves. There are also a large number of private reserves in this area. The second pinch point is when crossing the Drakensberg escarpment. Forestry patches as well as important Grasslands are encountered in this area.

4.2.9.2 Birds and bats

Bat species of Conservation Importance likely to be encountered in the proposed Phase 8 gas corridor include:

- Short-eared trident bat
- Damara woolly bat
- Greater long-fingered bat
- Rendall's serotine
- Large-eared free-tailed bat
- Blasius's horseshoe bat
- Swinny's horseshoe bat
- Cohen's horseshoe bat
- Light-winged lesser house bat
- Schreber's yellow bat
- Egyptian tomb bat

Table 18 presents red data species that occur in the biomes present in the proposed Phase 8 gas pipeline corridor.

Table 18: Red Data bird species likely to be encountered in the proposed Phase 8 gas corridor.

Species	Status	Biome			
		Savanna	Grassland	Forest	Azonal
Abdim's Stork	NT	✓	✓		✓
Black Harrier	EN		✓		
Black Stork	VU	✓	✓		✓
Blue Crane	NT		✓		✓
Caspian Tern	VU				✓
European Roller	NT	✓			
Greater Flamingo	NT		✓		✓
Black-rumped Buttonquail	VU	✓	✓		
Lanner Falcon	VU	✓	✓		✓
Lesser Flamingo	NT		✓		✓
Bush Blackcap	VU			✓	

Species	Status	Biome			
		Savanna	Grassland	Forest	Azonal
Maccoa Duck	NT				✓
Martial Eagle	EN	✓	✓		
Red-footed Falcon	NT		✓		
Secretary bird	NT	✓	✓		
Lappet-faced Vulture	EN	✓			
Verreaux's Eagle	VU	✓	✓		
Marabou Stork	NT	✓			✓
Denham's Bustard	VU		✓		
Orange Ground-Thrush	NT			✓	
Pink-backed Pelican	VU				✓
Half-collared Kingfisher	NT				✓
Greater Painted-snipe	NT				✓
Saddle-billed Stork	EN				✓
Short-tailed Pipit	VU		✓		
Southern Bald Ibis	VU		✓		
Cape Vulture	EN	✓	✓		
Chestnut-banded Plover	NT				✓
Southern Ground-Hornbill	EN	✓			
Tawny Eagle	EN	✓			
Wattled Crane	CR		✓		✓
African Grass-Owl	VU		✓		
Grey Crowned Crane	EN		✓		✓
Pallid Harrier	NT		✓		
White-bellied Korhaan	VU	✓	✓		
White-backed Vulture	CR	✓			
Yellow-billed Stork	EN				✓
Yellow-breasted Pipit	VU		✓		
African Crowned Eagle	VU			✓	
African Finfoot	VU				✓
African Pygmy-Goose	VU				✓
Bateleur	EN	✓			
Kori Bustard	NT	✓			
Lesser Jacana	VU				✓
White-backed Night-Heron	VU				✓
Bat Hawk	EN	✓			
Blue Swallow	CR		✓		
White-headed Vulture	CR	✓			
African Marsh-Harrier	EN		✓		✓
Black-winged Pratincole	NT		✓		✓
Hooded Vulture	CR	✓			
White-winged Flufftail	CR		✓		✓
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near threatened					

4.2.9.3 Freshwater Ecosystems

Rivers within the proposed Phase 8 gas pipeline corridor are predominantly perennial/permanently-flowing (80%), and flow through ecoregions such as the Highveld, Northern Escarpment Mountains, North Eastern Highlands, and down through the Lowveld. Major river systems include the Olifants, Komati, Crocodile and Sabie Rivers (Figure 34: Key aquatic ecosystem features of the proposed Phase 8 gas pipeline corridor). A significant proportion (approximately 71%) of the rivers are considered to be Threatened (i.e. CR, EN and

VU). Less than 25% of the rivers are in a natural/good condition, majority (47% are in a fair condition, 23% are in a poor condition, while 6% are in a poor condition.

Wetland habitats within this corridor occupy a large proportion of the corridor (~12%) comprising up to 93 different wetland types, dominated by channelled-valley bottom wetlands, and largely characteristic of the Mesic Highveld Grassland region. There are no Ramsar wetlands that occur within the corridor, and a small proportion (~8%) of the wetlands are classified as NFEPA wetland, mostly in the form of channelled-valley bottoms, depressions and seeps. Nevertheless, a significant (75%) of the wetlands are associated with Critically Endangered wetland groups, notably the Mesic Highveld Grassland Group 4 (54%) and Group 3 (9%).

Approximately 65% of the Phase 8 corridor comprises land that is largely natural with a further 2% degraded. A fairly large proportion (16%) of the corridor is protected by conservation areas, including parts of Kruger National Park. The remaining area is mostly transformed by cultivation (~19%) and plantations (11%), and to a lesser extent by urbanisation (3%) and mining (1%).

Existing drivers and pressures currently impacting freshwater ecosystems in the proposed Phase 8 pipeline corridor include:

- Plantations, concentrated in the central highlands, resulting in a number of impacts to freshwater ecosystems (e.g. streamflow reduction particularly dry-season baseflows, increased turbidity and sedimentation, removal of riparian vegetation and buffer zones, IAP infestation, loss of species diversity and abundance);
- Mining related activities (notably for coal resources) resulting in pollution of surface waters caused predominantly by acidification (i.e. acid mine drainage) and other mining-related effluents;
- Run-of-river abstraction and small farm dams for irrigation, which is more pronounced in the western parts of the corridor;
- Urbanisation in and around towns such as Emalahleni, Middleberg, Ermelo and Nelspruit placing increased pressure on water resources, largely due to increased stormwater runoff and decreased water quality from both point and non-point sources linked to residential and industrial areas);
- Very high (unacceptable) faecal pollution in regions such as Witbank/Middleburg and Nelspruit, which is affecting river systems such as the Crocodile and Olifants; and
- Extensive maize cultivation and livestock farming resulting in removal and/or degradation of freshwater habitat.

Box 21: Red Data aquatic biota likely to be encountered in Phase 8

The corridor supports two species of Odonata that are listed as Endangered (i.e. *Ceriagrion suave* and *Diplacodes pumila*), along with three that are Near Threatened. There are also 13 Red Listed fish that are known to inhabit the corridor, including the Critically Endangered *Chiloglanis bifurcus* and *Enteromius treurensi. Chiloglanis bifurcus* is an instream species, endemic to the Inkomati River System and within this system it is restricted to altitudes between 900 metres above sea level (m.a.s.l) to 1200 m.a.s.l. In addition, there are also 3 endangered fish species, one Vulnerable, five Near Threatened, and two Data Deficient. There are no Red Listed amphibians that are known to occur within the corridor. Only one Red Listed reptile occurs within the corridor, namely the Near Threatened *Macrelaps microlepidotus*. The corridor supports a high diversity of Red Listed mammals (up to 7 species), including three that are Vulnerable and four that are Near Threatened. This corridor supports a moderate diversity of Red Listed plants, including one that is Critically Endangered (i.e. *Aloe simii*) and one that is Endangered (i.e. *Disa zuluensis*). The majority of the Red Listed plants occurring with the corridor are either Vulnerable (7 species) or Near Threatened (7 species), while one is Data Deficient and two are rare.

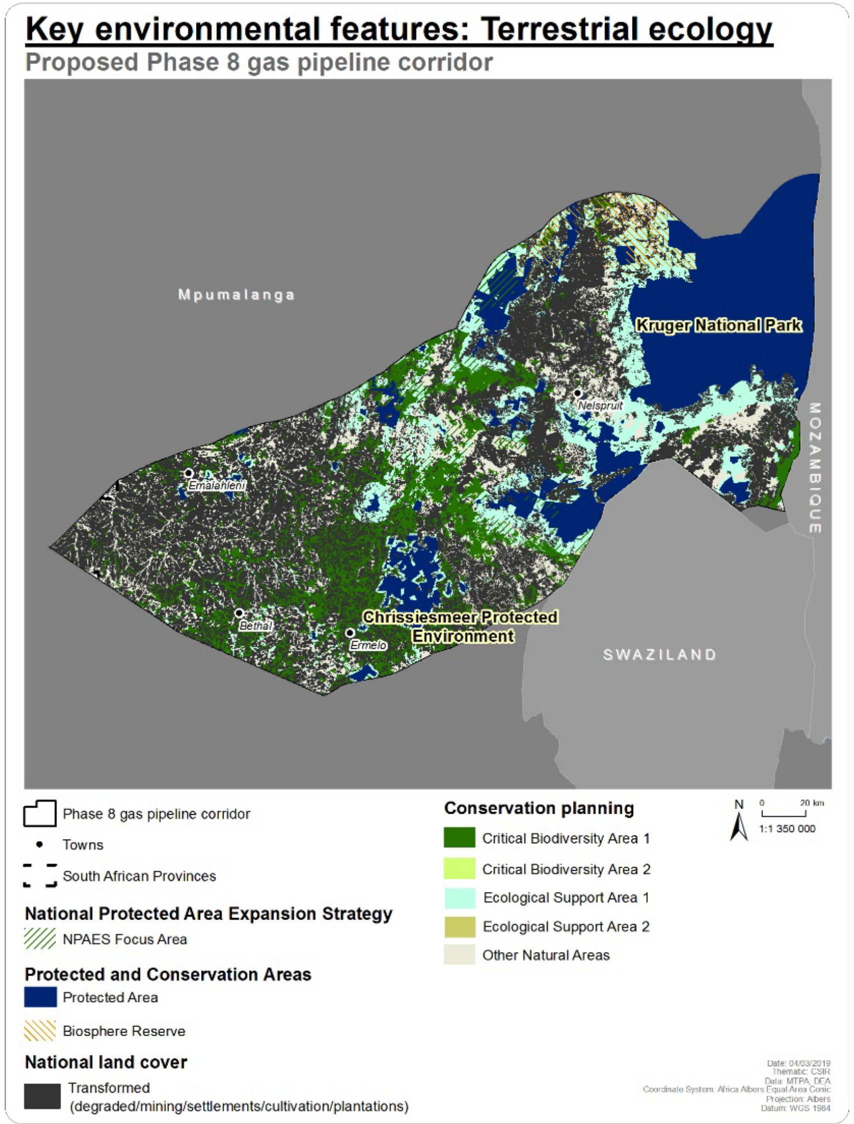


Figure 34: Key environmental features of the proposed Phase 8 gas pipeline corridor.

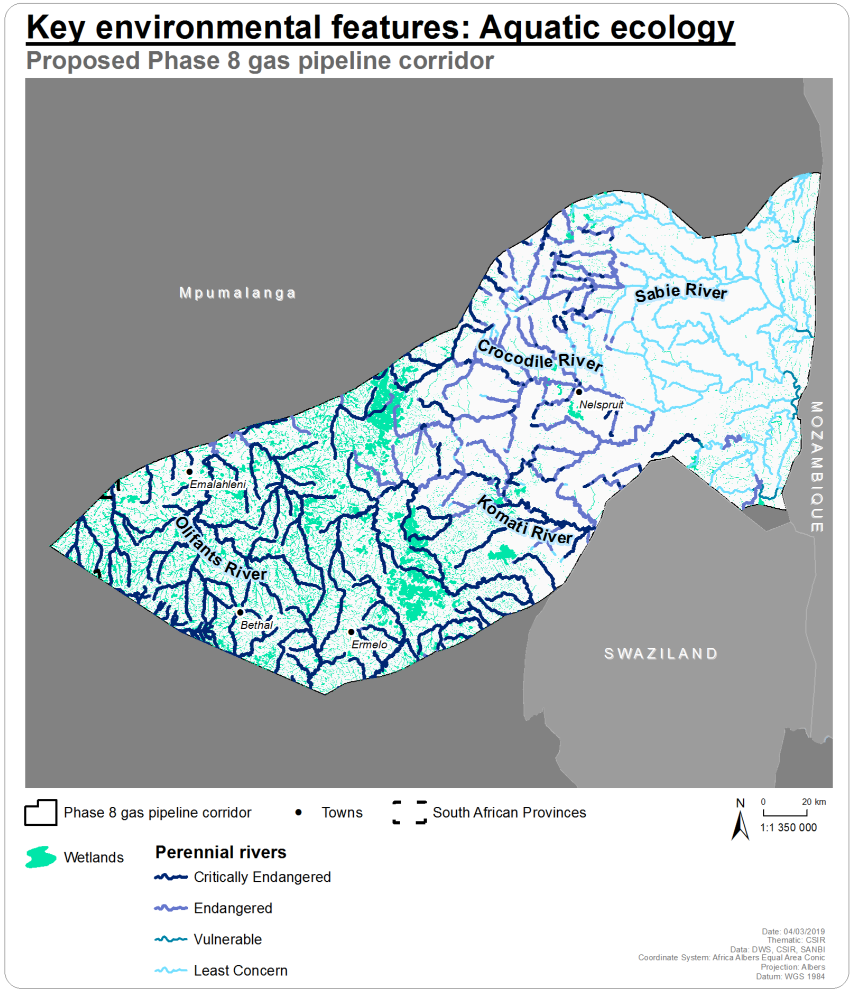


Figure 35: Key aquatic ecosystem features of the proposed Phase 8 gas pipeline corridor.

Note: Finer scale features may not be visible at the current map extent.

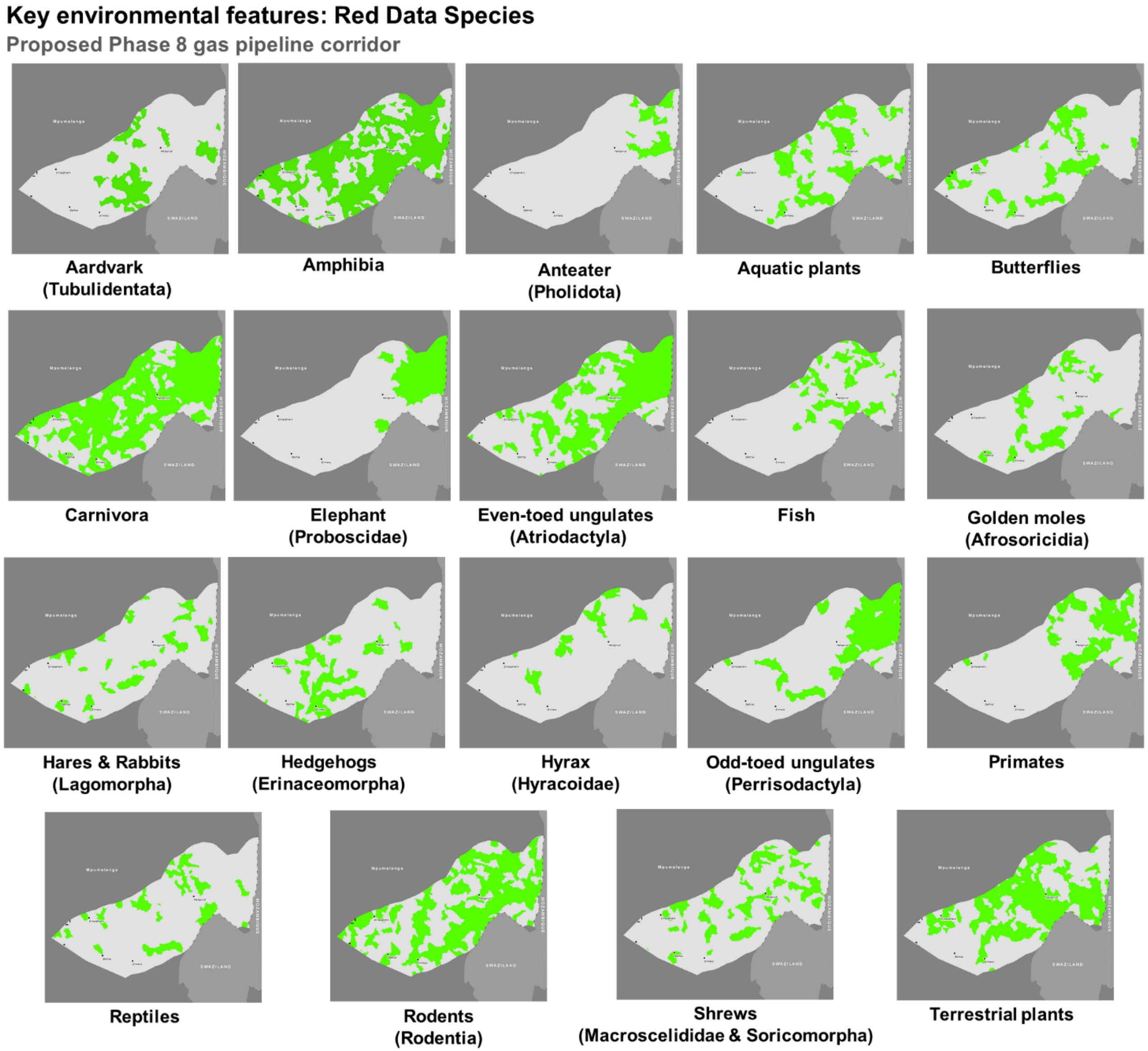


Figure 36: Distribution of recorded Red Data species in the proposed Phase 8 gas pipeline corridor (at quinary catchment scale).

5 SENSITIVITY ANALYSIS

5.1 Identification of feature sensitivity criteria

The data presented in Table 1 - Table 6 (Section 3.2) were used as the point of the departure for the sensitivity analysis. Sensitivities were assigned to various important environmental features and identified buffers (where relevant). The sensitivities of the different biomes may vary, as they are known to have various degrees of resilience and recoverability. For example: rehabilitation may be more easily and successfully achieved in the Savanna and Grassland vegetation types than in Fynbos and Karoo vegetation types.

5.1.1 Desert, Succulent Karoo and Nama Karoo

The biodiversity sensitivity values are adapted from CBA classifications from provincial systematic conservation plans for the Northern, Western and Eastern Cape provinces, as well as relevant specialist experience and previous SEAs conducted in these biomes (Table 19).

Table 19: Sensitivity ratings assigned to important environmental features of the Desert, Succulent Karoo and Nama Karoo biomes in the proposed gas corridor phases (i.e. Phases 6, 5, 1, 2, Inland and 7).

Feature Class	Sensitivity Rating
Conservation planning	
CBA 1	Very High
CBA 2	High
ESA	Low
Protected areas	
PA	Very High
NPAES Focus Area	Medium
Old agricultural fieldsOld Fields Layer	Low
Old agricultural fields + CBAs	Medium
Agricultural fields	Low
Specific Vegetation types	
Azonal wetland related vegetation types	Very High
Azonal non-wetland related vegetation types	High
Vegetation types which have a high abundance of SCC	High
Vegetation types which are considered vulnerable to disturbance (dunes)	High
Threatened ecosystems	
CR	Very High
EN	High
VU	Medium
Species of Conservation Concern	
Quinary catchments where fauna and flora SCC are present	High
SCC Plant Habitats	Very High
Other areas of biodiversity significance	
Specialist identified sensitive areas in Karoo and Desert ecosystems (Todd, personal observations)	High
Areas of biodiversity significance identified in the Shale Gas SEA.	High
PA = Protected Area; CBA = Critical Biodiversity Area; NPAES = National Protected Area Expansion Strategy; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; ESA = Ecological Support Area; SCC = Species of Conservation Concern	

5.1.2 Fynbos

The Fynbos sensitivity analysis relied primarily on the most recent conservation plans for the areas concerned as they already include all the relevant layers of information such as threatened vegetation, threatened vertebrates, protected area expansion strategies and climate adaptation corridors in their CBAs and ESAs and the latest information on the protected areas (Table 20).

Table 20: Sensitivity ratings assigned to important environmental features of the Fynbos biome in the proposed gas corridor phases (i.e. Phases 6, 5, 1, 2, Inland, and 7).

Feature Class	Sensitivity Rating
Protected Areas Western Cape	
- NPs, Nature Reserves, World Heritage Sites	Very High 10 km Buffer[a]: High
- Mountain Catchment Areas	High
- Private Conservation Areas (all types)	Medium 5 km Buffer: Medium
- Protected Environment	5 km Buffer: Medium
- NPAES	5 km Buffer: Medium
- Nature Reserve Buffer	5 km Buffer: Medium
Protected Areas Northern Cape (all types)	Very High
- PA	5 km Buffer[b]: High
- NPs	10 km Buffer[b]: High
Protected Areas Eastern Cape	
- WHS, NP, Nature Reserve, DAFF Forest Reserves	Very High
- Biosphere Reserves, Protected Environments	High
- Private Nature Reserves	Medium
Conservation planning	
- CBA1	Very High
- CBA2	High
- ESA	Medium
- Land Cover : Natural Area	Medium
- Land Cover: Transformed	Low
- Other Natural Areas	Medium
[a] EIA Regulations, No. R. 982, 4 December 2014 as updated in Government Notices 324 to 327 in Government Gazette 40772 of 7 April 2017.	
[b] In the Northern Cape CBA plan all PAs were buffered by 5 km and National Parks by 10 km as minimum.	
NP = National Park; WHS = World Heritage Site; NPAES = National Protected Area Expansion Strategy; PA = Protected Area; CBA = Critical Biodiversity Area; ESA = Ecological Support Area.	

5.1.3 Albany Thicket

The Albany Thicket sensitivity analysis made extensive use of data resources arising from the updated, revised Eastern Cape Biodiversity Conservation Plan (DEDEA, 2017) and the Western Cape Biodiversity Spatial Plan (Pool-Stanvliet et al., 2017) (Table 21).

The inherent fragility of the receiving environment will vary depending on the specific type of biodiversity feature being considered, however, for any given feature a number of contingent factors will influence fragility, typically these will include the slope and rainfall of the site being impacted. For any given impact, receiving environments on steep slopes (> 30%), and with very high or very low rainfall will be more fragile, and susceptible to cumulative and secondary impacts, such as erosion or poor recovery after rehabilitation. However, this criterion should be considered at finer scales of planning, where for example adjustments to routing paths may be considered based on topography.

Table 21: Sensitivity ratings assigned to important environmental features of the Albany Thicket biome in the proposed gas corridor phases (i.e. Phases 1, 2, Inland, and 7).

<table>
<tr><th colspan="2">Feature Class</th><th>Sensitivity Rating</th></tr>
<tr><td>-</td><td>PA (including Biosphere Reserves, World Heritage Sites, State Owned - SANParks and ECPTA, and Protected Environments)*</td><td>Very high</td></tr>
<tr><td>-</td><td>CA (including Private Nature Reserves, De Facto Private Nature Reserves, and DAFF Forest Reserves)*</td><td>High</td></tr>
<tr><td>-</td><td>CBA 1</td><td>Very high</td></tr>
<tr><td>-</td><td>CBA 2</td><td>High</td></tr>
<tr><td>-</td><td>ESA 1</td><td>Medium</td></tr>
<tr><td>-</td><td>ESA 2</td><td>Medium</td></tr>
<tr><td>-</td><td>Other Natural Areas</td><td>Medium</td></tr>
<tr><td>-</td><td>Non Natural Areas</td><td>Low</td></tr>
<tr><td colspan="3">*Buffers included as used in ECBCP (DEDEAT, 2017).</td></tr>
<tr><td colspan="3">PA = Protected Area; CA = Conservation Area; CBA = Critical Biodiversity Area; ESA = Ecological Support Area.</td></tr>
</table>

5.1.4 Indian Ocean Coastal Belt

For the IOCB areas of high conservation value and existing conservation plans were selected as basis for the sensitivity analysis (Table 22).

Table 22: Sensitivity ratings assigned to important environmental features of the Indian Ocean Coastal Belt biome in the proposed gas corridor phases (i.e. Phases 4 and 7).

<table>
<tr><th colspan="3">Feature Class</th><th>Sensitivity Rating</th></tr>
<tr><td>-</td><td colspan="2">Coastline</td><td>1 km buffer:
Very High</td></tr>
<tr><td>-</td><td colspan="2">PA</td><td>5 km buffer:
Very High</td></tr>
<tr><td>-</td><td colspan="2">WHS</td><td>Very High</td></tr>
<tr><td>-</td><td colspan="2">Ramsar Sites</td><td>High</td></tr>
<tr><td>-</td><td colspan="2">NPAES</td><td>Medium</td></tr>
<tr><td>-</td><td colspan="2">National Forests</td><td>Very High</td></tr>
<tr><td rowspan="3">-</td><td rowspan="3">Conservation categories from KZN BSP</td><td>CBA Irreplaceable</td><td>High</td></tr>
<tr><td>CBA Optimal</td><td>Medium</td></tr>
<tr><td>ESA</td><td>Low</td></tr>
<tr><td>-</td><td colspan="2">EKZN Wildlife Stewardship areas</td><td>Very High</td></tr>
<tr><td rowspan="7">-</td><td rowspan="7">Conservation categories (ECBCP)</td><td>PA</td><td>5 km buffer:
Very High</td></tr>
<tr><td>CA</td><td>High</td></tr>
<tr><td>CBA 1</td><td>High</td></tr>
<tr><td>CBA 2</td><td>Medium</td></tr>
<tr><td>ESA 1</td><td>Low</td></tr>
<tr><td>ESA 2</td><td>Low</td></tr>
<tr><td>Other Natural Areas</td><td>Low</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">Landcover</td><td>Modified</td><td>Low</td></tr>
<tr><td>Field Crop Boundaries</td><td>Low</td></tr>
<tr><td rowspan="5">-</td><td rowspan="5">Vegetation</td><td>LT</td><td>Low</td></tr>
<tr><td>VU</td><td>Medium</td></tr>
<tr><td>EN</td><td>High</td></tr>
<tr><td>CR</td><td>Very High</td></tr>
<tr><td>Thicket Vegetation</td><td>High</td></tr>
<tr><td>-</td><td colspan="2">Ecoregion</td><td>Medium</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">Private Nature Reserves and Game farms</td><td>Game Farms Title Deeds</td><td>5 km buffer:
Medium</td></tr>
<tr><td>Nature Reserves/Protected Areas</td><td>5 km buffer:
Medium</td></tr>
</table>

Feature Class	Sensitivity Rating
PA = Protected Area; WHS = World Heritage Site; CA = Conservation Area; CBA = Critical Biodiversity Area; ESA = Ecological Support Area; KZ – KwaZulu-Natal; LT = Least Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered; ECBCP = Eastern Cape Biodiversity Conservation Plan.	

5.1.5 Grassland and Savanna

The sensitivity of biodiversity and ecological features was based largely on sensitivities as used in Provincial biodiversity conservation plans (Table 23).

Table 23: Sensitivity ratings assigned to important environmental features of the Grassland and Savanna biomes in the proposed gas corridor phases (Phases 2, 3, Inland, 7, 4, and 8).

Feature Class		Sensitivity Rating
PAs: national and provincial parks, forest wilderness, special nature reserves and forest nature reserves		Very High
Coastlines		Very High
All indigenous forests		Very High
CBA (CBA1 for EC)		Very High
CBA 2 EC		High
Threatened ecosystems	CR	Very High
	EN	High
	VU	Medium
Land Cover: Natural Area Land Cover: Modified areas		Low
Game Farms		Medium
SANParks Buffer		High
Protected Environments		High
NPAES focus areas		Medium
Mountain Catchment Areas		High
Biospheres		Medium
Botanical Gardens		Medium
ESA		Medium
PA = Protected Area; CBA = Critical Biodiversity Area; NPAES = National Protected Area Expansion Strategy; EC = Eastern Cape; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; ESA = Ecological Support Area		

5.1.6 Freshwater ecosystems

The sensitivity rating for freshwater ecosystems is a combined rating for rivers, wetlands and freshwater biota (Table 24). The total score for each SQ4 catchment were collapsed into the four sensitivity classes using a quantile data split. This coverage provides an integration of all data pertaining to freshwater biodiversity and ecosystems, and is particularly useful for identifying preferred alignments for gas pipeline infrastructure in order to reduce impacts on freshwater ecosystems and associated biodiversity.

Table 24: Sensitivity ratings assigned to important freshwater features in the proposed gas corridor phases (All Phases).

Feature Class		Sensitivity Rating
Wetlands: Critically Endangered wetlands and Irreplaceable CBAs (aquatic)		200 m buffer: Very High
Wetlands: Ramsar wetlands, KZN priority wetlands, Endangered or Vulnerable wetlands, Optimal CBA (aquatic)		100 m buffer: High
Wetlands: NFEPA wetlands, Near Threatened wetlands and ESA (aquatic)		50 m buffer: Medium
Wetlands: probable wetland, non-NFEPA wetlands, least threatened wetlands, ONA (aquatic), formally protected aquatic features		32 m buffer: Low
River ecosystems (including instream and riparian habitats)		200 m buffer Very High
		100 m buffer: High
		50 m buffer: Medium
		32 m buffer: Low
Freshwater fauna and flora per quinary catchment	CR Data Deficient	Very High
	EN VU	High
	NT Rare	Medium
	LT	Low
CBA = Critical Biodiversity Area; NFEPA = National Freshwater Ecosystem Priority Areas; KZN = KwaZulu Natal;; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LT = Least Threatened; ESA = Ecological Support Area; ONE = Other Natural Area		

5.1.7 Estuaries

Sensitivity was assigned to a suite of environmental indicators for estuaries (Table 25).

Table 25: Sensitivity ratings assigned to important estuarine features in the proposed gas corridors phases (i.e. Phases 5, 1, 2, 7, and 4).

Sensitivity Indicator	Sensitivity Class
Estuaries in Formal / desired PAs	Very High
Estuaries of high biodiversity importance	Very High
Important nurseries	Very High
Important estuarine habitats	Very High
Natural or near natural condition estuaries	Very High
Estuaries that support species of conservation importance	Very High
Other estuaries	High
Coastal rivers, wetlands and seeps above or adjacent to estuaries	5 km around EFZ: High
Coastal rivers, wetlands and seeps	5 - 15 km buffer around EFZ: Medium
Terrestrial environment	15 km or more from EFZ: Low
PA = Protected Area; EFZ = Estuary Functional Zone	

5.2 Four-Tier Sensitivity Mapping

The sensitivity rating assigned to environmental features in Table 19 - Table 25 are expressed spatially as sensitivity maps in Sections 5.2.1 - 5.2.9 below.

5.2.1 Phase 6

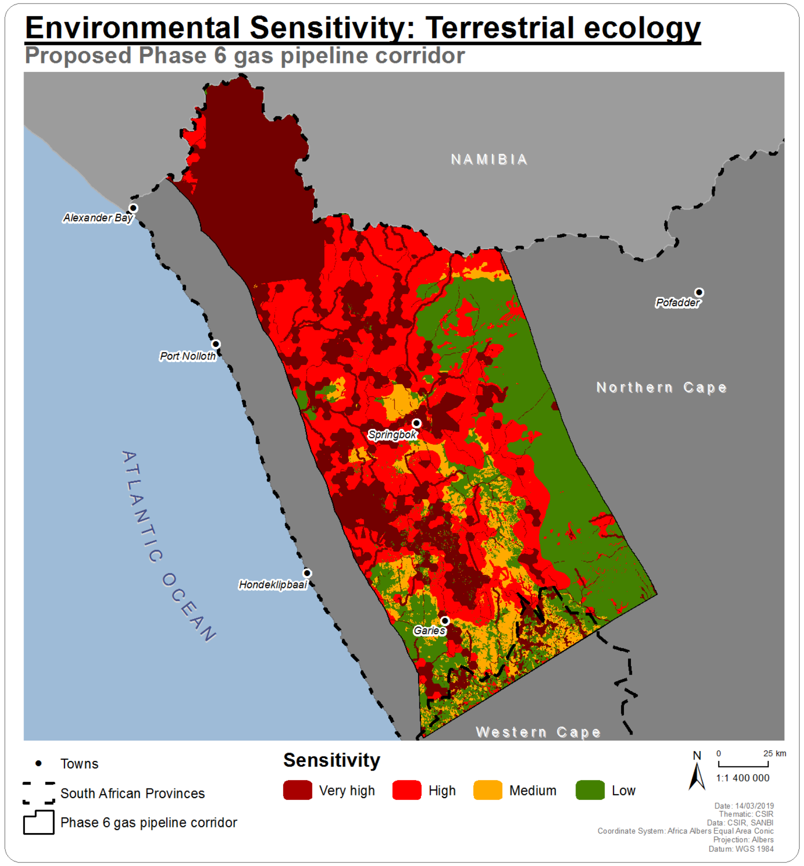


Figure 37: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 6 corridor.

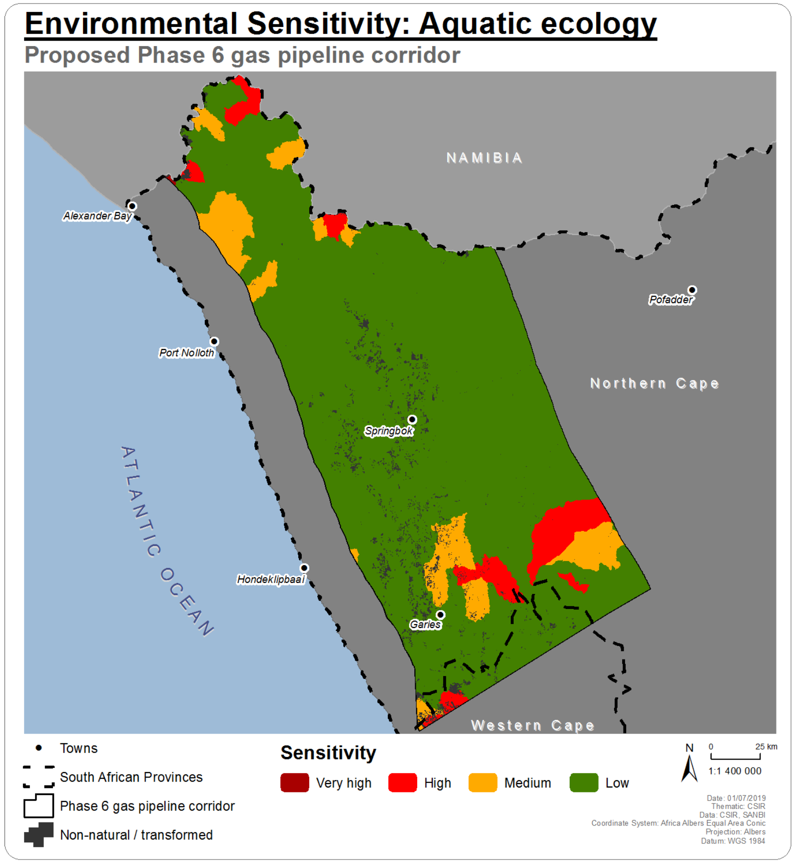


Figure 38: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 6 corridor.

5.2.2 Phase 5

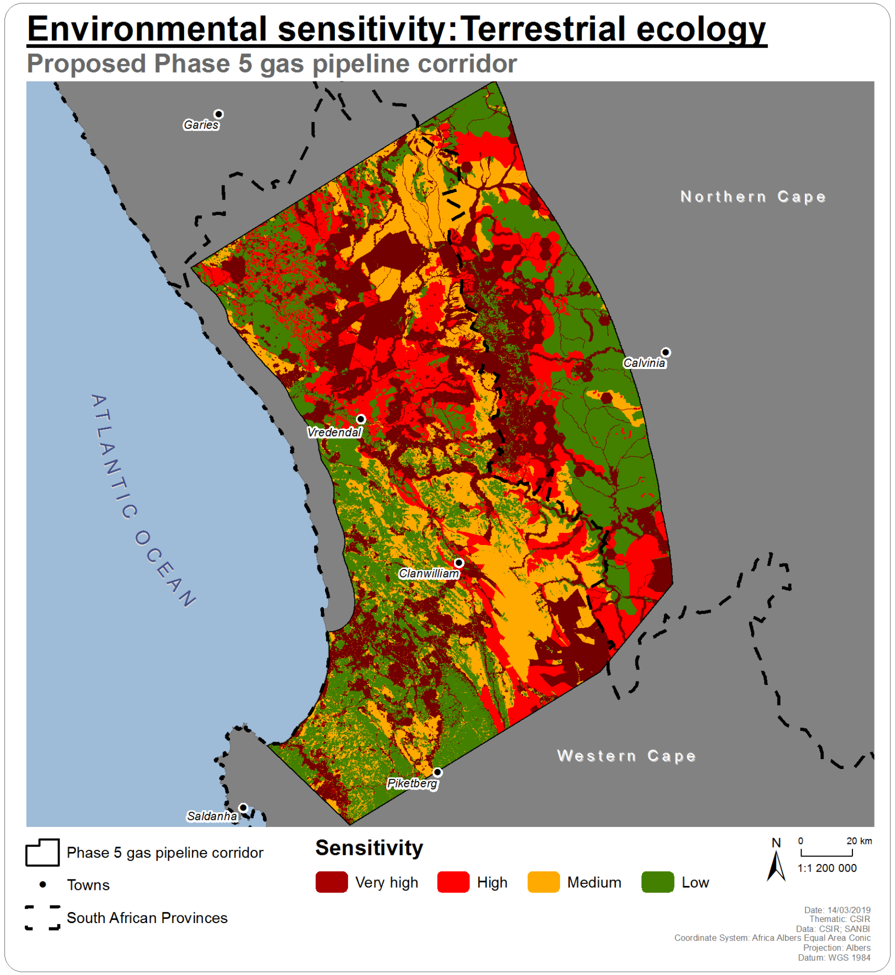


Figure 39: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 5 corridor.

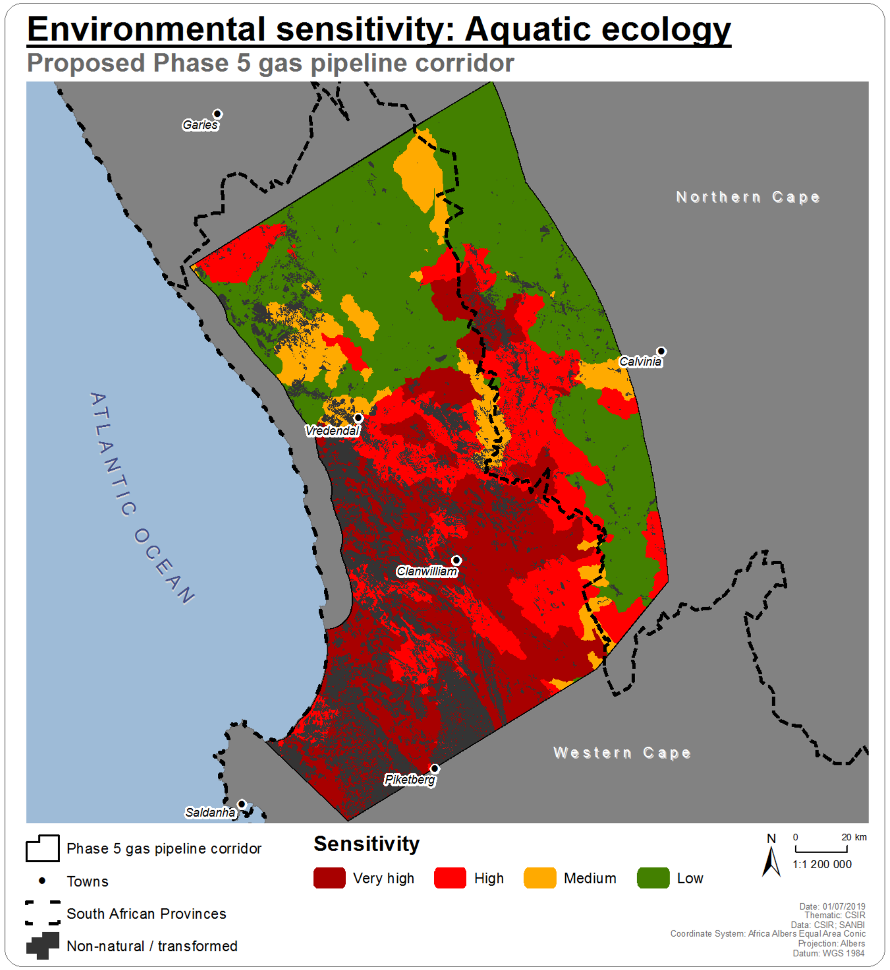


Figure 40: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 5 corridor.

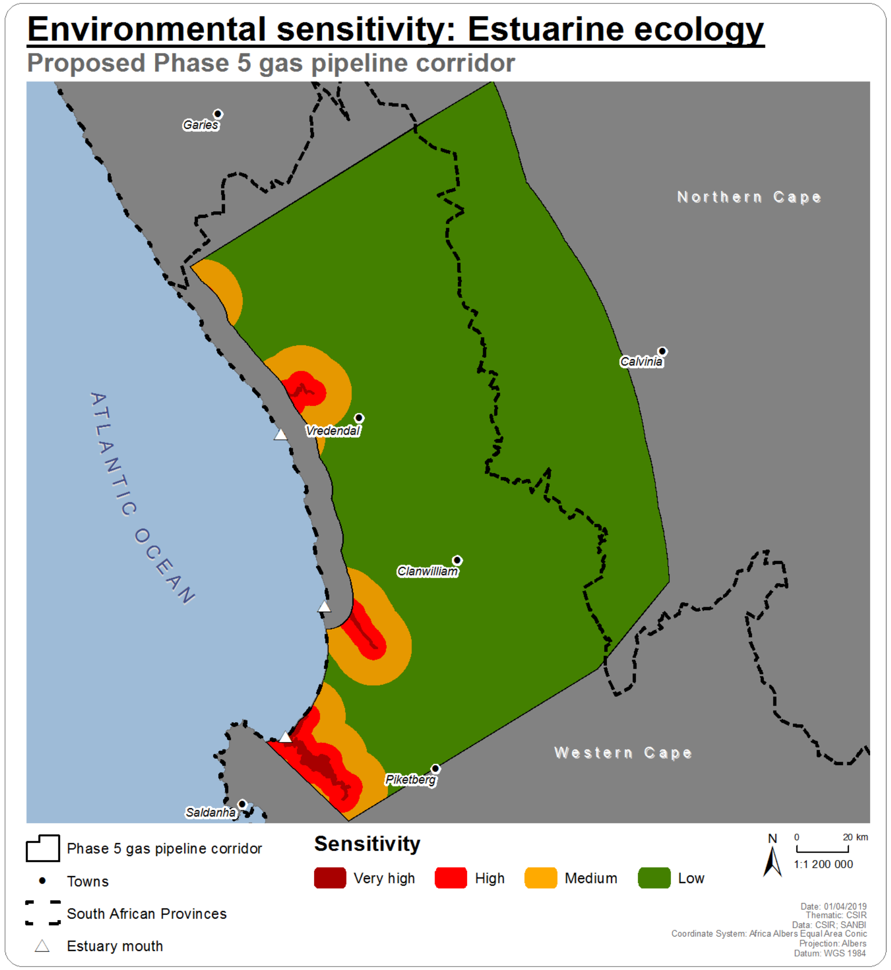


Figure 41: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development in the Phase 5 corridor.

5.2.3 Phase 1

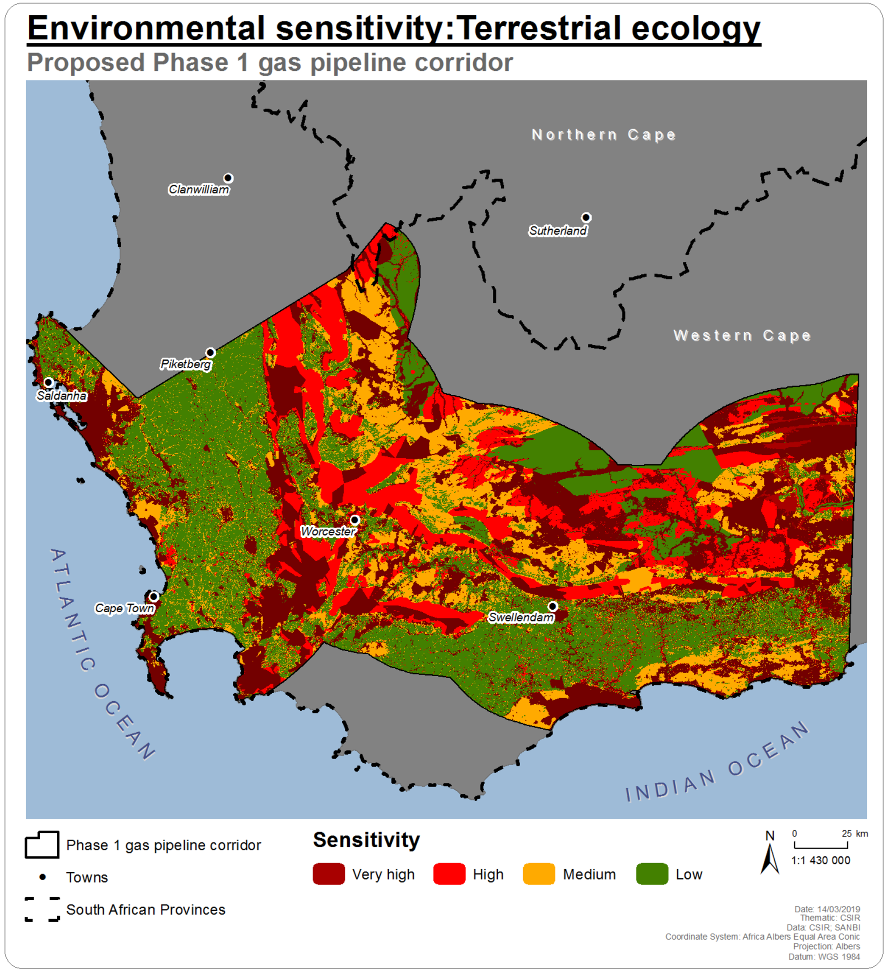


Figure 42: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 1 corridor.

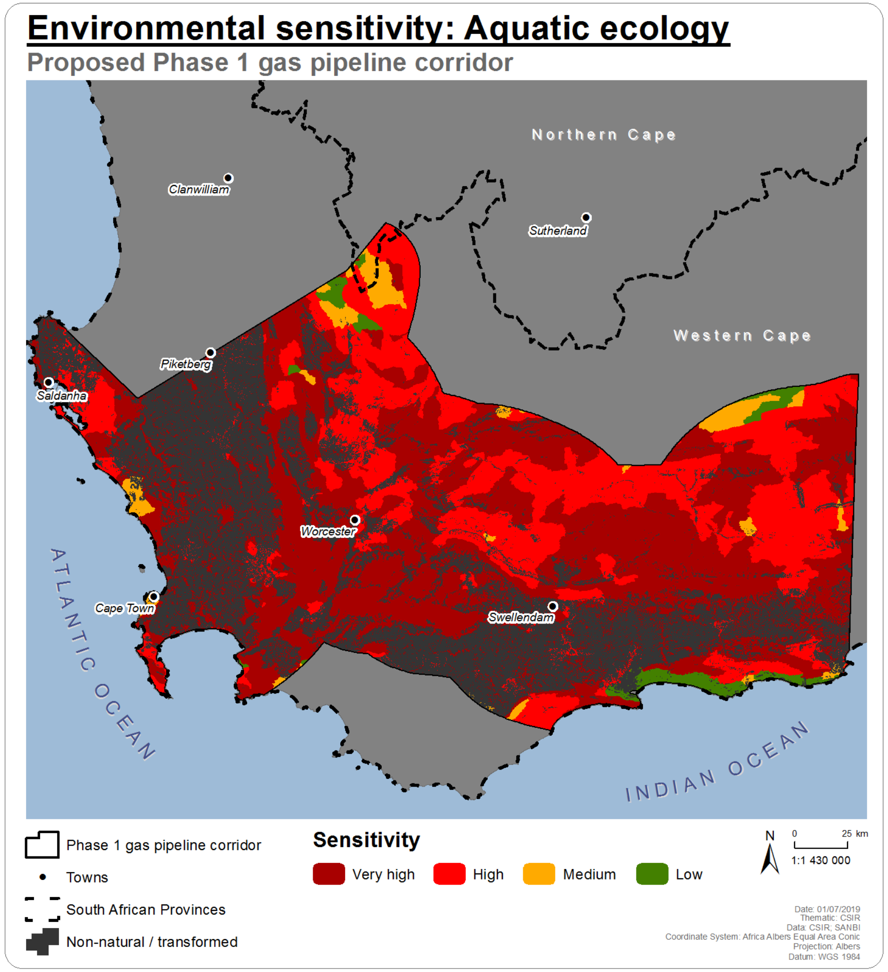


Figure 43: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 1 corridor.

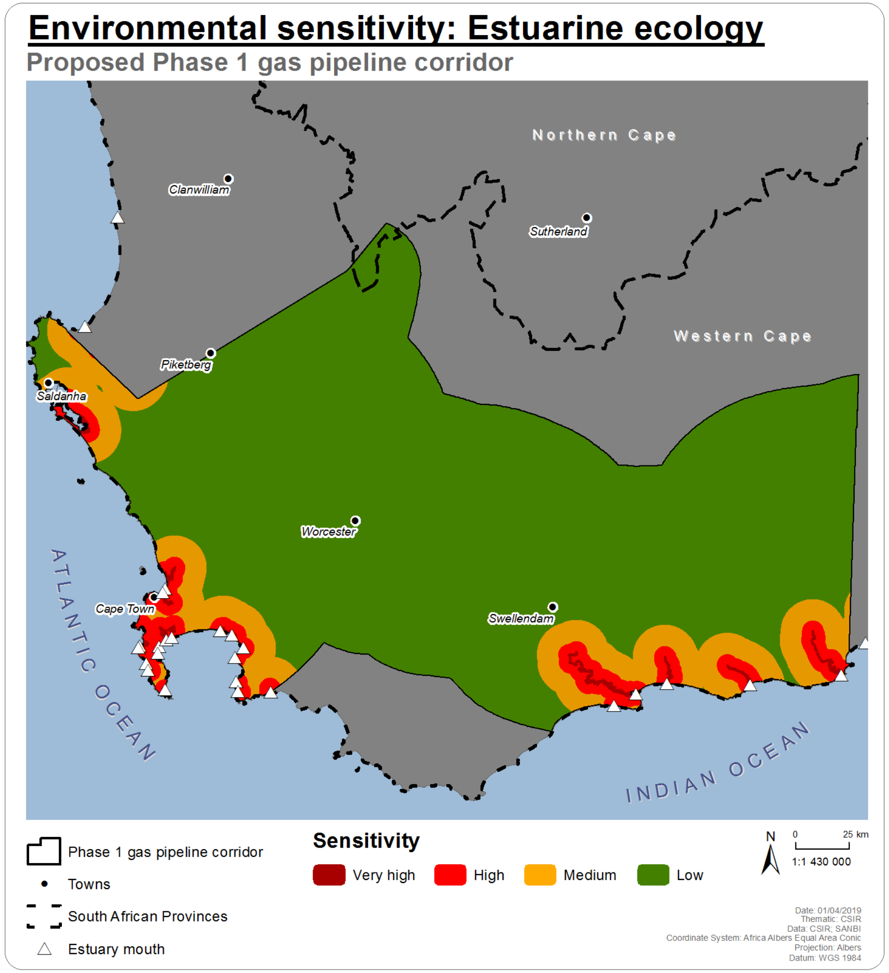


Figure 44: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development in the Phase 1 corridor.

5.2.4 Phase 2

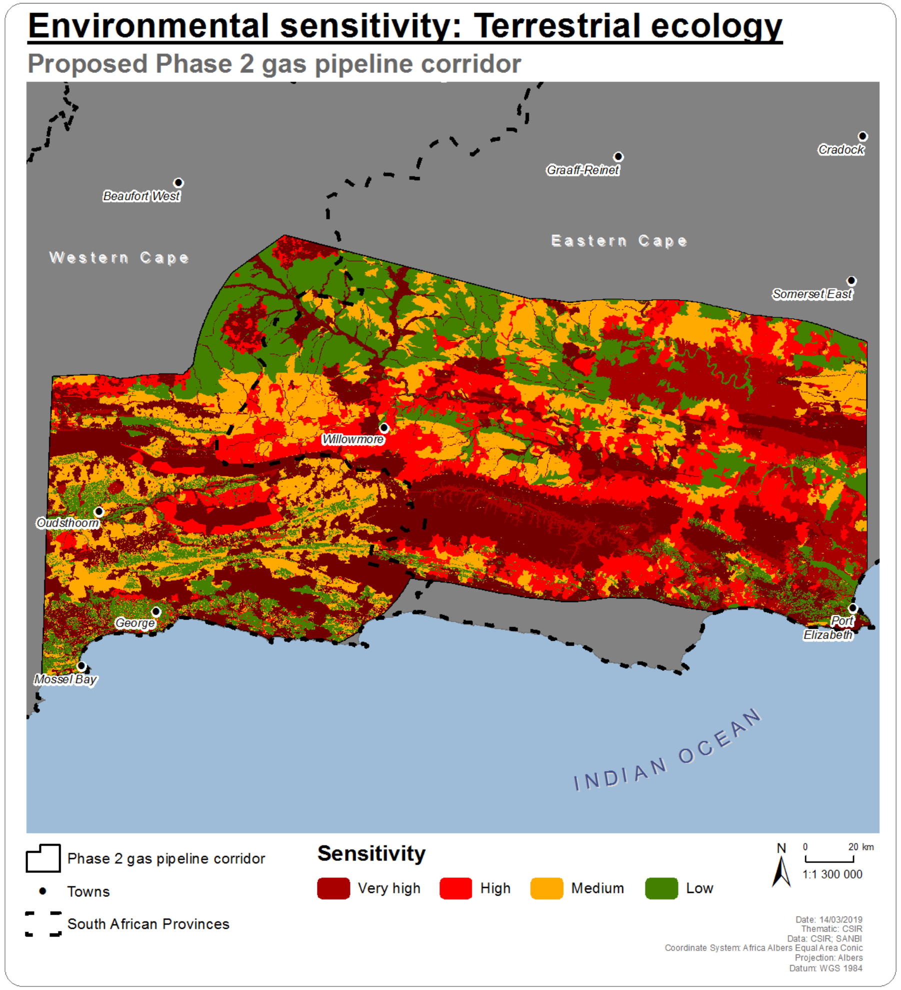


Figure 45: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 2 corridor.

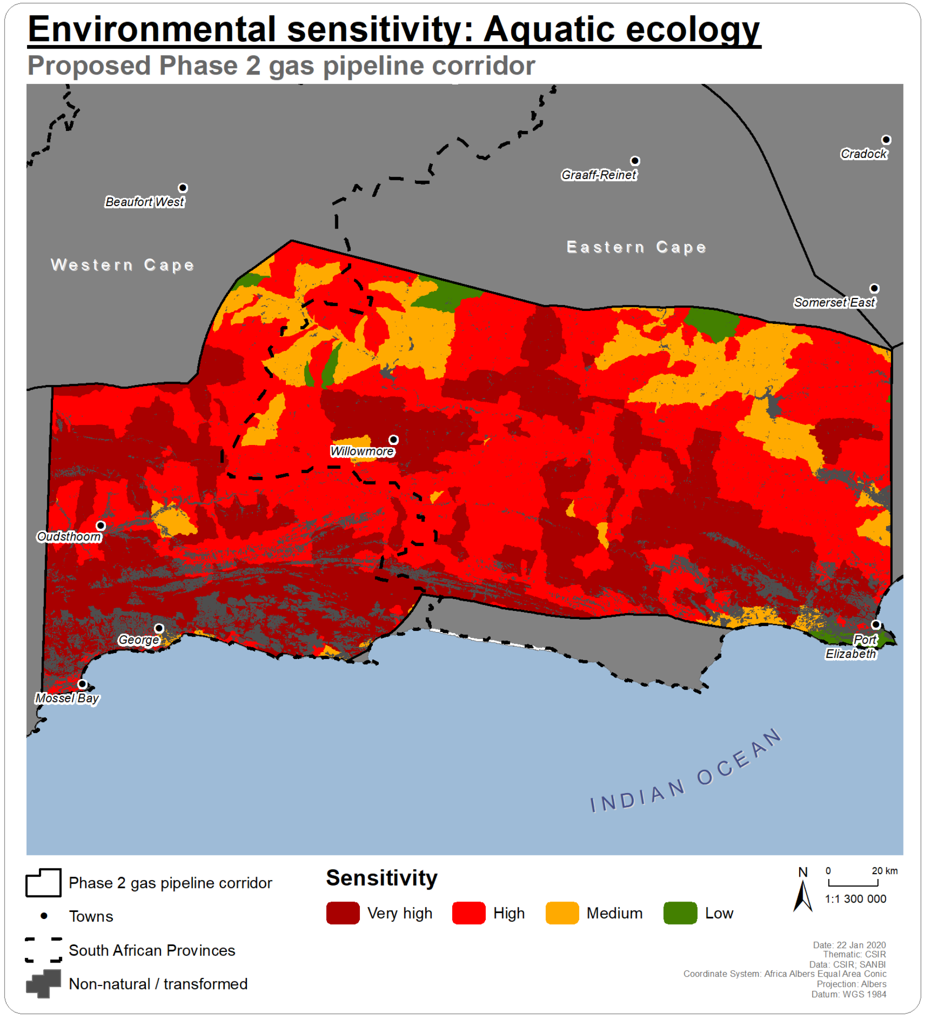


Figure 46: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 2 corridor.

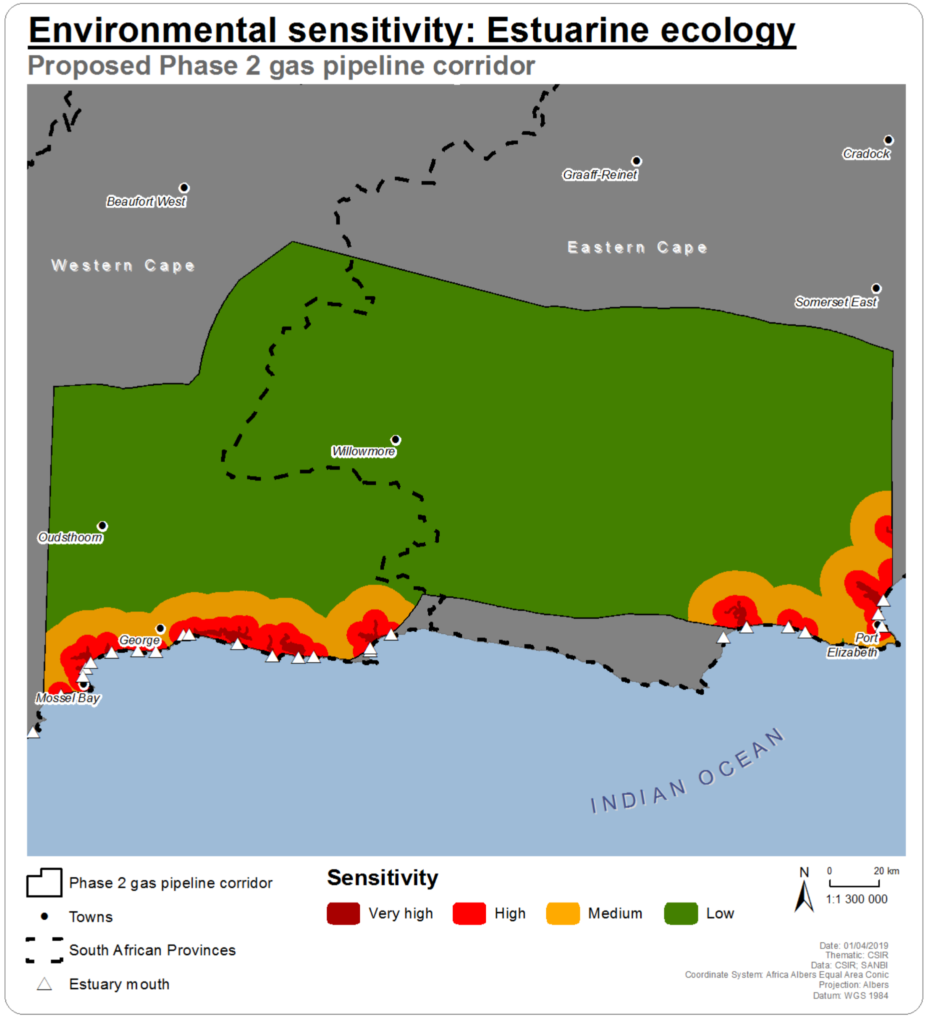


Figure 47: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development in the Phase 2 corridor.

5.2.5 Inland Phase

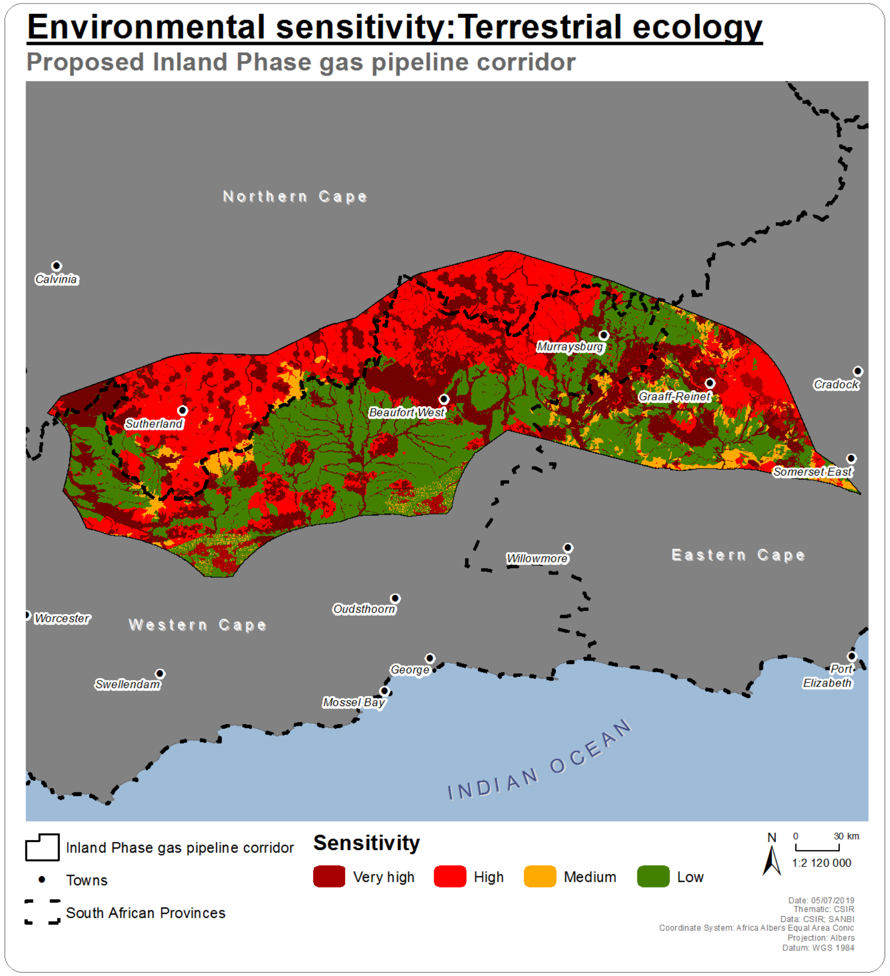


Figure 48: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Inland Phase corridor.

5.2.6 Phase 7

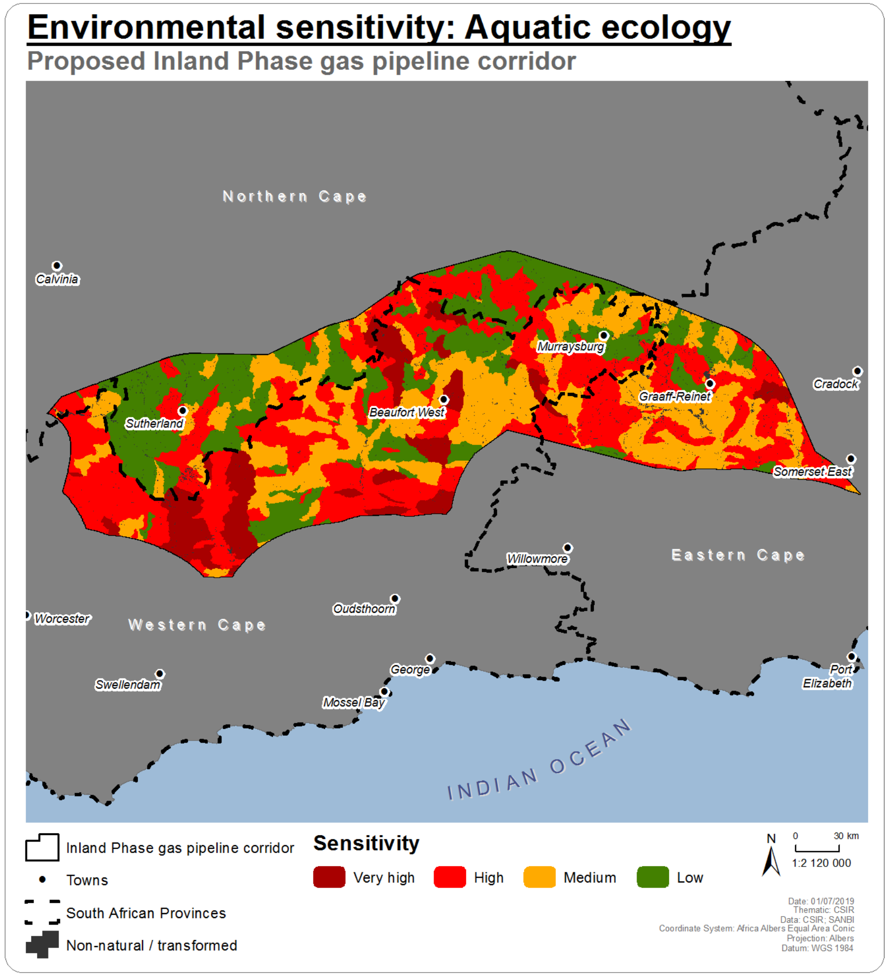


Figure 49: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Inland Phase corridor.

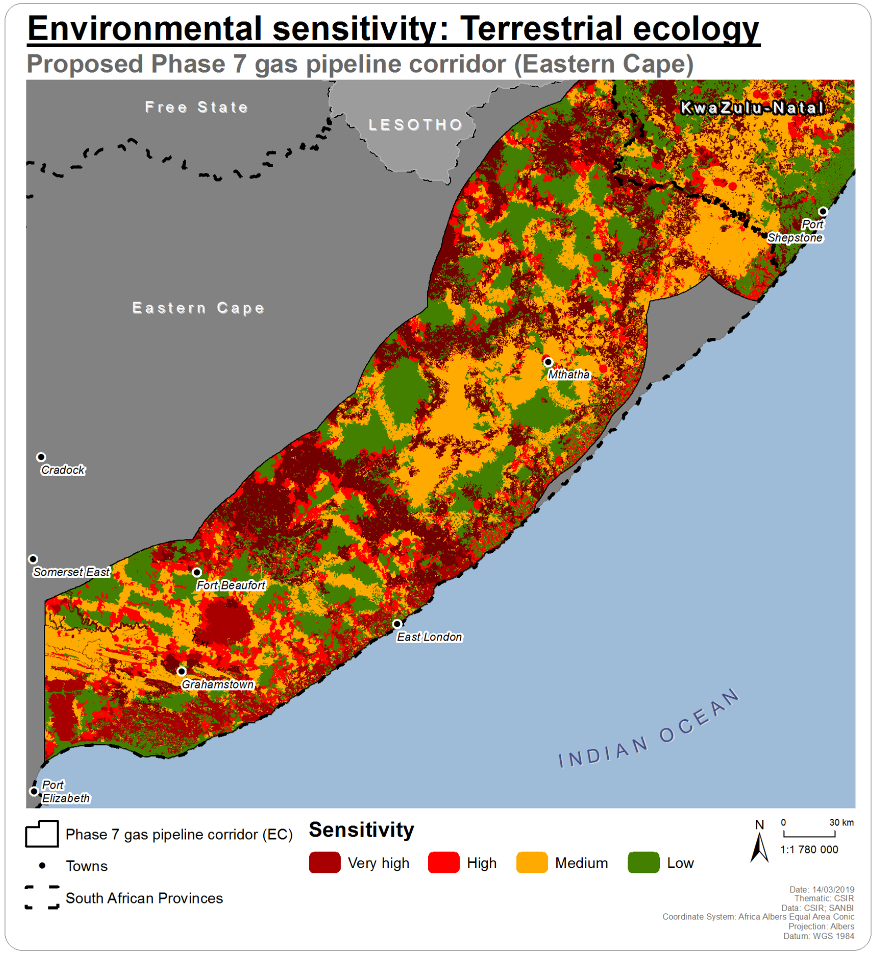


Figure 50: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 7 (Eastern Cape) corridor

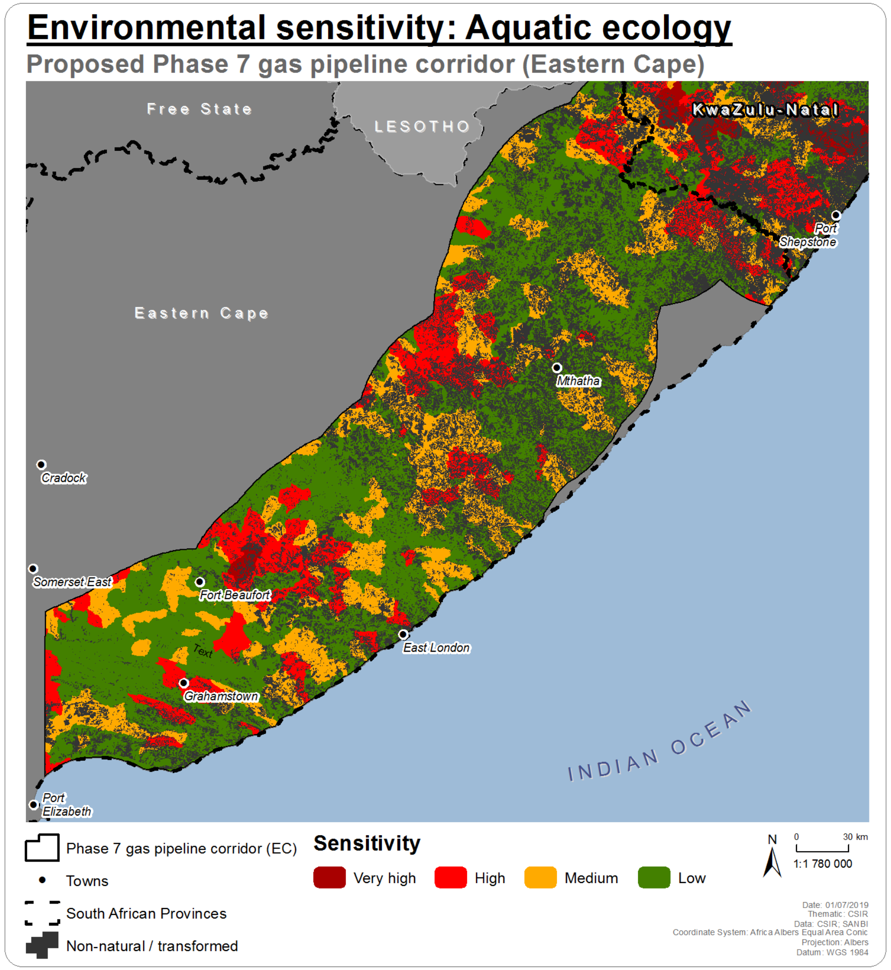


Figure 51: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 7 (Eastern Cape) corridor.

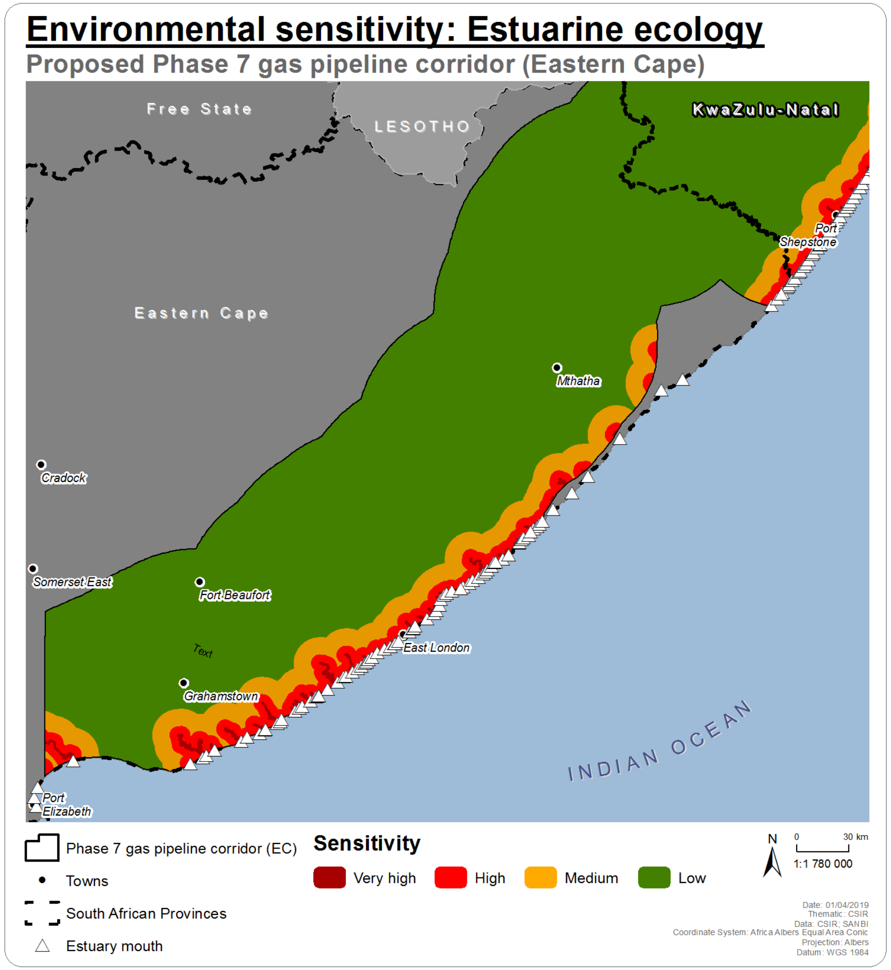


Figure 52: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development in the Phase 7 (Eastern Cape) corridor.

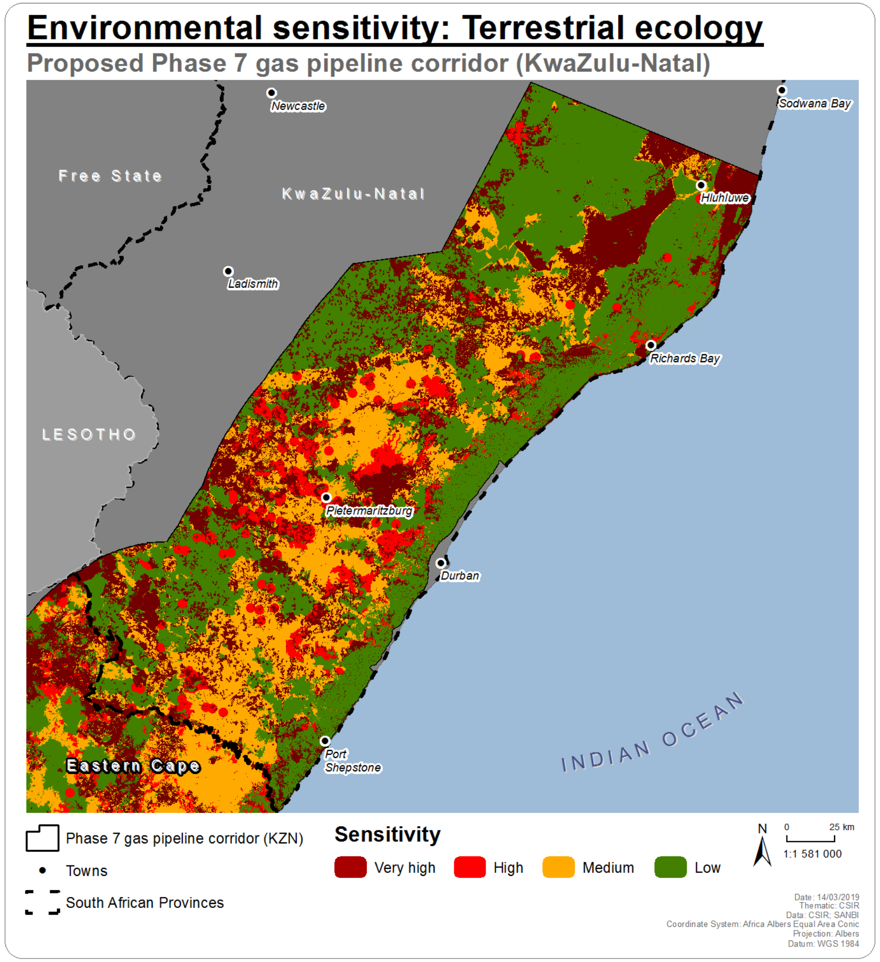


Figure 53: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 7 (KwaZulu-Natal) corridor.

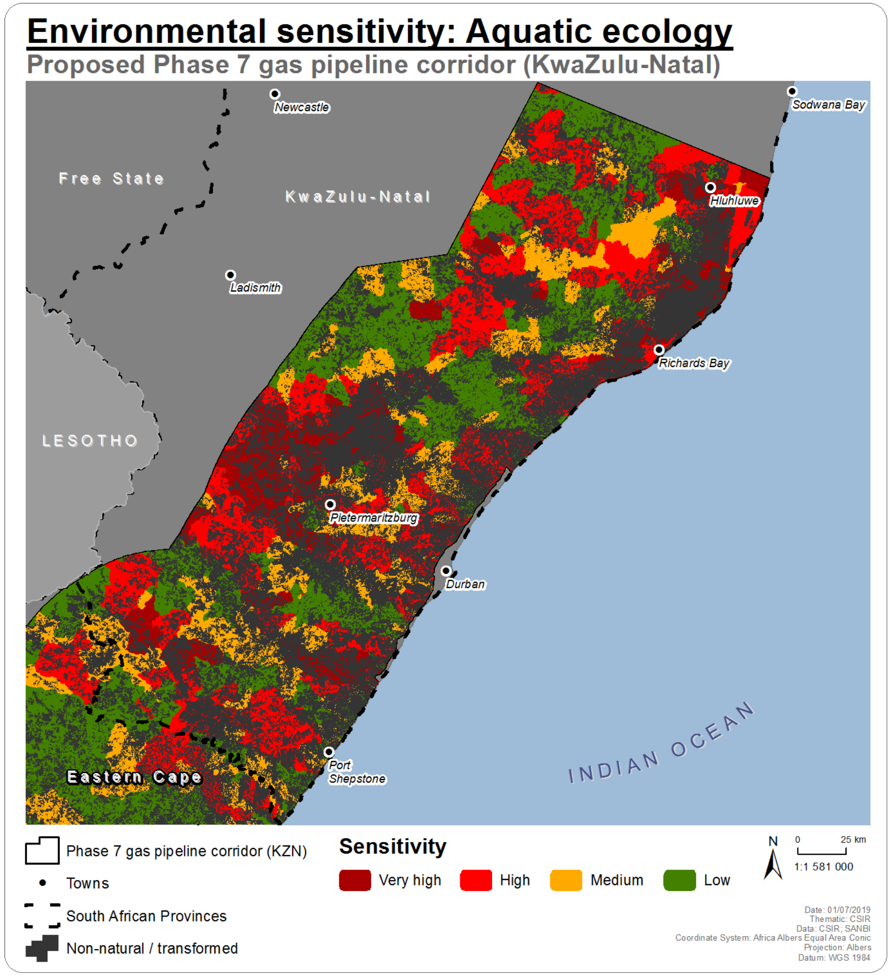


Figure 54: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 7 (KwaZulu-Natal) corridor.

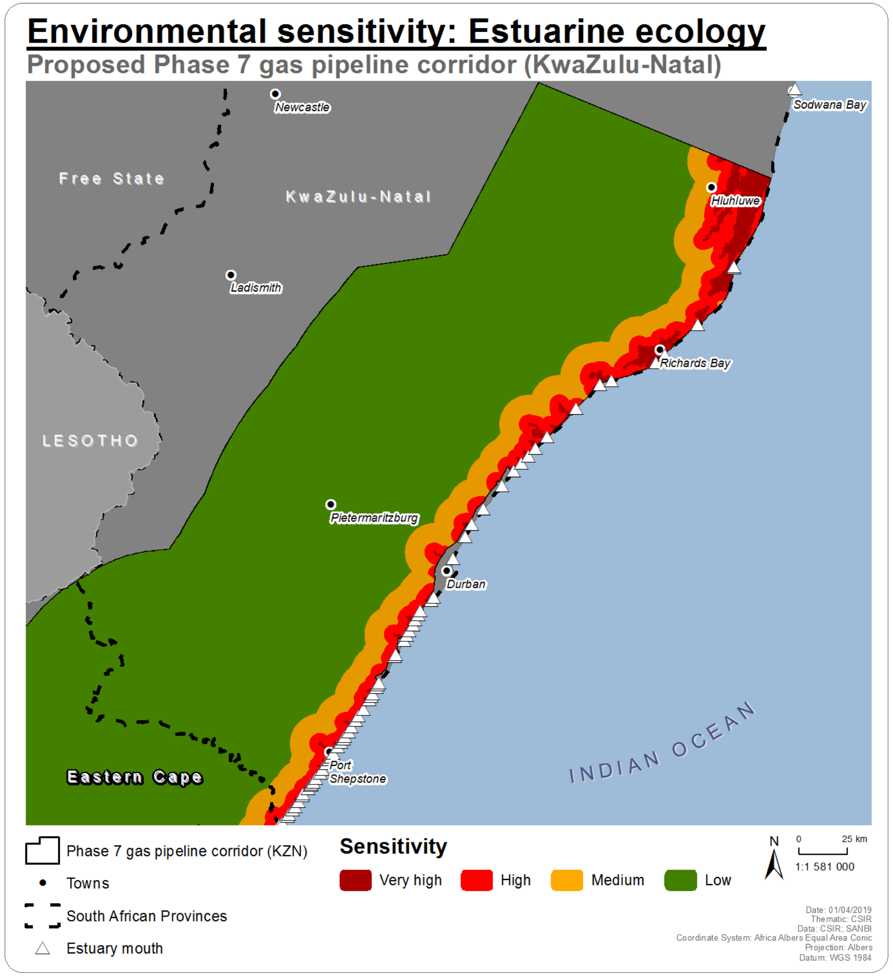


Figure 55: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development in the Phase 7 (KwaZulu-Natal) corridor.

5.2.7 Phase 4

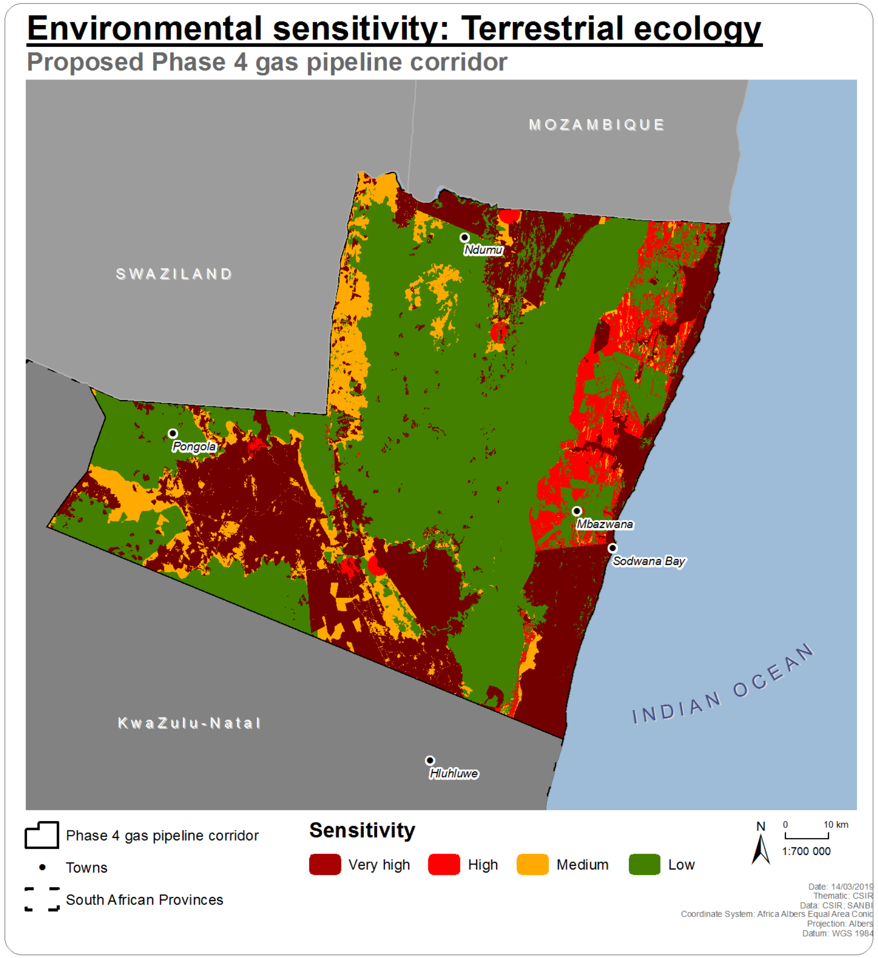


Figure 56: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 4 corridor.

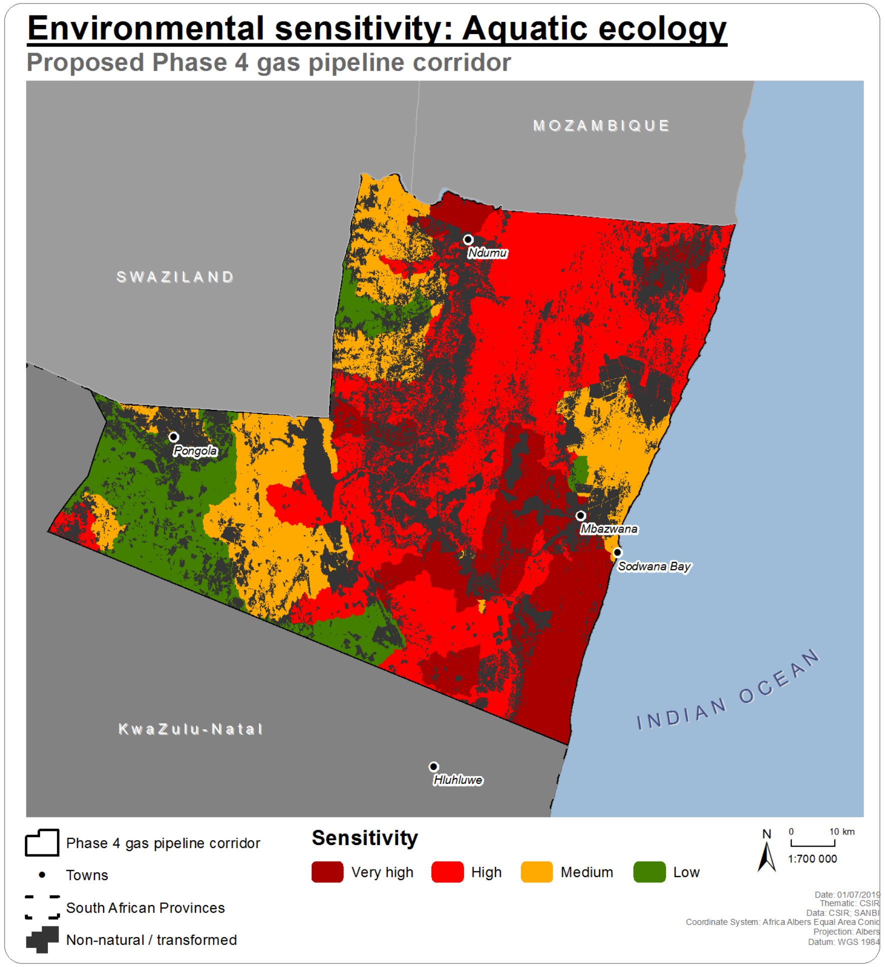


Figure 57: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 4 corridor.

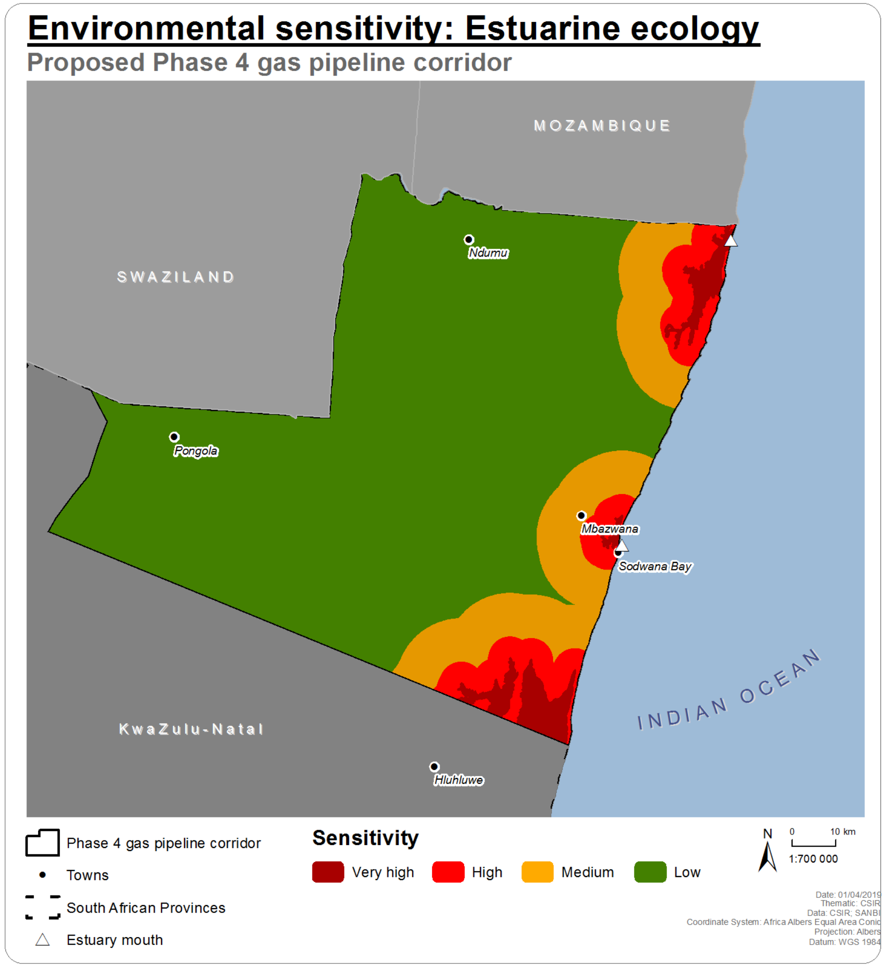


Figure 58: Environmental sensitivity of estuarine ecosystems to proposed gas pipeline development in the Phase 4 corridor.

5.2.8 Phase 3

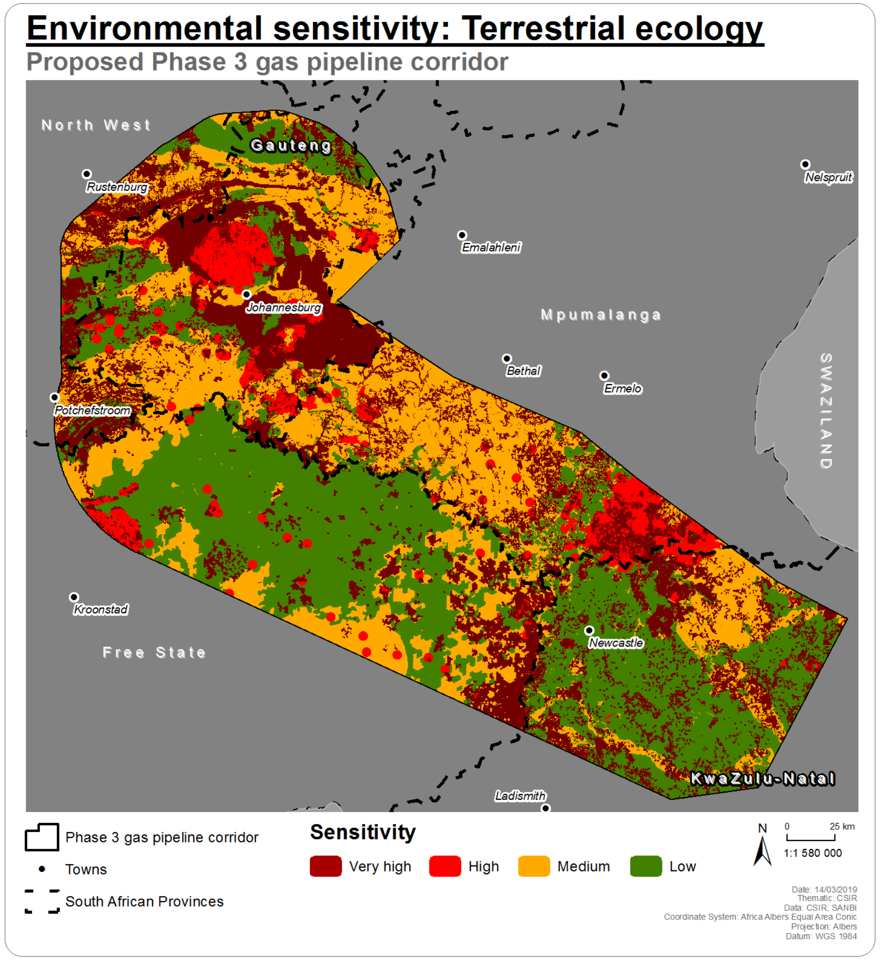


Figure 59: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 3 corridor.

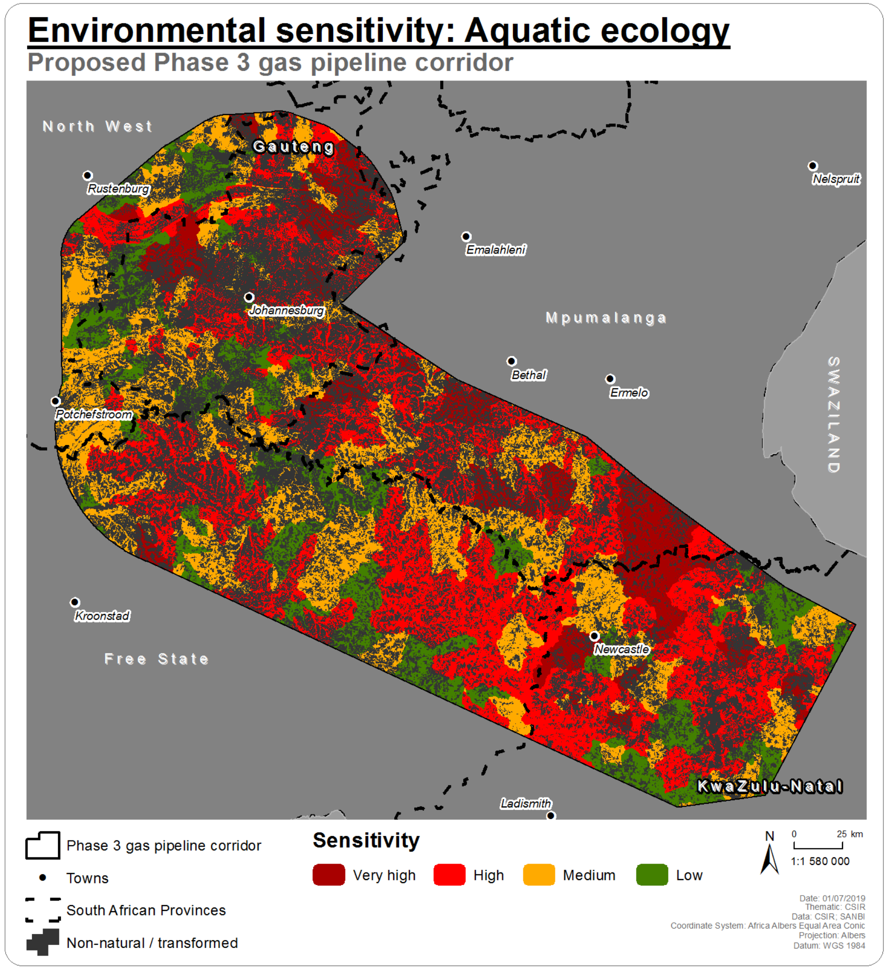


Figure 60: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 3 corridor.

5.2.9 Phase 8

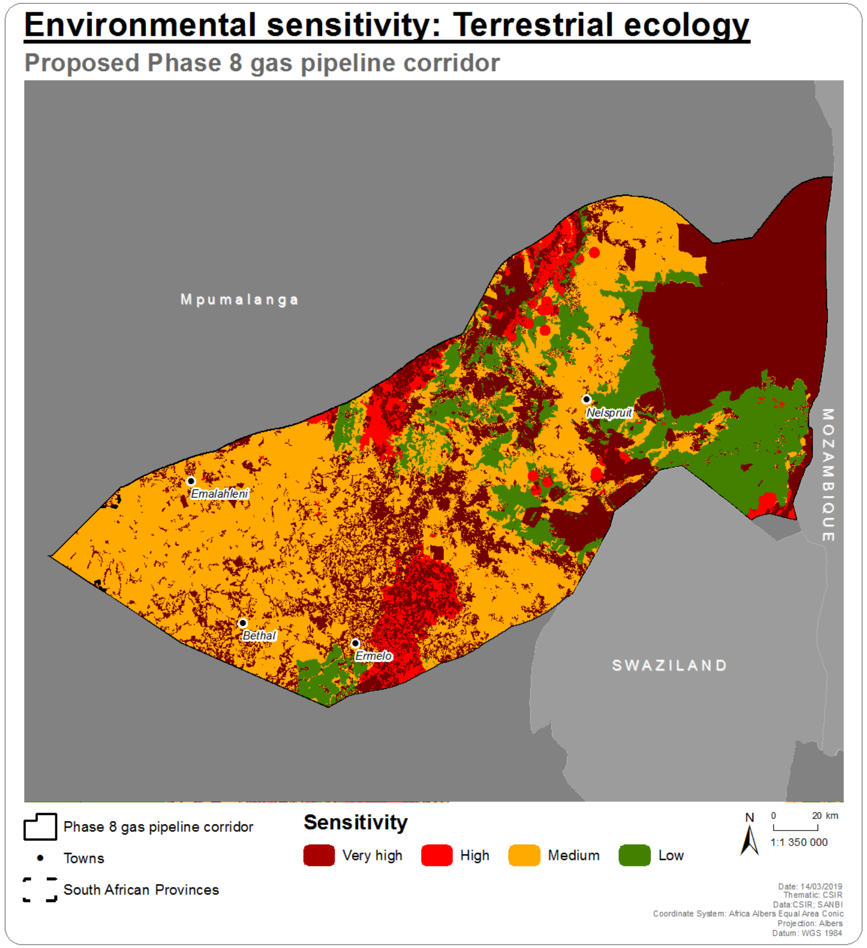


Figure 61: Environmental sensitivity of terrestrial ecosystems to proposed gas pipeline development in the Phase 8 corridor.

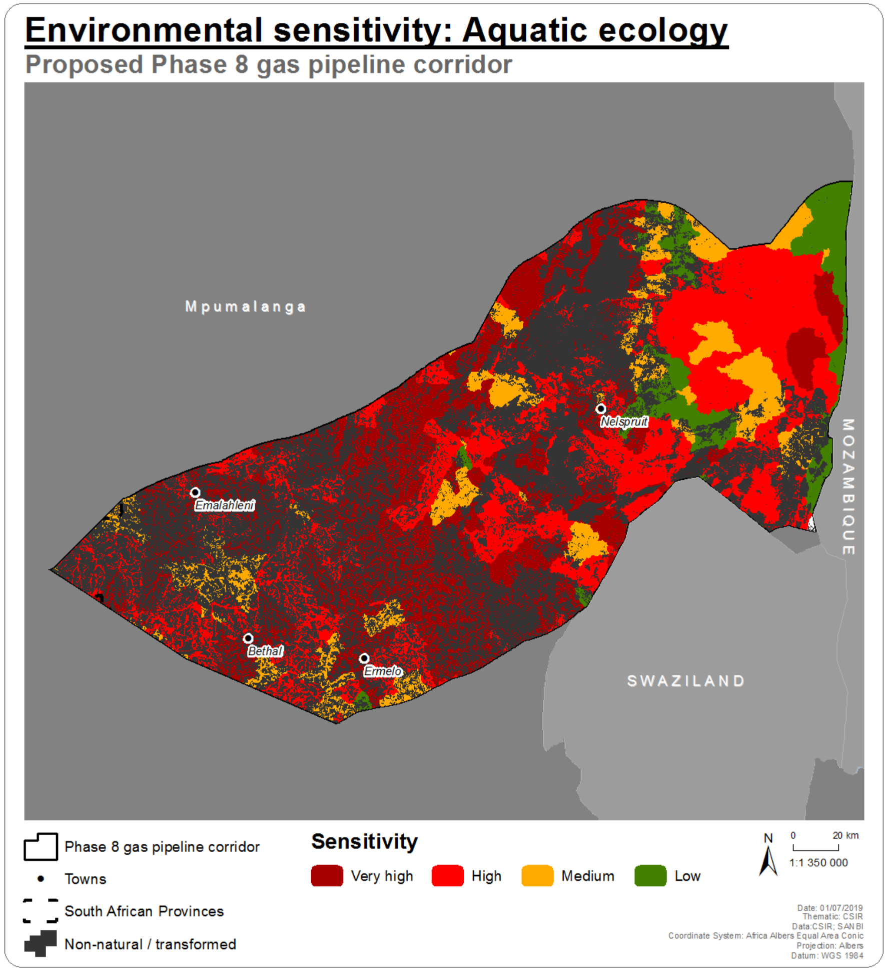


Figure 62: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed gas pipeline development in the Phase 8 corridor.

6 KEY POTENTIAL IMPACTS AND THEIR MITIGATION

The potential impacts of gas pipeline development are summarised as three key impacts to terrestrial ecosystems (Section 6.1) and four key impacts to aquatic ecosystems (Sections 6.2.1 – 6.2.4 - freshwater; Sections 6.2.5 - 6.2.8 - estuaries) (Table 26).

Table 26: Summary of the key impacts from gas pipeline development, and the development phase in which the consequences of the impacts are expected to manifest.

Impact	Phase		
	Construction	Operation & maintenance	Post-closure & rehabilitation
TERRESTRIAL ECOSYSTEMS			
Physical disturbance to soils, fauna and flora	x	x	
Establishment and spread of IAPs	x	x	
Ecosystem alteration and loss	x	x	x
AQUATIC ECOSYSTEMS			
Degradation and loss	x	x	
Reduction in habitat quality	x	x	
Hydrological alteration	x	x	
Water quality deterioration	x	x	x

The NEMA calls for the widely recognised mitigation hierarchy (avoid, mitigate/manage, rehabilitate, offset) (Figure 63) to be implemented to minimise or negate negative impacts, and maximise positive impacts of infrastructure development.

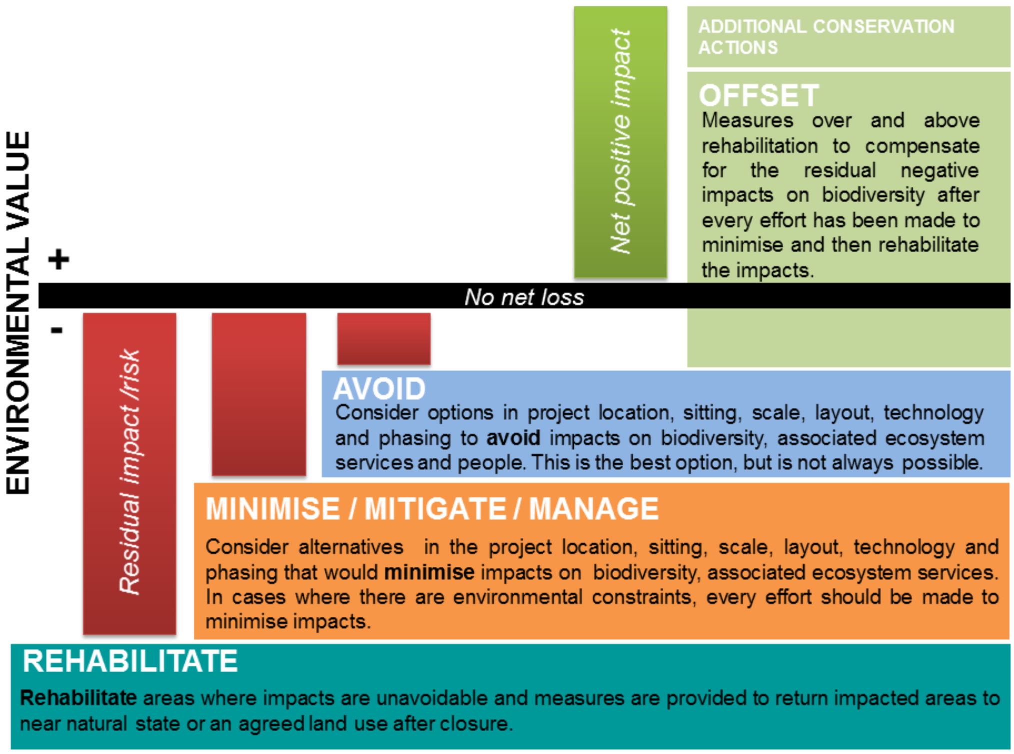


Figure 63: Implementation of the mitigation hierarchy is encouraged to ensure more sustainable and responsible development (after Rio Tinto, 2013).

6.1 Terrestrial ecosystems

6.1.1 KEY IMPACT 1: PHYSICAL DISTURBANCE TO SOILS, FLORA AND FAUNA

6.1.1.1 Drivers and consequences

Physical disturbance to soils, flora and fauna may be caused by the following activities associated with gas pipeline development:

- Arrival and movement of construction and operational personnel, vehicles and heavy equipment en route to and on site;
- Construction activities, including trenching, blasting, and drilling;
- Open trenches;
- Removal and disturbance of vegetation;
- Changes to surface stormwater runoff patterns and soil erosion where roads and other infrastructure is established;
- Exclusion of deeper-rooted vegetation from the pipeline route and the access routes;
- Potential oil and fuel spills from equipment and vehicles;
- Gas leaks and explosion, in the event unlikely of infrastructure failure during the operational phase.

The consequences of physical disturbance to soils, fauna and flora include:

- Loss of biodiversity;
- Establishment and invasion by IAPs (also see Key Impact 2, Section 6.1.2);
- Direct loss of foraging habitat and shelter for fauna (also see Key Impact 3, Section 6.1.3);
- Loss of SCC;
- Nuisances which may cause changes to fauna behaviour and movement:
    - Noise;
    - Dust; and
    - Vibration.
- Poaching, collection of plants and animals that are collectable or have indigenous/medicinal uses;
- Entrapment of animals open trenches (which could then have fatal consequences as a result of drowning in pools of collected water, dehydration, or starvation);
- Possible ensnarement of animals or ingestion of materials (e.g. cables), waste and litter (e.g. plastic) that are left on site;
- Road mortalities;
- Reduced movement and mortalities of sub-surface fauna (e.g. moles) due to soil compaction;
- Altered hydrological patterns, drainage and runoff movements;
- Loss of topsoil and changes in terrain morphology;
- Habitat fragmentation;
- Disrupted ecosystem services; and
- Declined ecosystem resilience.

6.1.1.2 Mitigation

Planning and pre-construction

AVOID

- Use of **environmental sensitivity maps** in the routing design;
- **Avoid**, as far as possible, **High and Very High sensitive areas, which may also contain valuable species,** during the route planning;
- **Avoid**, as far as possible, **crossing key migration or movement corridors for fauna** during the route planning;
- **Avoid** any construction on **steep slopes** (>25 degrees); and

- **Avoid areas of high erosion vulnerability** as far as possible.

MINIMISE / MITIGATE / MANAGE

- Design to **use common/shared infrastructure** as far as possible with development in nodes, rather than sprawling development;
- **Undertake specialist assessments:**
  - Where avoidance is not possible, in areas of Moderate to Very High sensitivity undertake specialist faunal and plant species assessments to propose site-specific mitigation or recommend alternatives prior to finalising the route; and
  - Undertake specialist surveys or inspections to establish/confirm whether threatened or endemic species are present in areas of lower sensitivity. If populations of threatened or endemic species are encountered and unavoidable then specialist inputs should be obtained.

Construction

AVOID

- **Avoid the roosts nests and burrows sensitive faunal species** (e.g. porcupines, aardvarks) and **establish sensitivity buffers** where they are in the vicinity;
- **Avoid** construction activities in the **breeding and/or migration seasons** of threatened and important taxa;
- **Avoid unnecessary vegetation clearing**;
- **Prohibit collection of 'fuel wood'** on site;
- **Prohibit poaching of animals, or illegal collection of rare species**. All instances of illegal collection should be reported to the applicable provincial Nature Conservation Authorities;
- **No dogs or other pets** should be allowed on site.

MINIMISE / MITIGATE / MANAGE

- **Undertake construction activities in short phased stretches** and continuously rehabilitate as sections are complete;
- **Minimise the development footprint and physical extent**;
- **Clearly demarcate the construction footprint;**
- **Keep the duration of the activities on-site to a minimum** - complete them in as short a time as possible;
- **Construction activities should take place outside of peak rain seasons** as much as possible;
- **Develop community environmental education programs** to ensure that all staff understand that no plants and animals may be intentionally harmed, killed, poached, or collected. Also **monitor staff behaviour** and **sanction transgressions.**
- Specialist inspection of proposed micro-sited route prior to clearing of vegetation and breaking of ground to **ensure no animal burrows, nests, and roosts are harmed**;
- **Flushing or active capture and removal of key faunal species** from the working area;
- If roads or structures are fenced, **use fencing that allows safe animal movement** through fences;
- **Electrical fences**, if installed, should be erected **at least 30 cm from the ground** or according to relevant norms and standards of Nature Conservation Authorities;
- **Equip open trenches with suitable ramps, ladders or steps** every 50 m so that trapped animals can escape;
- **In areas where there is high animal activity, fine-mesh fences should be laid out around the open section** and secured to minimise the likelihood that animals will fall in;
- Do **daily patrols to rescue trapped animals**;
- **Ensure that rare and endangered species are not buried** under the temporary soil dumps;
- **Use plant rescue to remove and relocate rare plants** in construction footprint;
- **Control dust** to minimise impacts by regulating vehicle speeds and using geotextiles, particularly on soil dumps;

- **Control soil erosion and sediments in runoff** through appropriate drainage and erosion control structures to minimise impacts on rivers and wetlands (e.g. barriers, geotextiles, active rehabilitation);
- **Where the pipeline cuts through unstable soils** (e.g. sodic soils) ensure that adequate interventions are taken to prevent erosion and piping;
- **Take care where the pipeline crosses dynamic swelling and contracting soils** (e.g. vertic soils) ensure that soil movement does not cause damage to the pipeline resulting in further secondary environmental damage;
- **Limit vehicle speeds** to minimise potential collisions with animals and dust creation;
- **Limit night driving**;
- **Use existing roads** as far as possible for access;
- Provide new **roads with run-off structures**;
- **Prevent fuel or oil leaks and make provision to contain them** (e.g. in drip trays) to reduce risk of contamination of surrounding soil and water.

Operations and maintenance

MINIMISE / MITIGATE / MANAGE

- **Limit vehicle speeds** to minimise potential collisions with animals and dust creation;
- **Surveillance and monitoring of potential poaching and illegal species collection** (e.g. snares, debarking, hunting); and
- **Employ all technical measures to reduce the likelihood of infrastructure failure** (e.g. sensors for loss of pressure as well as automatic cut off valves; prevent deep-rooted plant species establishing directly above the pipeline).

Post-construction and rehabilitation

REHABILITATE

- **Return the area to as near natural a state as possible**, with natural processes such as fire being retained;
- **Harvest seed before top soil removal** where necessary;
- **Retain rootstock of existing vegetation** where possible[3];
- **Maintain top soil for later rehabilitation;**
- **Replace soil in the sequence it was extracted** – this should be carried **out within a month of excavation**. This not only limits changes in the soil, but ensures that the exposed area of the trench, a potential trap for animals, is minimised;
- **Rehabilitate using locally indigenous plant species** (including any harvested seed and/or rootstock). Where feasible translocate savage plants. Where not feasible use a seed mix that includes both annuals and perennials;
- **Stabilise all slopes and embankments**;
- **Re-establish ecological connectivity** where fragmentation of key habitats has occurred using landscape design methods (e.g. over and under pass wildlife bridges); and
- **Develop an Open Space Management Plan**, which makes provision for favourable management of the infrastructure and the surrounding area for fauna.

[3] Savanna trees, particularly, have an incredible ability to sprout from felled trees and hence can re-colonise the area much faster than new seedlings.

6.1.2 KEY IMPACT 2: ESTABLISHMENT AND SPREAD OF ALIEN INVASIVE PLANTS

6.1.2.1 Drivers and consequences

Machinery and people can actively introduce and spread IAP propagules[4] on site (e.g. in the form of mud encrusted onto excavators or trucks). Construction materials, especially sand, stone and gravel from quarries can include propagules so all such materials should only be sourced from quarries or borrow pits which are free of invasive species.

Consequences related to the establishment and invasion by IAPs include:

- Alteration, reduction and loss of the effective habitat of a number of indigenous rare or endangered species.

6.1.2.2 Mitigation

Planning and pre-construction

AVOID

- **Incorporate, and budget for, control of invasive species** in environmental management plans for the construction, operation and decommissioning phases of the pipeline;
- **Identify and map IAPs** along and within the planned route prior to construction;
- **Prepare systematic and properly costed plans for invasive species control** for sections of the proposed route;
- **Avoid off road driving**; and
- **Carry out initial control measures prior to the construction.**

Construction

AVOID

- **Avoid unnecessary disturbance** of plant cover and topsoil;
- **Avoid off road driving**; and
- **Do not use soil sources contaminated with IAP seeds** for bedding of the pipe or for construction work.

Box 22: Invasive Alien Plants in the Fynbos Biome

Many of the Fynbos invaders are woody plants which have deep roots and would have to be controlled if they established in the pipeline servitude.

Alien grasses are particularly aggressive invaders in the Sand Fynbos and Renosterveld communities and possibly also the Strandveld communities.

Studies of invasive species control measures have shown that eradication of a species cannot be achieved except in the initial stage of establishment. Therefore, effective control in this context should be that IAP species cover within the pipeline servitude is reduced to, and maintained at, less than 5% canopy cover.

[4] Any parts or life stages of organisms which could enable them to establish new populations.

MINISMISE / MITIGATE / MANAGE

- **Environmental education programmes on IAPs** for staff to assist in the identification of existing and potential invasive species that may affect the servitude;
- **Use existing roads** as far as possible for access;
- **Ensure that machinery is properly cleaned** before being brought onto site and also before moving it from a section of the route where invading species were controlled to a section that is free of invading species;
- **Minimise imports of materials that could contain propagules of invasive species**, particularly plants and/or screening such materials to ensure they are propagule free;
- **Remove IAPs before they set seed** on or in vicinity of construction site; and
- **Dispose of all the cut plant material from site** immediately using carefully considered and suitable methods that are in compliance with relevant legislation and based on consultation with experts, as required.

Operations and maintenance

MINIMISE / MITIGATE / MANAGE

- **Develop and implement an Alien Invasive Species Management Plan**, which makes provision for regular alien clearing and monitoring.
- **Carry out regular surveys to identify invading species**; where they are found, carry out the necessary control operations;
- **Regular** (at least bi-annual) **IAP control** using the most appropriate and specific measures to control exotic species that have established (e.g. herbicides, fire, manual removal).
- **Ensure that appropriate follow-up operations are continued until the invading species are effectively under control;**
- **If and when the pipeline is replaced, then follow the same procedures as for the construction**;
- **Avoid off road driving**; and
- **Keep all livestock out of rehabilitated areas**.

Post-construction and rehabilitation

REHABILITATE

- **Ensure that appropriate follow-up operations are continued until the invading species are effectively under control;**
- **Avoid off road driving;**
- **If/when the gas pipeline is closed ensure that any invasions are controlled as part of the closure processes.** As part of the hand-over process, ensure that the land-owner's responsibility to maintain the cleared areas is acknowledged in writing.

6.1.3 KEY IMPACT 3: ECOSYSTEM ALTERATION AND LOSS

6.1.3.1 Drivers and consequences

Physical disturbance to soils, fauna and flora (Key Impact 1), and IAP establishment and spread (Key Impact 2) can ultimately manifest as ecosystem alteration and loss. It is also associated with the:

- Introduction of non-local genetic stock;
- Exclusion of deeper-rooted vegetation from the pipeline route and the access routes; and
- Partial or complete failure to achieve effective rehabilitation.

Consequences of ecosystem alteration and loss include:

- Changes in local habitat features and ecological processes;
- Changes in habitat suitability for local species;
- Reduction/loss in endemic and rare species populations;

- Transformation of intact habitat within a CBA. CBAs are areas required to meet biodiversity targets for ecosystems, species or ecological processes, as such development in these areas is discouraged;
- Transformation of habitat within an ESA. ESAs are areas that are not essential for meeting biodiversity targets, but play an important role in supporting the ecological functioning in a CBA;
- May affect the suitability of certain areas for inclusion in NPAES;
- Local or global extinction;
- Changes in species movements, abundance and distribution,
- Changes in ecosystem functions, interactions, and resilience;
- Decline in ecosystem services;
- Soil erosion;
- Habitat fragmentation; and
- Exposure of adjacent communities to unfavourable edge effects (susceptibility to invasions by alien species).

6.1.3.2 Mitigation

Planning and pre-construction

AVOID

- **Avoid CBAs** as far as possible;
- **Avoid impact to restricted and specialised habitats** such as cliffs, large rocky outcrops, quartz, pebble patches and rock sheets;
- **Use environmental sensitivity maps in routing design**;
- Design and layout of infrastructure to **avoid**, as far as possible **highly sensitivity areas**;
- **Conduct ground assessments** and verification before construction;
- **Design to use as much common/shared infrastructure** as possible with development in nodes, rather than spread out; and
- **Avoid**, as far as possible, construction on **steep slopes** (> 25 degrees).

Construction

MINIMISE / MITIGATE / MANAGE

- **Minimise construction in ESAs** as far as possible;
- **Locate temporary-use areas such as construction camps and lay-down areas in previously disturbed areas** as far as possible;
- **Obtain expert inputs on appropriate rehabilitation techniques and species choices** to ensure that ecosystem structure and function recover;
- **Rapidly rehabilitate** the area to pre-construction conditions where possible;
- **Replace top soil (seed bearing soil) as soon as possible;**
- **Control dust** to minimise impacts by regulating vehicle speeds and using geotextiles, particularly on soil dumps.
- **Ensure proper runoff management and erosion control**, especially on steeper slopes.

Operations and maintenance

- **Control dust** to minimise impacts by regulating vehicle speeds and using geotextiles, particularly on soil dumps.

Post-construction and rehabilitation

- **Obtain expert inputs on appropriate rehabilitation techniques and species choices** to ensure that ecosystem structure and function recover;
- **Rapidly rehabilitate** the area to pre-construction conditions where possible;
- **Replace top soil (seed bearing soil) as soon as possible**;
- **Planting of plant stock and reseeding should be timed to maximise the likelihood of successful recruitment** (e.g. do not revegetate after the end of spring);
- **All plant stock and seed must be from local populations** (or for example where seeds/rootstock were harvested before topsoil removal), whenever possible avoid introduction of non-local genetic material;
- **Use material from that section of the route in its rehabilitation** or, where this is not feasible, **from a source community matched as closely as possible**, excluding Very High sensitivity areas; and
- Wherever there is an evident change in the vegetation or community (i.e. between two neighbouring vegetation communities / types), **keep the rehabilitation material for each community's section separate to minimise introduction of non-local genetic stock.**

Box 23: Environmental Offsets

"Environmental / Biodiversity Offsets" are often promoted as a means of redressing the apparent disturbance or "loss" of natural habitat or systems. The benefit and success of offsets has yet to be proven (Bull et al., 2013) and is a debatable topic.

Offsets should not be considered as a first management/mitigation option, and should be avoided unless absolutely necessary.

Calculating, identifying and successfully establishing a suitable offset can be a complex and costly undertaking with no guarantee of success. Other forms of Offsets are also considered by various authorities, including financial contributions and stewardship programmes or partnerships with conservation authorities. Given the strategic importance of the proposed pipeline, the latter option may be the most practical offset strategy, if the offset approach is adopted.

Box 24: Potential impacts to Birds and bats

Birds

The potential negative impacts on **birds** by the proposed gas pipeline can be summarised as:

- Direct mortality due to the destruction of nests in the construction servitude;
- Displacement due to disturbance during the construction of the pipeline and associated infrastructure (compressor/pump stations); and
- Displacement of breeding individuals through habitat transformation.

Although the 50 m wide construction servitude will be revegetated through a process of vegetation rehabilitation and natural colonisation, a 10 m wide servitude will remain to provide access for maintenance. In the case of access roads, the transformation will be permanent. However, where possible, shallow rooted plants/crops can be allowed to re-grow in the 10 m wide servitude. No service road is planned to be built along the pipeline.

Assessment and mitigation measures specific to avifauna

- Nest surveys by a suitably qualified avifaunal specialist to identify all active nests in the servitude and immediately adjacent areas prior to the commencement of the servitude clearing.
- On discovery of a nest, the avifaunal specialist must be provided with a work schedule which will enable him/her to ascertain, if, when and where the breeding birds could be impacted by the clearing activities. Appropriate management measures would need to be implemented, the nature of which will depend on the conservation status of the species and the location of the nest.

Each case will have to be dealt with on an ad hoc basis but could include the following:

- Remove eggs and/or chicks to rehabilitation facility if the nest will be destroyed.
- If the nest falls outside the actual pipeline servitude, the timing of construction activities to avoid the disturbance of the breeding birds.

If the above assessment and mitigation measures are diligently adhered to, the risk that gas pipeline construction poses to avifauna can virtually be eliminated.

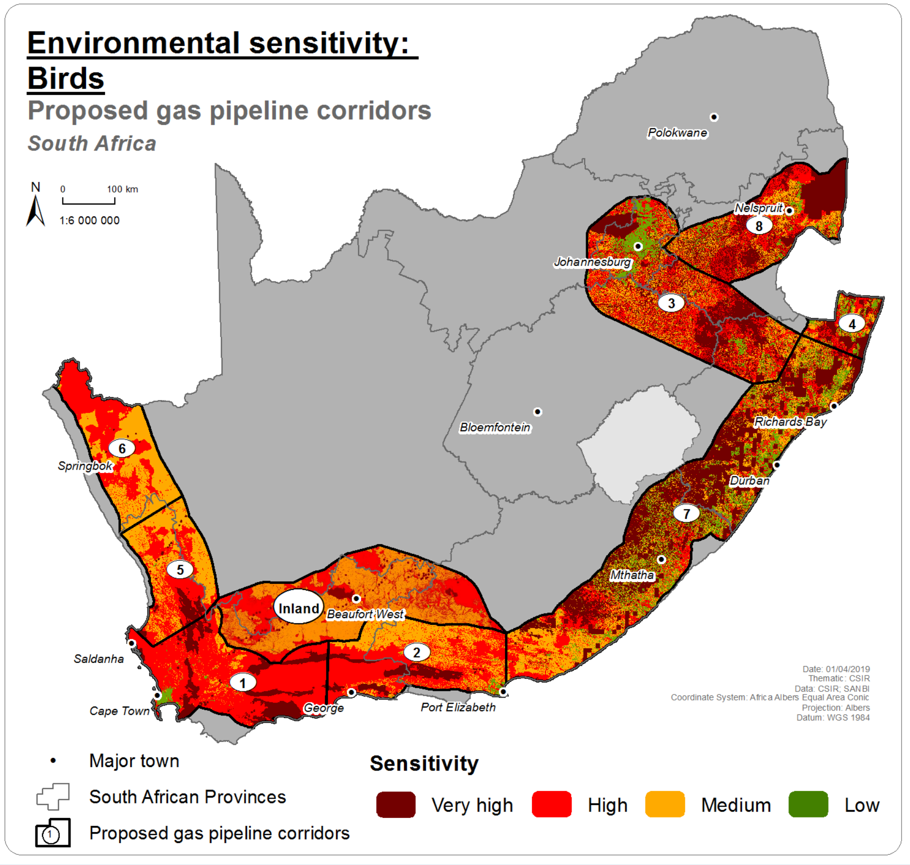


Figure 64: Bird sensitvitiy in the proposed gas pipeline corridors.

Bats

Construction activities, such as trenching, blasting and vehicle movement could cause noise, dust and vibrational disturbances to roosting **bat colonies**, especially during the breeding season from approximately October to March. These may lead to three key impacts to bats:

- Displacement and disturbance;
- Reduced foraging potential of habitats (through dust generation); and
- Reduction in habitat quality through the sedimentation of water bodies.

The best measure to avoid potential negative consequences for bats would be to avoid placing infrastructure in the vicinity of known and potential roosts, especially known large maternity roosts and near areas utilized by bats of conservation of importance. While species differ in their preferences, the following act as ideal habitats for bats to roost:

- Large trees or bush clumps;
- Caves and sinkholes;
- Rock crevices;
- Disused or old mining adits;
- Tunnels; and
- Dwellings/buildings with sufficient roosting space under roofs.

Additionally, bats require adequate surface water for feeding and drinking (Sirami et al., 2013; Lisóon and Calvo, 2014), particularly for insectivorous bats which hunt insects congregating above water bodies or wet soil.

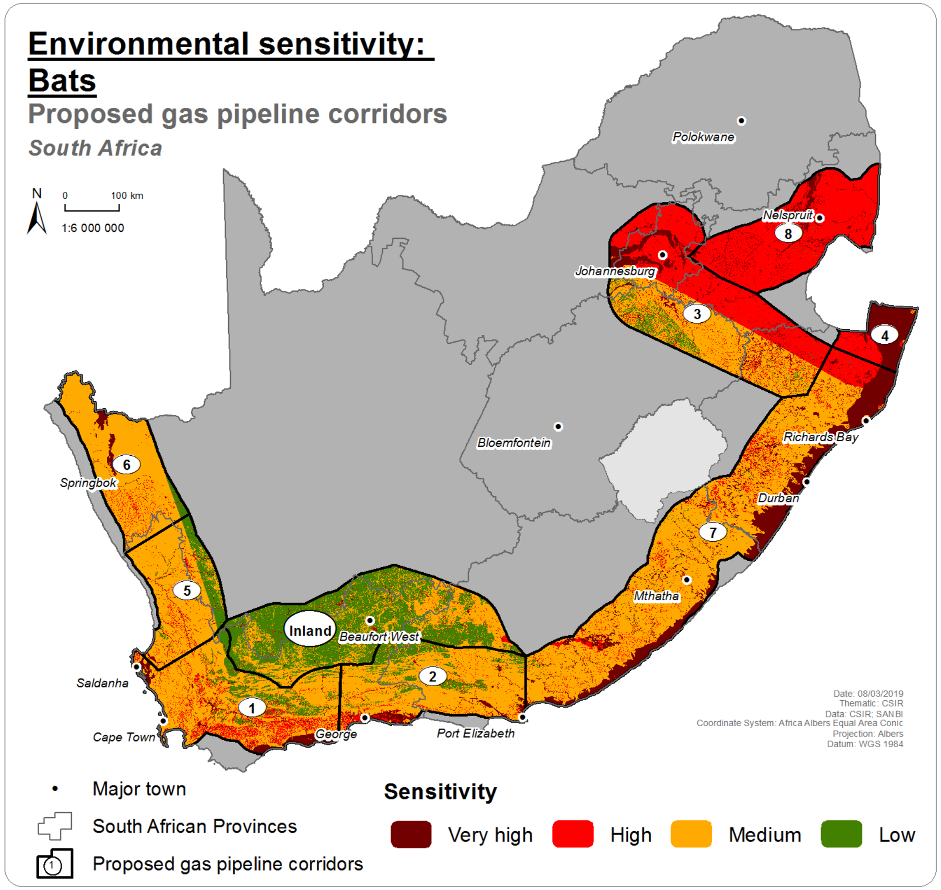


Figure 65: Bat sensitvitiy in the proposed gas pipeline corridors.

6.2 Aquatic ecosystems

6.2.1 KEY IMPACT 4: PHYSICAL DEGRADATION AND LOSS OF FRESHWATER ECOSYSTEMS

6.2.1.1 Drivers and consequences

Physical degradation and loss of freshwater ecosystems may be caused by the following activities associated with gas pipeline development:

- Placement of gas pipelines and pigging stations within ROWs, as well as construction camps, pipeline stockpiles, and access roads within or close to wetlands or rivers (including associated buffer habitat);
- Clearing or trimming of natural wetland or riparian vegetation;
- Clearing / infilling of wetlands and rivers and associated buffer habitat, potentially including threatened/ sensitive ecosystems;
- Workers and machinery operating within or in close proximity to wetlands or drainage lines, and through the establishment of construction camps or temporary laydown areas;
- Noise and vibration from and movement of construction teams and their machinery working within or in close proximity to wetlands and rivers; and
- Excavation of borrow pits for road construction acting as pitfall traps for amphibians and other terrestrial species leading to unnecessary death of species.

Consequences of physical degradation and loss of freshwater ecosystems include:

- Fragmentation of aquatic habitat;
- Soil erosion caused by loss of vegetation cover;
- Disturbance to and fatality of aquatic and semi-aquatic fauna;
- Stimulation of alien vegetation/invasive species;
- Loss of ecological functions and processes, freshwater biota (i.e. fauna and flora), and valuable ecosystem services; and
- Loss of ecosystem resilience and integrity through the disruption of biodiversity patterns and processes.

6.2.1.2 Mitigation

Planning and pre-construction

AVOID

- Gas pipeline routing to **avoid catchments with a very high sensitivity** as far as possible, and try to avoid catchments with a medium to high sensitivity.
- **Avoid clearing of sensitive indigenous vegetation,** as far as possible.

MINIMISE / MITIGATE / MANAGE

- Where highly sensitivity catchments area unavoidable, placement of pipeline infrastructure within these catchments (as well as catchments with a low sensitivity) should **avoid freshwater ecosystems and associated buffers**, which should be determined during route screening, validation and walk-throughs.
- **Ensure that a Water Use License (WUL) is undertaken where developments will occur within 500 metres of a wetland or 100 metres from a river** to authorise certain activities as per Section 21 of the National Water Act (Act 36 of 1998).
- **Use existing road networks and river crossings**, as far as possible.
    - Where it is not possible to utilise existing roads, **avoid and/or minimise road crossings through wetlands and rivers** as far as possible.
    - **Ensure that crossings are designed to minimise impacts**, as well as to ensure connectivity and avoid fragmentation of ecosystems, especially where systems are linked to a river channel.

- **Designs** to consider use of riprap, gabion mattresses, with pipe crossings or culverts.

- **Bank stabilisation measures** (gabions, eco logs, geofabric, sediment fences) are required when wetland or watercourse banks steeper than 1:5 are denuded during construction.

Construction

AVOID

- **All wetlands and watercourses should generally be** avoided (as far as possible) and appropriately demarcated as such.
  - No vehicles, machinery, personnel, construction materials, cement, fuel, oil or waste should be allowed into these demarcated areas without the express permission of and supervision by an on-site Environmental Control Officer (ECO).

MINIMISE / MITIGATE / MANAGE

- **Construction camps, ablution facilities, and temporary laydown areas should be located outside of the recommended buffer areas around wetlands and watercourses** and should be rehabilitated following construction.
- **Trenches/excavations should be backfilled and rehabilitated immediately after the pipes/pigging stations have been installed**, and should be done concurrently as the pipeline construction process progresses along the ROW.
- **Open trenches/excavations should be inspected daily** by an ECO
  - **Implement plans to rescue any vertebrate fauna that have become trapped within a trench/excavation.**
  - **Use low fences that will prevent fauna from entering the ROW**, especially in situations where trenches/excavations remain open for longer periods of time (i.e. a few weeks to several months).
- **All construction activities** (including establishment of construction camps, temporary lay-down areas, construction of haul roads and operation of heavy machinery), should ideally **take place during the dry season** to reduce potential impacts to freshwater ecosystems that are linked to rainfall-runoff.
- **Workers should be made aware** of the importance of not destroying or damaging the vegetation along watercourses and in wetland areas, of not undertaking activities that could result in the pollution of drainage lines or wetlands, and of not killing or harming any animals that they encounter. This awareness should be promoted throughout the construction phase and can be assisted through erecting appropriate signage
- **Fixed point photography to monitor vegetation changes and potential site impacts** occurring during construction phase

Post-construction and rehabilitation

REHABILITATE

- **Determine appropriate site-specific rehabilitation** approaches and methods;
- **Fixed point photography could be used to monitor** long-term vegetation changes and potential site impacts.
- **Active removal of alien vegetation/spraying to be guided by an IAP control programme** with long term monitoring.
- **Continuous erosion control.**

6.2.2 KEY IMPACT 5: REDUCTION IN AQUATIC HABITAT QUALITY

6.2.2.1 Drivers and consequences

Reduction in aquatic habitat quality may be caused by the following activities associated with gas pipeline development:

- Physical (natural wetland or riparian) vegetation clearing or trimming results in exposed soil vulnerable to erosion;
- Sedimentation of water courses and wetlands; and
- Excessive dust generation from road construction and vehicle traffic/haulage leading to impact on surrounding vegetation health and suspended solids/sediment entering nearby watercourses.

The consequences of reduction in aquatic habitat quality include the establishments of IAPs, the loss of ecosystem resilience through the disruption of ecological processes and thus a loss of ecosystem integrity.

6.2.2.2 Mitigation

Construction

AVOID

- ➢ **Avoid clearing sensitive vegetation** (especially indigenous vegetation from high and very highly sensitive environments).

MINIMISE / MITIGATE / MANAGE

- ➢ **Minimise disturbance to surrounding vegetation** as soon as possible when construction activities are undertaken, as intact vegetation adjacent to construction areas will assist in the control of sediment dispersal from exposed areas.
- ➢ **Implement dust suppression methods** (e.g. spraying surfaces with water) to minimise the transport of wind-blown dust.
- ➢ **Ensure adequate watercourse crossings** (i.e. culverts of the correct specification) are designed where roads traverse these areas so that the concentration of flow (particularly during high flow conditions) is minimised as far as possible.

Post-construction and rehabilitation

REHABILITATE

- ➢ **Roads/crossings not needed after the construction process should be decommissioned and rehabilitated** in accordance with detailed rehabilitation plans.
- ➢ **Fixed point photography could be used to monitor** long-term vegetation changes and potential site impacts.
- ➢ **Active removal of alien vegetation/spraying to be guided by an IAP control programme** with long term monitoring.
- ➢ **Continuous erosion control.**

6.2.3 KEY IMPACT 6: ALTERED HYDROLOGY

6.2.3.1 Drivers and consequences

Hydrological alteration is mainly caused by interrupted surface and/or subsurface water flows, as well as the concentration of water flows due to roads traversing wetlands or rivers.

Flow changes result in degradation of the ecological functioning of aquatic ecosystems that rely on a specific hydrological regime to maintain their integrity, which also leads to geomorphologic impacts within systems.

6.2.3.2 *Mitigation*

Planning and pre-construction

AVOID

- **Use existing road networks and river crossings**, as far as possible.
  - Where this is not possible, **avoid and/or minimise road crossings through wetlands and rivers as far as possible.**

MINIMISE / MITIGATE / MANAGE

- **Minimise the number of watercourse crossings** for access roads.
- **Ensure adequate watercourse crossings** (i.e. culverts of the correct specification) are designed where roads traverse these areas so that the concentration of flow (particularly during high flow conditions) is minimised as far as possible.

6.2.4 KEY IMPACT 7: WATER QUALITY DETERIORATION

6.2.4.1 *Drivers and consequences*

Water quality deterioration may be caused by the following activities associated with gas pipeline development:

- Stockpiling of materials and washing of equipment within or in close proximity to wetlands or watercourses;
- Runoff of contaminants such as fuel, oil, concrete, wash-water, sediment and sewage into these ecosystems;
- Application of herbicides.

The consequences of water quality deterioration includes the loss of ecosystem resilience through the disruption of ecological processes and thus a loss of ecosystem integrity. Furthermore, pollution (water quality deterioration) of freshwater ecosystems and potential contamination of groundwater/subsurface drainage may lead to bioaccumulation or poisoning of fauna and flora.

6.2.4.2 *Mitigation*

Planning and pre-construction

AVOID

- **Use existing road networks and river crossings**, as far as possible.
  - Where this is not possible, **avoid and/or minimise road crossings through wetlands and rivers as far as possible.**

MINIMISE / MITIGATE / MANGE

- **Minimise the number of watercourse crossings** for access roads.
- **Ensure adequate watercourse crossings** (i.e. culverts of the correct specification) are designed where roads traverse these areas so that the concentration of flow (particularly during high flow conditions) is minimised as far as possible.

Construction

AVOID

- **No washing of vehicles and machinery within 30 metres** of the edge of any wetland or watercourse.
- **No fuel storage, refuelling, vehicle maintenance or vehicle depots should be allowed within 30 metres** of the edge of any wetlands, rivers or drainage lines.

- **No effluents or polluted water should be discharged** directly into any watercourse or wetland areas.
- **No spoil material, including stripped topsoil, should be temporarily stockpiled within 30 m of the edge of any wetland or drainage line**.
  - Freshwater ecosystems located in close proximity to construction areas (i.e. within ~30 m) should be inspected on a regular basis by the ECO for signs of disturbance from construction activities, and for signs of sedimentation or pollution. If signs of disturbance, sedimentation or pollution are noted, immediate action should be taken to remedy the situation and, if necessary, a freshwater ecologist should be consulted for advice on the most suitable remediation measures.

MINIMISE / MITIGATE / MANAGE

- **Restrict construction activities** associated with the establishment of access roads through wetlands or watercourses (if unavoidable) **to a working area of ten metres in width either side of the road**.
  - **Clearly demarcate these working areas.**
  - **No vehicles, machinery, personnel, construction material, cement, fuel, oil or waste should be allowed outside of the demarcated working areas.**
- **Refuelling and fuel storage areas, and areas used for the servicing or parking of vehicles and machinery, should be located on impervious bases** and should have bunds around them. Bunds should be sufficiently high to ensure that all the fuel kept in the area will be captured in the event of a major spillage.
- **If construction areas are to be pumped of water (e.g. after rainfall), this water should be pumped into an appropriate settlement area**, and not allowed to flow straight into any watercourses or wetland areas.

Operations and maintenance

AVOID

- **Avoid the use of herbicides within 50 m** of wetlands or rivers.

6.2.5 KEY IMPACT 8: ESTUARINE HABITAT DESTRUCTION.

6.2.5.1 Drivers and consequences

Habitat destruction, and loss of estuarine and riparian habitat (e.g. mangroves, saltmarshes, reeds, swamp forest), may be caused by the following activities associated with gas pipeline development within and around the EFZ:

- Removal of the natural vegetation in and around an estuary during the construction phase;
- Movement of heavy vehicles and machinery during construction within the ROW and the EFZ, riparian area and floodplain; and
- Ongoing vegetation clearing for access roads and the operational servitude.

Consequences of habitat destruction, and loss of estuarine and riparian habitat as a result of the above activities include:

- Degradation and reduction of ecological function and productivity of affected estuaries;
- Reduction of overall estuarine habitat, protection for biota and loss of nursery area;
- Establishment of IAPs (which can further alter estuarine functioning);
- Estuary bank erosion by tidal action and river flow and floods causing destabilisation of the estuary channel, mud- and sand bank habitat;
- Habitat losses may occur from secondary impacts. Increased sedimentation during construction and backfilling of the trench in the estuary could cause drying out of the riparian habitat and loss of estuarine and associated floodplain vegetation;

- Increased soil bulk density, reduced porosity, and reduced hydraulic conductivity due to soil compaction;
- Altered soil chemistry (reflected in soil pH, organic matter and nitrogen content) in the trenched area;
- Population and diversity reduction of estuarine invertebrates, fish and birds. For example, decreased mangrove areas will decrease overall estuarine productivity and abundance of invertebrates, which will affect food availability for fish and birds. This in turn will impact on estuarine nursery function and the productivity for estuarine and coastal fisheries;
- Unpredictable trophic network and knock-on impacts are likely. For example, decreased mangrove areas will decrease overall estuarine productivity and abundance of invertebrates, which will affect food availability for fish and birds;
    - This in turn will impact on estuarine nursery function and the productivity for estuarine and coastal fisheries. In addition, the disturbance of estuarine habitat often results in a change in ecological functioning, and can allow for the introduction of IAPs; which in turn can further negatively impact estuarine functioning.

6.2.6 KEY IMPACT 9: ALTERED ESTUARINE PHYSICAL AND SEDIMENT DYNAMICS

Estuaries are high energy environments and their channel morphology is highly dynamic. Estuarine channels can develop and migrate anywhere within the EFZ under the influence of tidal flows, river inflow and floods.

Stabilising sections of the estuary morphology or floodplain (which are naturally dynamic) through pipeline construction, pipeline installation and operation, as well as placement of pigging stations or block valves can lead to changes in long-term physical and sediment dynamics, i.e. disrupting channel and bed formation, altering sediment structure, changing estuary hydrodynamics, mouth dynamics, and ultimately catchment and marine connectivity. This can lead to altered functioning of a system and ultimately affect biota. Loss of estuarine productivity and connectivity in turn will reduce nursery function and associated fisheries value derived along the South African coast.

Over time migrating estuarine channels will expose pipeline infrastructure, changing flow velocities, and cause ongoing sediment erosion from such sites. This, in turn, can cause sediment deposition and accumulation in other parts of the estuary, causing drying out of the riparian zone, loss of water column habitat and can result in premature mouth closure if the tidal flows are constricted enough. Changes in estuarine physical dynamics will lead to altered estuary productivity and biodiversity.

Stabilizing or constricting natural channel migration will also ultimately increase flood risk to riparian properties as it will prevent estuarine channels from increasing in dimension under high flow and flood regimes. Natural flood attenuation processes in estuaries can therefore be detrimentally impacted. During large floods (1:10 to 1:100 year) most estuaries scour down to -20 to -30 m if not constrained by bed rock. This scour channel is filled in by post-flood sediment. Constructing a hard structure in the EFZ will disrupt this process.

It should also be noted that floods (in the case of estuaries the cumulative flow of the entire catchment) pose a significant risk to pipe failure and the destruction of associated pipe infrastructure. Failure in turn represents a risk of altered estuarine habitat (i.e. hard structures now exists where only soft bedforms should occur) and water quality risk (pollution).

Sediment eroding from a construction site and backfilling of the trench can cause sediment deposition and build-up in other parts of the estuary, causing drying out of the riparian zone, loss of water column habitat and premature mouth closure if the tidal flows become constricted (loss of marine habitat access). Changes in estuarine physical dynamics will lead to altered estuary productivity and biodiversity.

6.2.7 KEY IMPACT 10: DETERIORATION OF ESTUARINE WATER QUALITY

Estuarine water quality may deteriorate as a result of sediment disturbance, the removal of estuarine vegetation, or pollution events, which could result in the following during the construction and operational phases:

- decreased pH as a result of disturbance of the anoxic sediment profiles characteristic of estuaries;
- increased Total Dissolved Solids (TDS);
- increased Total Suspended Solids (TSS);
- increased organic matter content, and
- increased nutrient content.

The changes in estuarine water quality can have knock-on effects on the biota. Increased nutrient loading can cause algal blooms/eutrophication in an estuary, and, in turn, result in anoxia or hypoxia. Increased turbidity in clear water systems in turn can also lead to smothering of primary producers, disrupted predator-prey relationships and fish and invertebrate kills.

Disturbance of estuarine water quality results in a change in ecological functioning, and increases the risk of introduction and establishment of invasive alien species (vegetation, invertebrates and fish). Currently, deteriorating water quality in KZN estuaries is contributing to the establishment of floating invasive macrophytes in pest proportions as well as the spread of the invasive snail *Tarebia granifera* (Appleton et al., 2009, Van Niekerk and Turpie, 2011). Once established invasive species out compete indigenous species and disrupt ecosystem processes.

The likelihood of impacts arising might be reduced as operational impacts will largely be limited to periods when pipeline maintenance is taking place. Some long-term impacts (for example increased suspended solids) might occur as a result of the placement of the pipelines themselves. Similar knock-on effects to the estuarine biota described above might also be expected during the operational phase.

6.2.8 KEY IMPACT 11: ESTUARINE HABITAT FRAGMENTATION AND LOSS OF CONNECTIVITY

Estuaries are highly connected aquatic systems, with river inflow and tidal flows maintaining important circulatory processes and ensuring catchment and marine connectivity. Road infrastructure and construction activities can disrupt processes that support this connectivity, affecting the migration of invertebrates and fish across freshwater-estuarine-marine systems. Estuaries serve as nursery habitats for both estuarine and marine fish, as well as act as migratory destinations or stops for many birds as well.

Thus, road infrastructure and pipeline construction pose a direct (e.g. road through EFZ, pipeline construction cutting through an estuary) and indirect (e.g. prolonged mouth closure due to infilling of open water area) threat to estuarine connectivity and can increase habitat fragmentation.

Permanent roads (mainly associated with pigging stations), the operational servitude and pipeline infrastructure, and maintenance activities associated with long-term operation will disrupt processes that support estuarine connectivity, affecting the migration of invertebrates and fish across freshwater-estuarine-marine systems.

Furthermore, the cumulative impact of pipeline construction on a multitude of estuaries along a stretch of coast and the collective risk it poses to estuarine connectivity and functioning is a concern. While individual impacts may appear insignificant, the cumulative resulting shifts in estuarine physical process, connectivity and production can have unacceptable consequences.

6.2.8.1 Mitigation (for all impacts to estuarine ecosystems)

Planning and pre-construction

AVOID

- **Avoid**, as far as possible:
  - construction or ROW clearance in the EFZ.
  - road infrastructure within the EFZ.
  - pipeline infrastructure such as Pipeline Intelligence Gauge Stations (PIGS) within the EFZ.
  - trenching within the EFZ.
  - pipe jacking within the EFZ as the ground water table is shallow and variable in estuaries and required burial depths cannot be achieved with elevated water tables.
  - pipeline infrastructure within the 1:100 year potential estuarine bed scouring levels.

Construction

MINIMISE / MITIGATE / MANAGE

- **Preserve natural estuarine indigenous vegetation** such as mangroves and saltmarsh.
- **Adopt below ground pipe construction methods** (HDD rather than trenching).

If pipeline infrastructure cannot be avoided within the EFZ, opt for:

- **HDD with pipe buried at bed rock level or to depths of greater than 1:100 year potential bed scouring levels** (estimated to be on average deeper than 20 m, (Personal communication, Prof G Basson, Stellenbosch University, 2018).
- Suspending pipelines over the EFZ, use existing infrastructure where possible, e.g. existing road and rail bridges[5].

Operations and maintenance

MINIMISE / MITIGATE / MANAGE

- **Regular control of IAPs**
- **Monitor the condition of the infrastructure** (including any access roads regardless of surface type) to ensure that there is ongoing erosion occurring or exposed gas pipeline section.
- **Should the pipe become exposed, suspend operations, and establish the pipe at greater depths below ground** (using HDD) within 6 months, once sediment engineering studies have been done to confirm new burial depth.
- **Operational staff should be made aware of the sensitivities** of estuarine and freshwater environments.

[5] From a technical and safety perspective it is not feasible to suspend a gas transmission pipeline on an existing road or rail bridge.

Box 25: Rehabilitation of estuarine ecosystems

While disturbances from the construction of the pipeline may not be long-term, the restoration of altered habitat and recovery of invertebrate, fish and bird population can be prolonged (and is not assured). This depends on the overall complexity and health of the systems (Yu et al., 2010). There are no examples in South Africa of successful estuarine restoration following largescale degradation as has occurred in systems such as Nhlabane, Mhlanga, and St Lucia in KwaZulu-Natal. In most cases it has only been possible to restore a degree of functionality as reflected by the overall low estuarine health score.

Box 26: Other potential impacts to consider: conflict with conservation initiatives

The identification of areas outside of the formally protected areas and avoiding other areas of ecological importance in the biome is being identified as an important guideline for the identification of an appropriate route. While such an approach may be a rational one to the identification of such servitude from a contemporaneous perspective, such routing, depending upon where it is located does serve to constrain the expansion and connection of protected areas.

In the declaration of protected areas, it is clear that following the proclamation process, the pipeline and servitude itself will remain the property of a third party with differing management objectives to that of the conservation authority. In practical terms this state would mean that the requirement to maintain the servitude, conduct regular inspections, maintain access and undertake pipeline maintenance will create additional disturbances and constraints that may hinder the management of the protected area. For example, a case in point is the Opathe – Imfolozi corridor (IOCB), which is a long term initiative to link these two reserves for the benefit of land conservation and migration of larger fauna.

To avoid or reduce the likelihood of constraining protected area expansion, where this may apply, the utilisation or adherence to extensive buffer zones around protected areas may be successful mitigation as would the avoidance of placing the servitude between proximal protected areas, where connection and expansion is likely to form a conservation objective. Additionally, where feasible, it may be useful to align vegetation management programmes and objectives along the servitude with that of the conservation authority.

Box 27: The importance and effectiveness of Avoidance

Figure 66 illustrates the importance and effectiveness of using avoidance options as the favoured mitigation option. In this example, a patch of Northern Coastal Forest (near Park Rynie on the KZN South Coast) will be affected by a pipeline following the routings indicated in red. These forest patches will also be affected, but to a lesser degree, by the yellow alignment and completely unaffected by the green route alignment. In this case the forest patch is surrounded by sugar cane and any alignment outside of the forest footprint will significantly reduce the likelihood and consequences of potential impact, as such virually eliminating the risk of direct negative effects.

If avoidance cannot be achieved, other mitigation options may reduce the impacts slightly – such as plant rescue, revegetation and AIP management. Rehabilitation is not an option due to the pipeline being kept clear of deeper-rooted plants. As such, the forest cannot recover and will be permanently lost. This may not necessarily be a serious concern in other vegetation types however, the likelihood of remaining forests being disturbed (outside of protected areas) within the IOCB is considered to be highly likely. For this reason the reliance on rehabilitation based mitigation measures is cautioned, as in many cases they will not effectively mitigate the impact.

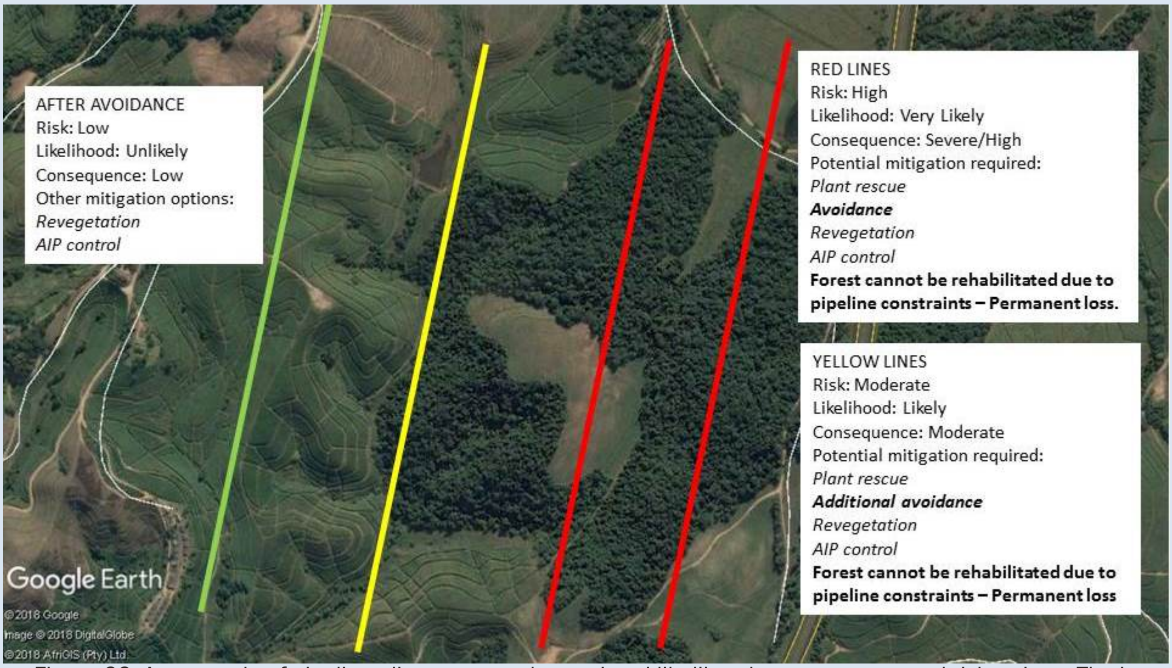


Figure 66: An example of pipeline alignments and associated likelihood, consequence and risk ratings. The image features a likely scenario, where forest habitat will be impacted within the IOCB.

7 RISK ASSESSMENT

7.1 Consequence levels

Table 27 presents the consequence levels assumed for this assessment for terrestrial, freshwater and estuarine ecosystems. This table should be perused when interpreting the risk assessment results (Section 7.2).

Table 27: Levels consequence that may result from impacts caused by gas pipeline development.

Slight	Moderate	Substantial	Severe	Extreme
TERRESTRIAL ECOSYSTEMS				
- No natural habitat is crossed. - <20% loss of coverage of an isolated natural habitat, forest or azonal vegetation type or any level of clearance of agricultural land, secondary vegetation and exotic vegetation. - No loss of an isolated population and affected individuals can move away freely/trapped individuals can be rescued and survival is a certainty. - Degree of IAP infestation in catchment of footprint = < 0.5%.	- Natural habitat impacted is of ‘Low’ sensitivity. - 20 to 40% loss of coverage of an isolated natural habitat, forest or azonal vegetation type. - No loss of an isolated population but affected individuals have limited opportunity to move away/trapped individuals can be rescued and survival is >50%. - Degree of IAP infestation in catchment of footprint = 0.5 - 2% of footprint.	- Any impact of 'Medium' sensitivity habitat caused by project activities. - 40 to 60% loss of coverage of an isolated natural habitat, forest or azonal vegetation type. - The loss of an isolated natural population where opportunity exists to rescue and relocate more than 50% of the affected individuals/or the loss of individuals due to the disturbance will be partial/ trapped individuals can be rescued but the potential for survival is 50%. - Degree of IAP infestation in catchment of footprint = 2 - 5%.	- Any loss of ' High’ sensitivity area caused by project activities. - 60 to 80% loss of coverage of an isolated natural habitat, forest or azonal vegetation type. - The loss of an isolated natural population where opportunity exists to rescue and relocate up to 50% of the affected individuals/trapped individuals can be rescued but the potential for survival is <50%. - Degree of IAP infestation in catchment of footprint = 5 - 10%.	- Any loss of Very High' sensitivity areas caused by project activities. - 80 to 100% loss of coverage of an isolated natural habitat, forest or azonal vegetation type. - The loss of an isolated natural population where no opportunity exists to save the individuals/trapped individuals cannot be rescued. - Degree of IAP infestation in catchment footprint > 10%

Slight	Moderate	Substantial	Severe	Extreme
FRESHWATER ECOSYSTEMS				
- No loss of riparian, river and wetland ecosystems - Impacts do not change aquatic systems in way that is discernible - Resource ecostatus class would not change - Limited in extent: Site specific - Readily reversible at any time and/or of short-term duration	- Some degradation in resource status/possible change in class - Some modification of riparian, river and wetland ecosystems - Readily reversible once activity ceased - Impacts will be well within the tolerance levels or adaptive capacity of the users (NWA) relying on the resource	- Marked degradation in resource status - Marked change in riparian, river and wetland ecosystems - Surface water impacts potentially reversible once activity ceases - Beyond the adaptive capacity of the users relying on the resource	- Considerable degradation in resource status - Considerable change in riparian, river and wetland ecosystems - Surface water impacts reversible only with human intervention over decades	- Total loss of riparian and wetland vegetation - Total loss of flora and fauna that inhabit wetland/river ecosystems and adjacent buffer/fringe habitats - Significant degradation in resource status - Resource impacts irreversible and remediation impractical

Slight	Moderate	Severe	Extreme
ESTUARINE ECOSYSTEMS			
- Limited modification in all zones. - Ecosystem attributes largely unmodified and little influence on other uses. - Small changes in natural habitats and biota in the area may occur, but the ecosystem functions are essentially unchanged. - Natural conditions and the resilience and adaptability of biota are not compromised. - Characteristics of the resource are determined by unmodified natural disturbance regimes. - Modification is of a temporary nature.	- Some modification in sensitive zones - Moderate modification in non-sensitive zones. - A loss and change of natural habitat and biota occurs, but the basic ecosystem functions are still predominantly unchanged. - Moderate modification of the abiotic template and exceedance of the resource base occurs of a permanent nature.	- Moderate modification in sensitive zones. - High modification in non-sensitive zones. - Largely modified. A large loss of natural habitat, biota and basic ecosystem functions occurs, with risk of modifying the abiotic template and exceeding the resource base. - Loss of well-being and survival of intolerant biota. Associated increase in the abundance of tolerant species does not assume pest proportions. - Modification is of a permanent nature.	- High modification in sensitive zones. - Extreme modification in non-sensitive zones. - Seriously and critically modified with loss of natural habitat, biota and basic ecosystem functions. - Modification is of a permanent nature.

7.2 Risk assessment results

7.2.1 Terrestrial ecosystems

Table 28: Summary risk assessment of physical disturbance to soils, flora and fauna to biodiversity and ecology in the proposed gas pipeline corridors.

Impact	Study area & topic	Sensitivity Class	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Key Impact 1: Physical disturbance to soils, flora and fauna (including avifauna habitat)	All Phases FYNBOS	Very High	Extreme	Very likely	Very high	Severe	Very likely	High
		High	Severe	Very likely	High	Severe	Very likely	High
		Medium	Substantial	Very likely	Moderate	Substantial	Very likely	Moderate
		Low	Moderate	Very likely	Low	Slight	Not likely	Very low
	All Phases ALBANY THICKET	Very High	Extreme	Very Likely	Very high	Severe	Likely	High
		High	Severe	Very Likely	High	Severe	Likely	High
		Medium	Severe	Likely	High	Substantial	Likely	Moderate
		Low	Moderate	Likely	Low	Moderate	Likely	Low
	All Phases IOCB	Very High	Substantial	Very Likely	High	Substantial	Likely	Moderate
		High	Moderate	Likely	Low	Moderate	Likely	Low
		Medium	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low
		Low	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low
	All Phases SAVANNA AND GRASSLAND	Very High	Severe	Very likely	High	Substantial	Very likely	Moderate
		High	Substantial	Very likely	Moderate	Moderate	Very likely	Low
		Medium	Moderate	Very likely	Low	Slight	Very likely	Very low
		Low	Slight	Very likely	Very low	Slight	Very likely	Very low
	All Phases SUCCULENT KAROO, NAMA KAROO, DESERT	Very High	Extreme	Very Likely	Very high	Severe	Very Likely	High
		High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
		Medium	Substantial	Very Likely	Moderate	Moderate	Likely	Low
		Low	Moderate	Very Likely	Low	Slight	Likely	Very low

Table 29: Summary risk assessment of establishment and spread of Alien Invasive Plants to biodiversity and ecology in the proposed gas pipeline corridors.

Impact	Study area & topic	Sensitivity Class	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Key Impact 2: Establishment and spread of Alien Invasive Plants	All Phases FYNBOS	Very High	Extreme	Very likely	Very high	Severe	Not likely	Moderate
		High	Severe	Very likely	High	Substantial	Not likely	Moderate
		Medium	Substantial	Very likely	Moderate	Moderate	Not likely	Low
		Low	Moderate	Very likely	Low	Slight	Not likely	Very low
	All Phases ALBANY THICKET	Very High	Extreme	Very Likely	Very High	Severe	Likely	High
		High	Severe	Very Likely	High	Substantial	Likely	Moderate
		Medium	Severe	Very Likely	High	Substantial	Likely	Moderate
		Low	Substantial	Very Likely	Moderate	Moderate	Very unlikely	Low
	All Phases IOCB	Very High	Severe	Likely	High	Substantial	Not likely	Moderate
		High	Substantial	Likely	Moderate	Moderate	Not likely	Low
		Medium	Moderate	Likely	Low	Slight	Not likely	Very Low
		Low	Moderate	Likely	Low	Slight	Not likely	Very Low
	All Phases SAVANNA AND GRASSLAND	Very High	Severe	Very likely	High	Moderate	Likely	Low
		High	Substantial	Very likely	Moderate	Moderate	Likely	Low
		Medium	Moderate	Very likely	Low	Slight	Likely	Very low
		Low	Moderate	Very likely	Low	Slight	Likely	Very low
	All Phases SUCCULENT KAROO, NAMA KAROO, DESERT	Very High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
		High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
		Medium	Substantial	Very Likely	Moderate	Moderate	Likely	Low
		Low	Moderate	Likely	Low	Slight	Likely	Very Low

Table 30: Summary risk assessment of ecosystem alteration and loss to biodiversity and ecology in the proposed gas pipeline corridors.

Impact	Study area & topic	Sensitivity Class	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Key Impact 3: Ecosystem alteration and loss	Phases 1, 2, 7 FYNBOS High rainfall areas	Very High	Extreme	Very likely	Very high	Severe	Very likely	High
		High	Extreme	Very likely	Very high	Severe	Very likely	High
		Medium	Severe	Very likely	High	Substantial	Likely	Moderate
		Low	Substantial	Likely	Moderate	Moderate	Likely	Low
	Phases 5, 6, Inland FYNBOS Low rainfall areas	Very High	Extreme	Very likely	Very high	Extreme	Very likely	Very high
		High	Extreme	Very likely	Very high	Extreme	Very likely	Very high
		Medium	Severe	Very likely	High	Severe	Very likely	High
		Low	Severe	Very likely	High	Severe	Very likely	High
	All Phases SAVANNA AND GRASSLAND	Very High	Severe	Very likely	High	Substantial	Very likely	Moderate
		High	Substantial	Very likely	Moderate	Moderate	Very likely	Low
		Medium	Moderate	Very likely	Low	Slight	Very likely	Very low
		Low	Slight	Very likely	Very low	Slight	Very likely	Very low
	All Phases ALBANY THICKET	Very High	Severe	Likely	High	Substantial	Not likely	Moderate
		High	Severe	Likely	High	Substantial	Not likely	Moderate
		Medium	Moderate	Not Likely	Low	Slight	Very unlikely	Very Low
		Low	Moderate	Not Likely	Low	Slight	Very unlikely	Very Low
	All Phases IOCB	Very High	Severe	Likely	High	Severe	Likely	High
		High	Substantial	Likely	Moderate	Substantial	Likely	Moderate
		Medium	Slight	Likely	Very Low	Slight	Likely	Very Low
		Low	Slight	Very Likely	Very Low	Slight	Likely	Very Low
	All Phases SUCCULENT KAROO, NAMA KAROO, DESERT	Very High	Extreme	Very Likely	Very High	Severe	Very Likely	High
		High	Severe	Very Likely	High	Substantial	Likely	Moderate
		Medium	Substantial	Likely	Moderate	Moderate	Likely	Low
		Low	Moderate	Likely	Low	Slight	Not Likely	Very Low

7.2.2 Freshwater ecosystems

Table 31: Summary risk assessment of physical degradation and loss of freshwater ecosystems, reduction in aquatic habitat quality, altered hydrology, and water quality deterioration in the proposed gas pipeline corridors.

Impact	Study area & topic	Sensitivity Class	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Physical degradation and loss of freshwater ecosystems	All Phases FRESHWATER ECOSYSTEMS	Very High	Extreme	Very Likely	Very High	Severe	Likely	High
		High	Severe	Very Likely	High	Substantial	Likely	Moderate
		Medium	Substantial	Very likely	Moderate	Slight	Not likely	Very Low
		Low	Moderate	Very Likely	Low	Slight	Likely	Very Low
Reduction in aquatic habitat quality	All Phases FRESHWATER ECOSYSTEMS	Very High	Substantial	Likely	Moderate	Moderate	Likely	Low
		High	Substantial	Likely	Moderate	Moderate	Likely	Low
		Medium	Moderate	Likely	Low	Slight	Likely	Very Low
		Low	Moderate	Likely	Low	Slight	Likely	Very Low
Altered hydrology	All Phases FRESHWATER ECOSYSTEMS	Very High	Substantial	Likely	Moderate	Substantial	Not likely	Moderate
		High	Substantial	Likely	Moderate	Moderate	Not likely	Low
		Medium	Moderate	Likely	Low	Slight	Not likely	Very Low
		Low	Slight	Likely	Very Low	Slight	Not likely	Very Low
Water quality deterioration	All Phases FRESHWATER ECOSYSTEMS	Very High	Extreme	Likely	High	Substantial	Likely	Moderate
		High	Severe	Likely	High	Moderate	Likely	Low
		Medium	Substantial	Likely	Moderate	Slight	Likely	Very Low
		Low	Moderate	Likely	Low	Slight	Likely	Very Low

7.2.3 Estuarine ecosystems

Table 32: Summary risk assessment of estuarine habitat destruction, altered physical and sediment dynamics, deteriorated water quality, and habitat fragmentation and loss of connectivity in the proposed gas pipeline corridors.

Impact	Study area & topic	Sensitivity Class	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Estuarine habitat destruction	Phases 1, 2, 4, 5,7 ESTUARIES	Very High	Extreme	Very likely	Very high	Severe	Very likely	High
		High	Severe	Very likely	High	Moderate	Very likely	Moderate
		Medium	Moderate	Very likely	Moderate	Slight	Very likely	Low
		Low	Slight	Very likely	Low	Slight	Very likely	Low
Altered physical and sediment dynamics	Phases 1, 2, 4, 5,7 ESTUARIES	Very High	Extreme	Very likely	Very high	Extreme	Likely	Very high
		High	Severe	Very likely	High	Severe	Likely	High
		Medium	Moderate	Very likely	Moderate	Moderate	Likely	Moderate
		Low	Slight	Very likely	Low	Slight	Likely	Low
Deterioration of water quality	Phases 1, 2, 4, 5,7 ESTUARIES	Very High	Severe	Very likely	High	Moderate	Likely	Moderate
		High	Moderate	Very likely	Moderate	Slight	Likely	Low
		Medium	Slight	Very likely	Low	Slight	Likely	Low
		Low	Slight	Very likely	Low	Slight	Likely	Low
Habitat fragmentation and loss of connectivity	Phases 1, 2, 4, 5,7 ESTUARIES	Very High	Severe	Very likely	High	Moderate	Likely	Moderate
		High	Moderate	Very likely	Moderate	Slight	Likely	Low
		Medium	Slight	Very likely	Low	Slight	Likely	Low
		Low	Slight	Very likely	Low	Slight	Likely	Low
Note: The estuary risk assessment here assumes the pipeline construction method of Horizontal Directional Drilling (HDD) at shallow depths (< 20 m). Mitigation is unlikely to be possible / effective for isolated open trenches if placed in the EFZ, whilst HDD at depths greater than 20 m reduces the overall risk to estuaries to Moderate / Low. Avoidance of the EFZ greatly reduces/virtually negates risk to estuaries.								

7.3 Limits of Acceptable Change

7.3.1 Terrestrial ecosystems

Limits of acceptable change are driven as much by the values held by society as by ecological theory. But, for threatened species and ecosystems, it is clear from legislation and other measures that society has determined that adverse changes are not acceptable. There are specific policy and legal requirements for species nationally classified as CR, EN, VU and Protected and some provinces have their own lists of protected species with a similar status. These require that the pipeline development should not lead to the destruction of individuals of any CR species, and should set a goal of not destroying any individuals of any endangered or vulnerable species.

There are a number of national and provincial legislative requirements that relate to destruction of threatened ecosystems or habitats of threatened species (see Table 7). No further adverse changes should be allowed in threatened ecosystems assessed as CR or EN, and should be avoided if at all possible in those assessed as VU or which occur in protected areas.

The individual provincial Critical Biodiversity Assessments are the key basis for defining acceptable change for conservation features. They require that CBA1 and CBA2 areas must be avoided if at all possible. If these cannot be avoided appropriate Biodiversity Impact Assessments should be undertaken and mitigation management guidelines followed.

For example, the Western Cape conservation planners have provided some specific constraints for certain activities or developments – pipeline routes are not acceptable in CBA 1s in terms of the land-use guidelines in the WCBSP (Pool-Stanvliet et al., 2017). Similarly, crossing of formal protected areas will only be considered if the pipeline route is aligned with other linear features already in the protected area. These constraints are considered best practice and should be applied in all provinces.

Whilst species destruction or loss is important, the protection of key ecological processes is fundamental to the long-term viability of ecosystems (Driver et al., 2003; Pressey et al., 2003). Changes in disturbance regimes (e.g. fires, extreme rainfall or drought), pollination and other gene flows, gene pools of populations hydrological flows, dispersal and migration, could have detrimental impacts that extend far beyond the actual footprint of the development. The impacts on these processes is also the main reason why the fragmentation of communities, especially dividing remnants by separating them into pieces, by the pipeline route needs to be minimised. As a general rule, the smaller the remnant the more the processes are altered, especially those that maintain species populations (Cowling and Bond, 1991; Heijnis et al., 1999; Sandberg et al., 2016). The result is that fragmentation results in the loss of species, and the smaller the fragment the greater the loss. These losses can trigger further losses, and example being the loss of a pollinator which then results in the loss of plant species it pollinated and so the cascade can continue.

7.3.2 Aquatic Ecosystems

Legislation, policies and guidelines can be used to gauge Levels of Acceptable Change for aquatic ecosystems.

The NWA Preliminary Reserve Determination and Classification provides for setting desired state ("management class") and measurable targets for water flow ("Reserve"), and water quality, habitat and biota in aquatic ecosystems ("Resource Quality Objectives"). Objectives for physical processes, water quality, habitat and higher biota are set under the NWA. These provide the benchmark conditions to maintain and/or restore aquatic ecosystems – freshwater and estuarine.

Where necessary, a water use licence (WUL) process will be required to authorise certain activities as per Section 21 of the NWA based on the DWS assessment requirements for all wetlands that occur within 500 metres of the gas pipeline development.

7.3.2.1 Water quality

The Water quality guidelines for South Africa provides guidance on limits of acceptable change for fresh- and marine water (DWAF, 1996; DWAF 1995).

7.3.2.2 Estuarine ecosystems

Emerging as most critical in the context of the present assessment is the Recommended Ecological Category, as defined by the NWA, which is set as desired state as part of the National Estuaries Biodiversity Plan (Turpie et al., 2011).

Where any construction or operation will occur within the Very High or High sensitivity areas the following permits may be required:

- Permits are likely to be required for any activities that require the discharge of an effluent into the EFZ under the ICM Act. This will set targets for use specific chemical in marine waters and sediments to protect ecosystems.
- Permits are likely to be required for any activities that may affect listed Endangered and/or Vulnerable species, ToPs, and/or regionally protected fauna and flora.

Table 33: Suggested limits of acceptable change for biodiversity and ecosystems.

Variable	Threat Status	Acceptable Change
Vegetation / Ecosystem Types	CR	▪ No nett Loss of Vegetation/Ecosystem Type
	EN	▪ No nett Loss of Vegetation/Ecosystem Type
	VU	▪ No more than 1% of the remaining extent of the vegetation type. ▪ No loss resulting in the vegetation type being elevated to a higher threat status
	NT	▪ No more than 5% of the remaining extent of the vegetation type ▪ No loss resulting in the vegetation type being elevated to a higher threat status
Plant SCC	CR	▪ No nett Loss of plant SCC
	EN	▪ No nett Loss of plant SCC
	VU	▪ No more than 1% of the remaining local population ▪ No loss resulting in a species being elevated to a higher threat status
	NT	▪ No more than 5% of the remaining local population ▪ No loss resulting in a species being elevated to a higher threat status
Fauna SCC	CR EN VU Data Deficient	▪ No nett loss of fauna SCC or resulting in a SCC being elevated to a higher threat status. Should sections of the planned Gas Pipeline routes transect the known Extent of Occurrence / distribution of a fauna SCC, a taxon-specific specialist should be appointed to confirm the sensitivity and assess the significance of potential impacts on that SCC. The impact assessment process must prove to the relevant competent authority that the proposed development will not have an unacceptable negative impact on SCC populations, both locally and regionally. Any identified impacts should be avoided or mitigated. All mitigation measures from the specialist study are to be incorporated into the Environmental Management Programme. A South African Council for Natural Scientific Professions (SACNASP) accredited zoologist must conduct the impact assessment in accordance with the NEMA regulations.
AIP invasion	All sensitivity categories	▪ No invasion of adjacent natural habitats
Soil erosion	All sensitivity categories	▪ No long-term, irreversible soil erosion
Loss of CBAs	CBA1	▪ No loss of irreplaceable CBAs ▪ No loss resulting in it no longer being possible to meet biodiversity targets
Marine and Fresh Water quality		▪ See Water quality guideline for South Africa - http://www.dwa.gov.za/IWQS/wq_guide/index.asp
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SCC = Species of Conservation Concern; CBA = Critical Biodiversity Area		

8 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

In addition to the mitigation and management actions recommended in Section 6, the following key best practice guidelines and monitoring requirement recommendations (summarised from the individual specialist investigations attached as annexures to this chapter) need to be taken into account.

8.1 Planning and pre-construction

Avoidance of areas of very high sensitivity, and as far as possible avoiding areas of high sensitivity, has the potential to greatly reduce impacts on terrestrial and aquatic ecosystems and associated fauna and flora.

- The following areas should be avoided as far as possible:
    - Areas of critical biodiversity or conservation importance;
    - Steep slopes where erosion may be more prevalent and inhibit rehabilitation success;
    - Avoid estuaries (EFZ); if unavoidable, establish the appropriate depth for pipeline construction (through HDD) to reduce risk to the environment and the infrastructure on a case-by-case (estuary crossing – by – estuary crossing) basis.
    - Wetlands and watercourses (and their associated buffers).
- Biodiversity Offsets:
    - Consider biodiversity offsets where high and very high sensitivity areas absolutely cannot be avoided;
    - Identify, at a strategic level, areas where biodiversity offsets may be required;
    - If areas where biodiversity offsets may potentially be required are identified, undertake a biodiversity offset study;
    - The site-specific biodiversity offset study should:
        - Ascertain whether an offset is an appropriate mechanism to offset the impact on the high sensitivity area;
        - Assess the degree to which the offset would be able to compensate for the assessed impacts;
        - Identify appropriate offset receiving areas;
        - Identify financial mechanisms to secure effective and long-term management of offset receiving areas.
- Plan the route to follow, as far as possible, existing disturbance corridors.
- Develop robust pre-construction environmental baseline, including identified indicator species as reference for monitoring;
- Where wetlands and watercourses cannot be avoided, a detailed desktop investigation should be followed to determine whether the gas pipeline alignment and development footprint can avoid the actual freshwater ecosystems (i.e. wetland and river habitats) and associated buffers.
- Planning stage avoidance of high-threat status ecosystems, as well as fauna and flora species populations of conservation concern is required.
    - In many areas, the known extent of occurrence (EoO) / distribution range of SCC are not well known and as such, the planning phase should make provision for flexibility in determining the final pipeline alignment to avoid locally sensitive features and populations of SCC.
    - Should sections of the planned gas pipeline route transect the known EoO / distribution of an SCC, a taxon-specific specialist should be appointed to confirm the sensitivity and assess the significance of potential impacts on that SCC.
    - The impact assessment process must prove to the relevant competent authority that the proposed development will not have an unacceptable negative impact on SCC populations, both locally and regionally.
    - Any identified impacts should be avoided or mitigated. All mitigation measures from the specialist study to be incorporated into the EMPr. A SACNASP accredited botanist and zoologist must conduct the impact assessment in accordance with the NEMA regulations.

- The final gas pipeline route should be checked in the field by the appropriate accredited specialists and at the appropriate time of year. In the winter rainfall areas, all fieldwork for flora should take place from late July through to mid-September depending on the exact timing of rainfall. In the summer rainfall areas, fieldwork should take place following good rainfall and growth of the vegetation. In most areas this is usually late summer to early autumn (February to April).
- Pre-construction walk-through and on-site assessment by a SACNASP accredited botanist and zoologist of the final pipeline route is mandatory to identify any features that should be avoided or buffered from impact, and to identify and locate any plant and animal SCC that should be subject to search and rescue prior to construction.
- Where high sensitivity areas cannot be avoided and there is significant habitat loss in these areas, an offset study should be conducted to ascertain whether an offset is an appropriate mechanism to offset the impact on the high sensitivity area. This should include an identification of offset receiving areas as well as an estimate of the required extent of the offset and the degree to which the offset would be able to compensate for the assessed impacts.
- Groundwater and dewatering of excavations:
    - Consult a qualified and experienced geohydrologist to establish, during the route planning stage, whether any shallow or vulnerable aquifers intersect the proposed route which may require dewatering during construction activities.
    - Vulnerability of geohydrological features / aquifers must be determined using appropriate and relevant assessment, such as the DRASTIC method.
    - If shallow aquifers cannot be avoided and / or dewatering of excavations are required, determine the:
        - dewatering technique to be employed;
        - anticipated dewatering flow rate, volume and duration;
        - water quality; and
        - options for water collection, storage and/or disposal (based on established water quality) to reduce potential impacts to groundwater and the surrounding environment.

8.2 Construction

- Limit disturbance footprint;
- The construction operating corridor should be clearly delimited and demarcated with construction tape or similar markers to limit construction activity and disturbance to the pipeline corridor.
- Temporary lay-down areas should be located within previously transformed areas or areas that have been identified as being of low sensitivity. These areas should be rehabilitated after use.
- Implement sound “housekeeping” of construction activities;
- Proper topsoil storage, for minimal timespans;
- Minimise soil erosion and IAP establishment risk;
- Relocate threatened species based on expert advice;
- Construction activities should only occur in appropriate seasons (e.g. avoid breeding/migrating season of threatened fauna, avoid peak rain seasons);
- Limit the duration of open trenches;
- Regular checks of open trenches to rescue trapped animals;
- Environmental awareness and training of construction workers on-site;
- Measures should be taken to prevent and limit poaching of fauna and harvesting of flora by construction crews or other people accessing the pipeline route.
- All construction vehicles should adhere to a low speed limit (30 km/h for trucks and 40 km/h for light vehicles) to avoid collisions with susceptible species such as snakes and tortoises.
- All hazardous materials should be stored in the appropriate manner to prevent contamination of the site and groundwater. Any accidental chemical, fuel and oil spills that occur at the site should be cleaned up in the appropriate manner as related to the nature of the spill:

  - Regularly service vehicles and other equipment that require fuel / oil (generators etc.) to ensure they do not spill oil.
  - Refuel vehicles and other equipment that require fuel / oil on paved, impervious areas.
  - If liquid product is being transported it must be ensured this does not spill during transit.
  - Emergency measures and plans must be put in place and rehearsed in order to prepare for accidental spillage.
  - Diesel fuel storage tanks must be above ground in a bunded area.
  - Engines that stand in one place for an excessive length of time must have drip trays.
- If excavations need to be dewatered, ensure that appropriate dewatering techniques are employed and water is properly collected, stored and/or disposed of.
- Appoint and involve an ECO to provide oversight and guidance to all construction activities, as well as ensure full consideration and implementation of the Environmental Management Programme.

8.3 Operations and maintenance

- If parts of the pipeline such as compressor stations (which is not part of the scope of the assessment) need to be lit at night for security purposes, this should be done with low-ultraviolet (UV) type lights (such as most Light Emitting Diodes (LEDs)), which do not attract insects.
- If any parts of the pipeline, or any work area in the vicinity of the pipeline need to be fenced, then no electrified strands should be placed within 30 cm of the ground as some species such as tortoises are susceptible to electrocution from electric fences as they do not move away when electrocuted but rather adopt defensive behaviour and are killed by repeated shocks.
- All vehicles accessing the pipeline should adhere to a low speed limit (30 km/h max) to avoid collisions with susceptible species such as snakes and tortoises.
- Oils, fuels and other hazardous materials required for machine and vehicle maintenance and repair are to be securely stored to prevent spill and contamination during operation and maintenance of the gas pipeline infrastructure.
- Access to the pipeline servitude should be restricted to service and maintenance staff and affected landowners.
- Monitor vegetation recovery using photographic methods;
- Ongoing IAP and erosion management.
  - An annual check with follow-up rehabilitation and remediation should be sufficient in most areas. It is important to note that erosion can be severe in semi-arid environments due to the occasional occurrence of heavy showers and the lack of sufficient vegetation cover to protect the soil or slow runoff, with the result that occasional high-risk erosion events can cause large amounts of damage.

8.4 Post-construction and rehabilitation

- Clear rehabilitation targets should be set for each area based on the background perennial vegetation cover.
- All species used in rehabilitation should be locally occurring, indigenous, perennial species. A mixture of different functional type species is recommended.
- No fertilizers or irrigation should be applied during rehabilitation as this is likely to lead to a green flush after rain and failure of perennial species to establish in competition with annuals and ephemerals.
- There should be annual monitoring and follow-up action on IAP occurrence and erosion.
- Undertake rehabilitation processes as soon as possible (i.e. in a rolling manner – after a section of pipeline has been installed).
- Rehabilitation and post-closure measures would be mostly required for ROWs within or in proximity to freshwater ecosystems, as well as for areas degraded by access routes, operation of vehicles/heavy machinery, and infestation of servitudes by IAPs. In general, the following processes/procedures as recommended by James and King (2010):

  - Initiation – to assemble the rehabilitation project team/specialists, identify problem/target areas, establish reference condition and desired states, and define rehabilitation targets and objectives;
  - Planning- to account for constraints, budgeting and timeframes;
  - Analysis – evaluation of alternatives and strategies to achieve the objectives, and to develop preliminary designs and inform feasibility;
  - Implementation – a including detailed engineering designs, construction and inspections; and
  - Monitoring – to establish need for maintenance and repair of interventions, as well as provide feedback regarding success and failure.

Box 28: Environmental rehabilitation in arid areas

Arid areas are very difficult to rehabilitate with a variety of constraints limiting success. In most cases topsoil management is a key factor as the soils deeper down may have a very high pH, be salt- or metal-laden, be very nutrient poor or otherwise inhospitable to plant establishment. Furthermore, in most instances, the restoration of pre-construction levels of diversity is not a realistic goal and the rehabilitation should focus on the establishment of an ecologically functional cover of locally-occurring species to protect the soil and provide some cover for fauna.

A reasonable rehabilitation target for arid areas would be 60% of the vegetation cover of adjacent indigenous vegetation achieved after five years.

8.5 Monitoring requirements

- Populations of key fauna and flora SCC, of which the known extent of occurrence or distribution range was identified and confirmed by a SACNASP accredited botanist and zoologist during the planning (pre-construction) phase and which are being transected by the planned gas pipeline route, should be monitored throughout construction and operation to ensure that these SCC are not being poached or otherwise negatively impacted by the presence and operation of the gas pipeline.
  - Monitoring frequency depends to some extent on the longevity of a specific species, but should also be informed by its threat status and the consequences of not identifying unacceptable negative impacts beforehand.
  - Any identified impacts should be avoided or mitigated. As such, the following basic monitoring schedule is proposed – Pre-construction, Post-construction and every 3-5 years during operation depending on the species.
- The successful establishment and persistence of plant species of high conservation concern translocated during the search and rescue should be monitored for at least five years after construction is completed. An appropriate frequency would be a year after translocation and every second year thereafter.
- Develop robust pre-construction environmental baseline, including identified indicator species as reference for monitoring;
- Biodiversity monitoring programme should consider:
  - Vegetation rehabilitation progress;
  - State of rare/endangered vegetation types within reasonable proximity to the infrastructure;
  - Overland flow patterns of water (runoff), sedimentation and erosion, especially on steep slopes and near watercourses.
- Conduct monitoring of terrestrial ecosystems in spring and autumn seasons;
- Use of Geographic Information Systems, spatial data and aerial photography / satellite imagery is recommended as a key tool for long-term monitoring and management.

- Estuaries:
    - Direct impacts to the EFZ require monitoring of:
        - Hydrodynamics;
        - Sediment dynamics;
        - Water Quality;
        - Macrophytes;
        - Microalgae;
        - Invertebrates;
        - Fish;
        - Birds.
    - Indirect impacts to the EFZ require monitoring of:
        - Water Quality;
        - Microalgae;
        - Invertebrates;
        - Fish.

- Sites/areas where freshwater ecosystems are likely to be affected by gas pipeline development, according to the various phases of development (including rehabilitation), appropriate measures of monitoring should be considered, including:
    - Upstream and downstream biomonitoring to include appropriate indicators/measures of assessing rivers (e.g. diatoms, water quality/clarity, macro-invertebrates using the SASS5 method, instream and riparian habitat using the Index of Habitat Integrity (IHI) method) and wetland habitats (e.g. WET-Health and WET-EcoServices) of a potential impact is recommended at suitable sites to be determined in-field by a specialist.
    - Monitoring/sampling is to be conducted by suitably qualified specialists (e.g. DWS accredited SASS 5 practitioners) with sufficient experience in assessing aquatic ecology and water quality;
    - A single sampling event is recommended prior to construction taking place to serve as a reference condition;
    - Monthly monitoring is recommended for the duration of construction to evaluate trends;
    - Biannual monitoring is recommended thereafter during the operation phase, up to the point in time when the monitoring can establish that the systems are stable;
    - Fixed point photography to monitor changes and long term impacts.

9 GAPS IN KNOWLEDGE

9.1 Desert, Succulent Karoo, Nama Karoo

There is a paucity of baseline information for the Desert, Succulent Karoo and Nama Karoo biomes as the area is generally poorly sampled and species are sparsely distributed. Resultantly, extensive areas will have no records for fauna or flora in the existing biodiversity databases. Areas with generally good records include the national parks, along the main access roads and near to towns and other popular tourist destinations. As a result, all areas should receive detailed baseline data collection in the appropriate season to inform the final pipeline routings.

9.2 Fynbos

There have been very few studies of root systems in Fynbos, Renosterveld and Strandveld plant species but the shrubs, especially the tall shrubs, can have root systems that reach depths of 2-3 m or more (Cramer et al., 2014; Le Maitre et al., 1999; Smith and Higgins, 1992).

Furthermore, there exists insufficient knowledge at present to determine whether or not specific treatments fire should be given as part of the rehabilitation process to stimulate germination of Fynbos species.

9.3 Albany Thicket

The following gaps in knowledge have been identified in terms of the Albany Thicket biome:

- Limited success of techniques of rehabilitation for degraded thicket types;
- Extent, stability and distribution of rare and endangered thicket fauna and flora species;
- Differential responses of sensitive biodiversity features to pre- and post-construction activities, and how best to mitigate;
- Impact of climate change on the drivers of changes impacting on rare vegetation types, particularly in transformed and degraded landscapes of the Albany Thicket biome; and
- Uncertainty around long-term fragmentation impacts of long linear structures on terrestrial fauna.

9.4 Indian Ocean Coastal Belt

Faunal records are limited to primarily, conservation areas and areas where monitoring is safe to undertake e.g. gated residential estates, protected areas. As such, the presence of larger fauna can only effectively be correlated with habitat, rather than observation. This situation clearly skews the data, rendering its use at a fine scale level of spatial analysis, dubious. The data is however useful for supporting the importance of certain intact habitat, where there is a correlation.

Transformation across the IOCB region is both rapid and generally pervasive. Such a state renders the accuracy of such spatial information to be of limited temporal duration. In this regard the importance of site specific evaluations during the impact assessment and detailed planning phases is very high.

9.5 Grassland and Savanna

Location of specific sites with rare and threatened species is based on relatively crude assessments that are not of sufficient detail for detailed route planning and would require onsite inspections. In many cases the location of rare and threatened species is recorded at the level of a ¼ degree square (1:50 000 map sheet). In many cases the species is likely to occur only within specific habitat types within this broad location and specialist input will be required. Development of habitat specific location maps could increase the usability of this data in the future.

Core to this assessment is the use of the provincial biodiversity plans. This assessment is therefore subject to all the gaps in knowledge that underpinned the provincial plans.

9.6 Avifauna

The potential impact of pipeline developments on avifauna in South Africa is not as well studied as for example the impacts of powerline networks or wind energy. The reasons for that could be that the impacts on avifauna may on average not be as significant as those associated with powerlines and wind energy.

Areas where the lack of knowledge is a constraint are the following:

- It is unclear how some Red Data species will react to the disturbance associated with the construction of pipelines and associated infrastructure - more scientifically verifiable knowledge of the disturbance thresholds of these species would improve predictive capabilities.
- The population sizes of many Red Data species are not well known. The impact of nestling mortality on the population is therefore difficult to assess.

9.7 Bats

- No publicly available studies investigating the impacts of gas pipeline development on bats. Potential adverse effects based on other human-induced landscape-level changes can be inferred only.
- Bat roost data is limited to data voluntarily supplied by bat specialists and published literature. The co-ordinates provided by some of the published sources are old and/ or they are only provided in degrees and minutes, therefore there are potentially accuracy concerns.
- It would be more accurate to map “Area of Occurrence” (AoO) rather than “Extent of Occurrence” (EoO) for species of conservation importance, but this level of detail was beyond the scope of this high level SEA.

9.8 Freshwater ecosystems

The following gaps in knowledge are presented as follows in terms of influencing the freshwater assessment:

- The study was developed using available spatial data covering freshwater habitats and species, and these datasets are not exhaustive across the entire study area. Species occurrence data in particular is only based on known records, and thus does not necessarily account for the true distribution of species. Furthermore, occurrence data for certain taxonomic groups is poorly represented, particularly in certain corridors (e.g. Odonata within the Phase 6 and Inland corridors, as well as in large parts of the Phase 3 and 7 corridors).
- Complete data of wetland habitat that includes characterisation of wetland condition and HGM units, was not available for the purpose of determining threat status of wetlands based on HGM type. The conservative approach that was adopted in based on the threat status derived for the broader-scale wetland vegetation groups.
- Species-level data and conservation assessments is limited for certain taxonomic groups, notably aquatic invertebrates. Thus, in the case of invertebrates (excluding Family: Odonata), only family-level data was used.
- This study does not make use of any ground-truthing and verification as a means to validate system importance and sensitivity, and therefore assumes that the data obtained is accurate and representative of the on-the-ground situation. The precautionary approach is to ensure that ground-truthing and infield assessments will be required once the gas pipeline alignments have been established (including alternatives), especially in the more sensitive areas. This will be particularly important to ensure that the extent/boundary of freshwater habitats (including the adjacent buffer zones), as well as the presence of conservation important species, is confirmed firstly, then avoided and/or appropriately managed.
- As with any large-scale project the likelihood for cumulative impacts developing are potentially great, especially when considering the knock-ons effects that gas development could have on other developments that in-turn also may impact on freshwater systems. This study obviously does not account for full extent of cumulative impacts linked both directly gas development (e.g. gas-to-power and storage facilities) and indirectly (through other developments that respond to the distribution of gas as a source of power).

9.9 Estuarine ecosystems

The most critical information gap for the purposes of confident assessment of estuarine impacts relates to the site specific sedimentary processes occurring within each potentially affected estuary. Without this detailed estuary-specific sediment process understanding it is difficult to assess likelihood and consequences of impacts arising from planned structures across and under estuaries. Most important in this regard are issues relating to planned pipelines obstruction to flows during floods and causing long-term estuary bed transformation and infilling. Estuarine physical processes are highly dynamic requiring detailed information over long planning horizons, e.g. understanding the impacts of a 1:100 year flood.

Once a specific project has been determined (based on market demand and the securing of a source of gas), the following detailed information is required at each system in the event an estuary is crossed. This information would be required prior to the construction of the gas pipeline, to inform the depth of HDD, e.g. 20m below bed level and for the actual site specific assessments.

- Estuary bathymetry of the entire system corrected to mean sea level (not just at the crossing site);
- Information on the sediment structure (i.e. sediment core samples taken to bed rock or at a minimum 20 m depth at small to medium sized systems and at a depth of > 20 m at estuaries with a high MAR);
- Estimates of daily sediment loads from the catchment;
- Hourly flood hydrographs of the 1:5, 1:10, 1:20, 1:50 and 1:100 year flood to determine the scouring potential at each system;
- Detailed flood and sediment modelling to determine the degree to which the estuary may scour below its current bed during a flood (before infilling occurs again).

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Addendum 1: List of estuaries present in the proposed gas pipeline development corridors.

Proposed Phase 5 gas pipeline corridor

- Olifants
- Verlorenvlei
- Groot Berg

Proposed Phase 1 gas pipeline corridor

- Langebaan
- Rietvlei/Diep
- Sout (Wes)
- Houtbaai
- Wildevoëlvlei
- Bokramspruit
- Schuster
- Krom
- Buffels Wes
- Elsies
- Silvermine
- Sand
- Zeekoei
- Eerste
- Lourens
- Sir Lowry's Pass
- Steenbras
- Rooiels
- Buffels (Oos)
- Palmiet
- Klipdrifsfontein
- Breë
- Duiwenhoks
- Goukou (Kaffirkui
- Gourits

Proposed Phase 2 gas pipeline corridor

- Blinde
- Gericke
- Tweekuilen
- Hartenbos
- Klein Brak
- Groot Brak
- Maalgate
- Gwaing
- Kaaimans
- Wilderness
- Swartvlei
- Goukamma
- Knysna
- Noetsie
- Piesang
- Keurbooms
- Matjies
- Kabeljous
- Gamtoos
- Van Stadens
- Maitland
- Baakens
- Papenkuils
- Swartkops
- Coega (Ngcura)
- Sundays

Proposed Phase 7 gas pipeline corridor

- Coega
- Sundays
- Boknes
- Bushmans
- Kariega
- Kasuka
- Kowie
- Rufane
- Riet
- Kleinemond Wes
- Kleinemond Oos
- Klein Palmiet
- Great Fish
- Old Womans
- Mpekweni
- Mtati
- Mgwalana
- Bira
- Gqutywa
- Ngculura
- Mtana
- Keiskamma
- Ngqinisa
- Kiwane
- Tyolomnqa
- Shelbertsstroom
- Lilyvale
- Ross' Creek
- Ncera
- Mlele
- Mcantsi
- Gxulu
- Goda
- Hlozi
- Hickman's
- Mvubukazi
- Ngqenga
- Buffalo
- Blind
- Hlaze
- Nahoon
- Qinira
- Gqunube
- Kwelera
- Bulura
- Cunge
- Cintsa
- Cefane
- Kwenxura
- Nyara
- Mtwendwe
- Haga-haga
- Mtendwe
- Quko

- Morgan
- Gxara
- Ncizele
- Nxaxo/Ngqusi
- Zalu
- Nebelele
- Ngadla
- Mbashe
- Mngazana
- Kwanyana
- Mpahlanyana
- Mtentwana
- Sandlundlu
- Kandandhlovu
- Kaba
- Bilanhlolo
- Vungu
- Boboyi
- Mtentweni
- Koshwana
- Mhlabatshane
- Kwa-Makosi
- Mvuzi
- Sezela
- Mpambanyoni
- Ngane
- Lovu
- Mbokodweni
- Mhlanga
- Mhlali
- Nonoti
- Matigulu/
- Mlalazi
- Nhlabane
- Cwili
- Ngogwane
- Timba
- Cebe
- Ngqwara
- Qora
- Shixini
- Xora
- Mzimvubu
- Mtolane
- Mpahlane
- Mtamvuna
- Ku-Boboyi
- Mpenjati
- Mbizana
- Uvuzana
- Mhlangeni
- Mbango
- Mhlangamkulu
- Intshambili
- Mhlungwa
- Mnamfu
- Fafa
- Mkumbane
- Mahlongwa
- Umgababa
- Little Manzimtoti
- Sipingo
- Mdloti
- Mvoti
- Zinkwasi
- Nyoni
- Mhlathuze
- Mfolozi
- Great Kei
- Qolora
- Kobonqaba
- Gqunqe
- Sihlontlweni/Gcin
- Jujura
- Nqabara/Nqabarana
- Mtata
- Sikombe
- Mnyameni
- Mzamba
- Zolwane
- Tongazi
- Umhlangankulu
- Mvutshini
- Kongweni
- Zotsha
- Mzimkulu
- Damba
- Mzumbe
- Mfazazana
- Mtwalume
- Mdesingane
- Mzinto
- Mkomazi
- Msimbazi
- Manzimtoti
- Mgeni
- Tongati
- Mdlotane
- Thukela
- Siyaya
- Richards Bay
- St Lucia

<u>Proposed Phase 4 gas pipeline corridor</u>

- St Lucia
- Mgobezeleni
- Kosi

Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa

Appendix C.1.1

Biodiversity and Ecological Impacts
(Terrestrial Ecosystems and Species) - Fynbos Biome

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

FYNBOS BIOME

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CONTENTS

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

CBA	Critical Biodiversity Area, numerals 1 and 2 indicate differing conservation importance
CR	Critically Endangered
DEA	Department of Environmental Affairs
ECBCP	Eastern Cape Biodiversity Conservation Plan
EMP	Environmental Management Plan
EN	Endangered
ESA	Ecological Support Area, numerals 1 and 2 indicate differing conservation importance
IDP	Integrated Development Plan
iGas	A company linked to the Central Energy Fund, developer of natural gas resources
LT	Least Threatened
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act (Act 107 of 1998, as amended)
NP	National Park
NPAES	National Protected Area Expansion Strategy
ONA	Other Natural Area
PA	Protected Area
SANBI	South African National Biodiversity Institute
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
spp	Species plural
SWSA	Strategic Water Source Area
TMG	Table Mountain Group
VU	Vulnerable
WCBSP	Western Cape Biodiversity Spatial Plan

1 SUMMARY

The Fynbos Biome forms part of six of the proposed Gas Pipeline Corridor Phases (i.e. 1, 2, 5, 6, 7 and Inland) which, between, them cover almost all the biome.

The Fynbos Biome is globally recognised for its high diversity of plant species with about 7 500 species, 69% of which are endemic and 1 889 are listed as threatened (Raimondo et al., 2009). Many of these species occur in the lowlands which are the logical route for the proposed pipeline. On the inland side and in the drier valleys in the western part of the biome the Fynbos adjoins the Succulent Karoo and in the east the Albany Thicket in low rainfall areas and Grasslands in high rainfall areas. There are numerous patches of Afromontane Forest in fire-protected kloofs throughout the Fynbos with extensive areas of forest on the coastal slopes in the Outeniqua-Tsitsikamma region. The vegetation in the Fynbos Biome can be divided into three major types: (a) typical Fynbos vegetation on nutrient poor soils; (b) Renosterveld vegetation on more nutrient-rich soils; and (c) Western Strandveld with a dense overstorey of evergreen shrubs and herbaceous species in the gaps. The western part of the biome experiences winter rainfall, the southern part has bimodal (spring, autumn) rainfall and the eastern peaks in spring and summer. This will affect the timing of vegetation re-establishment. Summers are hot and dry in the west with strong, desiccating, south-easterly winds which create conditions of moisture stress, particularly in the north-western part of the biome.

The hot, dry conditions in summer dry out plant litter and dead fuels, creating high-fire danger conditions in the west but in the east, large fires can occur at any time of the year. Fynbos requires fires at intervals of 10-30 years to maintain biodiversity and ecosystem functioning but fires in arid Fynbos are rare and may not be essential for regeneration. Many species' seeds will only germinate after fires and many species require fires to flower, produce seed and reproduce. Fires occur in and do stimulate regeneration in Renosterveld, but it is able to persist for decades without fires, especially in the drier areas such as the inland slopes of the mountains and the Roggeveld escarpment. Strandveld rarely burns but can do so under extreme weather conditions and regeneration apparently is not fire-dependent.

All forms of Fynbos are highly susceptible to invasion by alien (introduced) tree species, notably the Australian *Acacia* (wattle), *Hakea* and *Leptospermum* species, and *Pinus* species (pines). Sand-plain Fynbos and Renosterveld are very prone to invasion by alien herbaceous species, particularly grasses but invasions in Strandveld are not well-known. Invasive species control will be an important part of the construction and operational phases.

The diversity and endemism of the terrestrial fauna in Fynbos is not particularly high except for certain groups such as amphibians (60 spp in the Western Cape, 36 endemic and 15 threatened), reptiles (146 spp, 18 threatened), fossorial mammals (moles) and invertebrates (particularly butterflies, dragon flies, long-tongued flies, beetles). **Many of the Fynbos shrub species are known to be deep rooted and the pipeline servitude would have to be kept clear of these plants.** The loss of these plant species will change the habitat suitability for fauna that live, feed on, shelter under, or otherwise use or depend on them, so that areas without them may become a barrier to the movement of some terrestrial fauna, notably reptile and invertebrate species.

There is a growing body of research on the restoration of Fynbos, but it is still a developing science. There are a couple of guidelines and handbooks for restoration. Research has shown that removing the upper few centimetres of the topsoil, returning it to the site as soon as possible, and the use of treatments to stimulate seed-germination can facilitate recovery. Most of the research conducted, and experience that has been gained is in the higher rainfall parts of the biome. There is little research or experience in the arid areas, such as Phase 5, 6 in the west and in the interior valleys in Phase 2, to guide rehabilitation. These areas are at the limits of the climatic tolerance of Fynbos species, so there is a high likelihood of failure at the establishment stage, and recovery after disturbance could be slow. Active restoration will be required but, even then, there is a high risk of failure. The uncertainties about the role of fire and the poor understanding of the potential for restoring Fynbos in these areas are strong rationales for making every effort to avoid Fynbos in arid areas when selecting the final gas pipeline routes. Disturbance also facilitates

invasion, so regular monitoring and control operations will be required as part of the Environmental Management Plans for the construction and operational phases.

The high diversity of the Fynbos together with a lack of adequate knowledge of most species' responses to the pipeline construction makes it very difficult to assess the sensitivity with much confidence, especially the impacts of an extensive linear habitat alteration. It also makes it very difficult to assess the effectiveness of the proposed mitigation for many species, especially ground dwelling and/or slow-moving, small bodied animals with narrow distributions and/or specific habitat requirements that are confined to natural or near natural vegetation remnants. Examples would include tortoises, chameleons, small burrowing or slow-moving surface dwelling snakes and potentially many invertebrate species.

Summary of the overall environmental suitability of the proposed Gas Pipeline corridors

Corridor	Overall Suitability	Comment
Phase 1	Low to moderate suitability for gas pipeline development	The coastal lowland areas have a very high concentration of vegetation remnants with a high or very high sensitivity. These remnants typically harbour endemic and threatened plants and fauna. Finding an acceptable route through these will be very difficult. The first 10 km from Ankerlig northwards to Saldanha is difficult because of the West Coast National Park and adjoining sensitive areas. The most feasible option from Saldanha-Ankerlig east to Mosselbay is via the Tulbagh-Ashton valley, but the Nuwekloof Pass will be difficult as will the initial section from Ankerlig or Saldanha into the Swartland. There is a pinch point near Robertson and routes over the north-south oriented river systems between Swellendam and Mosselbay (e.g. GouKou, Duiwenhoks, Gouritz) will have to be chosen with care as these are also climate change adaptation corridors.
Phase 2	Low to moderate suitability for gas pipeline development	The coastal lowlands between Mosselbay and Coega have a high density of high and very high sensitivity features. These remnants typically harbour endemic and threatened plants and fauna. Finding an acceptable route through these will be very difficult. The mosaic of Fynbos and Forest between George and Natures Valley and Plettenberg Bay almost certainly rules out a route through this area. The best option is probably the inland through the Little Karoo and Langkloof but the pinch points at the feasible passes from the coast inland are a problem. There are also pinch points between about Joubertina and Kareedouw and between there and the Gamtoos River valley. Another option is to avoid the Langkloof and go via Uniondale, Willowmore and, Steytlerville to Coega. Most of this route is through Succulent Karoo and Albany Thicket which are assessed in separate studies (Appendix C.1.4 and Appendix C.1.5 of the Gas Pipeline SEA Report, respectively).
Phase 5	Low to moderate suitability for gas pipeline development	The coastal lowlands that are the preferred route between Ankerlig-Saldanha and Abrahamvilliersbaai have a high density of high and very high sensitivity features. These remnants typically harbour endemic and threatened plants and fauna. Finding an acceptable route through these will be very difficult. The main pinch point is from the Piketberg through the Sandveld to Graafwater. The route westwards into the Olifants River valley is through high sensitivity areas and difficult terrain.
Phase 6	Low to moderate suitability for gas pipeline development	Fynbos occupies very little of this Phase but the Fynbos that there is, is also characterised by a high density of high and very high sensitivity features. These areas typically harbour endemic and threatened plants and fauna. They are also located on the upper slopes and crests of mountain ranges which makes them unlikely to be selected for the final route.
Phase 7	Moderate to low suitability for gas pipeline development	Fynbos occupies very little of Phase 7 and is mainly confined to the upper slopes and crests of the east-west oriented mountain ranges. None of the Fynbos vegetation types are considered threatened and there appears to be relatively few endemic and threatened plants and fauna. However, there are extensive areas which are shown as high or very high sensitivity in the biodiversity conservation plan.
Phase Inland	Moderate to low suitability for gas pipeline development	Fynbos is confined to the western and extreme south of this Phase and is mainly confined to the upper slopes and crests of the mountain ranges and the Roggeveld escarpment. These features make it unlikely that the final routing will include Fynbos and the routes will be determined by the sensitivity of the Succulent Karoo, Nama Karoo and Albany Thicket biomes.

2 INTRODUCTION

The Department of Environmental Affairs (DEA) appointed the CSIR to undertake a Strategic Environmental Assessment (SEA) for the Identification of Energy Corridors as well as Assessment and Management Measures for the Development of a Gas Pipeline Network for South Africa. The CSIR, in turn, appointed Dr David Le Maitre to carry out an assessment of the potential impacts of these developments on terrestrial ecosystems in the Fynbos biome.

The purpose of this assessment is to inform decision makers about the potential impacts and facilitate coordination between the authorities responsible for issuing authorisations, permits or consents and so streamlining the environmental authorisation process.

The specific **Terms of Reference** are to provide expert input as a Contributing Author to a Strategic Issue Chapter (specialist assessment report) on the impact on Biodiversity and Ecology (Terrestrial Ecosystems, Flora and Fauna), specifically for the Fynbos Biome.

Note that this Specialist Assessment Report was peer reviewed prior to release to stakeholders for review. The report was updated, as required, following the peer review findings. A copy of the peer review report and responses from the Specialist Team is included in Appendix A of this report.

3 SCOPE OF THIS STRATEGIC ISSUE

This study covers the terrestrial ecosystems of the Fynbos Biome as defined by Mucina and Rutherford (2006) including all the taxa except for birds and bats and amphibians. These taxa were excluded because they are the subject of separate specialist studies and the amphibians which fall under the rivers and wetlands specialist studies (Appendix C.1.7 of the Gas Pipeline SEA Report). The study also excludes all aquatic ecosystems, including streams, rivers, and wetlands of all kinds whether ephemeral, seasonal or perennial as these are the subject of a separate specialist study (Appendix C.1.7 of the Gas Pipeline SEA Report). The outputs from the various specialist studies will be integrated by the Integrating Authors listed at the beginning of this report.

3.1 Data Sources

This assessment has made extensive use of the Western Cape Biodiversity Spatial Plan (WCBSP) (Pool-Stanvliet et al., 2017) which covers most of the Biome, the Eastern Cape Biodiversity Conservation Plan (ECBCP, 2017), the 2016 Northern Cape Critical Biodiversity Areas (CBAs) (Holness and Oosthuysen, 2016), and datasets supplied to the CSIR by the South African National Biodiversity Institute (SANBI) in January 2018 (Table 1). The most recent Biodiversity Network (2017[1]) for the Cape Town Metropole has not been used at this stage as the proposed terminal for the Phase 1a and Phase 5 corridors will be located at Ankerlig near Atlantis (near the northern boundary of the metropole) but its information has been included in the WCBSP in a simplified form (Pool-Stanvliet et al., 2017). The information from the City's plan should be used when the detailed pipeline routing options are assessed. The routing of the proposed pipeline in this section of the corridor (i.e. Phases 1 and 5) is also likely to follow the routing proposed in the screening study for this development (CSIR, 2014). Primary data sources used in these studies include a variety of organizations and databases as documented in the respective reports, including many of those listed in the table below. All of the plans used in this assessment conform to the standards for bioregional planning (DEA, 2009).

The datasets also incorporated the best available information on the locations of threatened flora and fauna (Table 1). The WCBSP included threatened plants, mammals, reptiles, amphibians[2], birds, butterflies,

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[1] https://web1.capetown.gov.za/web1/opendataportal/DatasetDetail?DatasetName=Biodiversity%20network
[2] Some amphibian species are independent of water and thus terrestrial but those species are not included in this assessment

dragon and damselflies, and species with management plans (Pool-Stanvliet et al., 2017). The planning process involved selecting priority areas to focus on and could have excluded some species locations as part of the optimisation process. A similar process was used in the generation of the Eastern Cape Biodiversity Conservation Plan (ECBCP, 2017).

The Northern Cape Biodiversity Conservation Plan included locations of populations of threatened species of plant, butterfly, and reptiles based on data from SANBI, and the province, as CBA1 minimum (Table 1). However, it is important to note that the terrestrial fauna of the Fynbos vegetation types in the Northern Cape have not been well studied and are not as well-known as those in the Western Cape.

In the 2016 Northern Cape Biodiversity Conservation Plan, areas supporting high climate change resilience were included as Ecological Support Areas (ESA) polygons based on data from the National Biodiversity Assessment (NBA) 2011 (Driver et al., 2011) and sourced from SANBI (Table 1). These areas are included in the ESAs and CBAs in the WCBSP based on the Table Mountain Fund Climate Adaptation Corridors (Pence, 2009), edited to exclude all portions within the urban edge (Pool-Stanvliet et al., 2017).

The full set of threatened species locations for all the taxa within the corridors was supplied by SANBI to address this deficiency. The species data were point locations and have been buffered with buffer radiuses of different sizes depending on the likely home range of the particular species. The buffering was done in a way that will not allow the exact location to be determined by species collectors. The radius to use for each taxon was determined by discussions among the specialists involved in this SEA as follows:

- Mammals:
    - 50km buffer for Perissodactyla (Zebras, Rhinos) and the larger Carnivora (African Wild Dogs, Cheetahs, Leopards);
    - 10 km around the larger Artiodactyla (Antelope) – Tsessebe, Bontebok, Roan Antelope, Sable Antelope, Mountain Reedbuck;
    - 2.5km around the Rodentia, Soricomorpha (Shrews) and Afrosoricida (Golden moles)
    - 5km for all other mammals (Hyracoideae (Hyraxes), Lagomorpha (Rabbits, Hares), Macroscelidae (Elephant shrews), Pholidota (Pangolins), Primates, Tubulidentata (Aardvarks))
- For reptiles, amphibians and butterflies a 2.5 km buffer except for crocodiles with a 25 km buffer.
- For the fauna a bounding polygon was also created around the outer boundaries of the localities as a way of defining the range. In practice though this leads to overly wide ranges for species with few occurrence records. As such this information has not been shown in this assessment.
- Plant locations have not been buffered for this assessment because this also results in very extensive areas which are not meaningful. In some cases it is evident that threatened plant records are linked to features such as roads (e.g. see Phase 5 map of plant locations Figure 10), perhaps because the species only occurs in the road reserve.

The threatened species that would be most at risk typically occur within remnants of natural vegetation, especially on the lowlands (e.g. Sandveld, Swartland, and Overberg). Whether or not the pipeline would have to be routed through such remnants can only be determined at the next level of assessment and not at this strategic level which can simply emphasise: (a) that there are many species, often recorded from more than one locality; and (b) that it is highly likely that there are more, undocumented occurrences which means that at least all the natural remnants which will be affected must be subject to a thorough impact assessment.

In the case of the large mammals the buffered locations are so large that they appear to occupy the very wide ranges, often collectively spanning most of the corridor. These wide ranges also tend to obscure those of the taxa with smaller ranges. Although the larger mammals will be disturbed during the construction phase, and some species may become trapped in the open trench, they are highly unlikely to be permanently affected by the changes in habitat composition and structure and so are not shown in the maps for each corridor presented in this assessment.

Table 1: Summary of the data sources used in this assessment.

Data title	Source and date of publication	Data Description
Protected Areas	SANBI (2018) supplied for the SEA from the South African Protected and Conservation Areas Database with permission from DEA	Protected Areas classified according to the Protected Areas Act. Broadly as Formal (i.e. government: national, provincial and local authority, World Heritage Sites, Private Nature Reserves and certain forms of Stewardship) and Informal (e.g., Conservancies, some forms of Stewardship Sites). This includes Protected Environments, Biosphere unprotected areas which are part of the outer zone of a Biosphere Reserve
Other Natural Areas	Geoterraimage. 2015. 2013-2014 South African National Land-Cover. Department of Environmental Affairs. Geospatial Data. https://egis.environment.gov.za/.	All untransformed (i.e. natural or near natural) areas based on the 2013-14 land cover
National Protected Areas Expansion Strategy 2016	DEA. 2016. National Protected Areas Expansion Strategy for South Africa.	Areas systematically identified for expansion of the protected areas where direct and visual impacts of the pipeline route and infrastructure would compromise the potential Protected Area value
Listed Threatened Ecosystems of South Africa	DEA (2011). National list of ecosystems that are threatened and in need of protection. Government Gazette No. 34809, Notice No. 1002, 9 December 2011. Supplied by SANBI for the SEA	Gazetted list of threatened ecosystems classified as Critically Endangered, Endangered, or Vulnerable; loss of parts of these ecosystems to development should be avoided or minimised, especially for the first two categories
South African Vegetation Map 2012	Mucina L. & Rutherford, M.C. (eds) (2006). The Vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. SANBI, Pretoria.	The 2012 version of this map was downloaded from the BGIS and used to identify the specific vegetation types involved
Land cover / extent of natural remnants	South African National Land Cover 2013-2014, 72 class data set DEA open licence (GTI, 2015)	Used to derive natural vs. not natural habitat classes. A customised version of this dataset with some additional classes was used in the Western Cape Spatial Biodiversity Plan
Western Cape Biodiversity Spatial Plan datasets	(Pool-Stanvliet et al., 2017) Datasets downloaded from the BGIS at municipal level and province-wide CBA and ESA layers obtained from Therese Forsyth of CapeNature.	The most recent biodiversity conservation plan available for the Province and includes all the relevant priority biodiversity areas and ecological infrastructure that require protection. The handbook includes definitions of CBA and ESA categories with associated land-use constraints and management recommendations.
		Protected Areas of all kinds excluding some forms of Stewardship areas. Private Conservation Areas included Biodiversity Agreements, Natural Heritage and Nature Reserves (private and contract) and Stewardships
		CBA 1 & 2 (terrestrial) for the Western Cape
		ESA 1 (terrestrial) & 2 for the Western Cape
2016 Northern Cape Critical Biodiversity Areas	(Holness and Oosthuysen, 2016) Datasets downloaded from the BGIS	The most recent biodiversity conservation plan available for the Province. This report and map updates, revises and replaces all older systematic biodiversity plans and associated products for the province
		Critical Biodiversity Areas One and Two
		Ecological Support Areas (no sub-categories)
		Protected Areas (no sub-categories)
		Other Natural Areas
Eastern Cape Biodiversity Conservation Plan	ECBCP (2017) Eastern Cape Biodiversity Conservation Plan Handbook. Department of Economic Development and Environmental	The most recent biodiversity conservation plan available for the Province. The final report and map will replaces all older systematic biodiversity plans and associated products for the province

Data title	Source and date of publication	Data Description
	Affairs (King Williams Town). Compiled by G. Hawley, P. Desmet and D. Berliner. Draft Version December 2017	Critical Biodiversity Areas 1 and 2
		Ecological Support Areas 1 and 2
		Protected Areas (no sub-categories)
		Other Natural Areas
Critically Endangered, Endangered and Vulnerable species	Mammals (Child et al., 2016), reptiles (Bates et al., 2014), plants (Raimondo et al., 2009), butterflies (Henning et al., 2009; Mecenero et al., 2013)	As prepared by SANBI and by the Endangered Wildlife Trust (mammals) with buffers matched to the species ranges and designed to obscure the detailed locality

3.2 Assumptions and Limitations

This study has focused on the construction and operation of the gas pipeline itself and excludes the associated infrastructure such as the onshore facilities at the landfall and the facilities at the termini of the gas pipeline for distributing the gas (e.g. receiving terminals). It also excludes any other facilities for servicing the line and detecting gas leaks as these should be considered at the detailed engineering stage. Many other aspects such the specific location and impacts of access routes, workers camps, lay down and storage areas, waste disposal or borrow pits cannot be included at this level of assessment.

This desktop assessment of biodiversity sensitivity is based primarily on the most recent provincial conservation planning documents supplemented with the data supplied by SANBI to the CSIR in January 2018. The CBA, ESA and protected area data were taken from the Western Cape Biodiversity Spatial Plan 2017 for the Western Cape, the 2016 Northern Cape CBA Plans and the draft Eastern Cape Biodiversity Conservation Plan (ECBCP, 2017). This was done so that the assessment could distinguish between CBA 1 and CBA 2 features.

The scale and thus the spatial resolution of the input data used in these plans varied from points for occurrences of species observations or populations through graded data at different spatial resolutions (e.g. 30x30 m for land cover) to units mapped at approximately 1:250 000 scale such as vegetation types. This heterogeneity is inappropriate for fine-scale analysis and interpretation, such as proposing provisional routes, except in a very general sense.

An important assumption in relating qualitative sensitivity classes to the conservation categories (e.g. CBA, ESA) is that their biodiversity value is directly related to their sensitivity to impacts. And that this sensitivity is the same for all such units in all places. While there is a general relationship, a number of factors could influence how specific species or groups of species respond to impacts. For example the specific features or combination of features that result in a taxon or other biodiversity feature being placed in a particular conservation category. For example, a CBA 1 may be there because that area of land has a threatened ecosystem, or contains threatened flora or fauna, or is irreplaceable or a vital link in a climate change movement corridor, or is a combination of some or all of these things. The short, medium and long-term effect of the construction and operation of a gas pipeline through that area on those different features could be very different, even depending on the species involved. The plant species responses differ in many respects for the different vegetation groups that comprise Fynbos. For example Renosterveld plant species may have different responses to disturbance during clearing from Strandveld and both may differ from Fynbos – an example being the roles of fire in regeneration. This means that their sensitivities would differ and cannot be reduced to one single sensitivity rating. In turn, this means that the risk assessment based on the sensitivity is even more subject to uncertainty, and is only relevant to the strategic level of this study. The only way to reduce this uncertainty would be to examine every feature traversed by each of the alternative and assess its sensitivity at the project level for a specific proposed gas pipeline routing. When this line of reasoning is followed through the risk assessment to predicting the outcomes of mitigation, it should be very clear why there is very low confidence in the mitigation component of this study. The existing knowledge is simply not sufficient to have much confidence in the ability to achieve effective mitigation, even when following best practice described in the sections on mitigation. This is not a conclusion that has been reached lightly. Although the recommended approach has been followed and the best available knowledge has been applied, the results must be treated with great circumspection and caution as emphasised in that section.

The feature maps are also merging data captured at very different scales, spatial resolutions and accuracies. For example, there may be species location (point) data, land cover (which is used in some cases to assess ecosystem structure and degree of degradation) at 30x30 m, and vegetation types mapped to a scale of roughly 1 in 250 000 where the boundaries are possibly accurate to 10s of metres or more. These data cannot simply be mixed and used to assess routes with a high degree of confidence without field verification. The extent of the corridors that need to be assessed means that fine-scale features cannot be assessed at this level. All this study can do is a high level screening that identifies where there are concentrations of features and highlights those as areas where route selection will need additional field assessments. Even then, this assessment may miss fine-scale details with features that could make them Very Highly sensitive and to be avoided if at all possible.

This assessment also only focuses on terrestrial ecosystems and their fauna and flora, but aquatic systems are embedded in and threaded through the terrestrial ones and these ecosystems have functional interactions that could be disrupted by the changes caused by the pipeline (Mouquet et al., 2013; Nakano and Murakami, 2001; Samways and Stewart, 1997). There is a separate assessment of aquatic systems (Appendix C.1.7 of the Gas Pipeline SEA Report) but, ideally, the terrestrial and aquatic experts should sit together and come up with an integrated assessment. Only such an integrated assessment by specialists working together can provide the knowledge required to properly assess sensitivity and the risks that pipeline construction and operation would pose.

Although sensitivity maps do reduce the level of detail that needs to be taken into account when making choices, they cannot be the basis for choosing whether to take one alternative route or another. That choice has to be based on a proper assessment of the nature of the underlying features that determine the sensitivity class. Final route selection must entail more detailed field work by specialists to ground-truth and verify these assessments as well as consultation with local experts.

Given these fundamental limitations on what this level of assessment can realistically achieve, any attempt to assess sensitivity and risk feature by feature and corridor by corridor will be of little value and even misleading. It will also require a level of knowledge of these diverse ecosystems that is only available for a few of them and does not exist for most. This assessment has, therefore, adopted a pragmatic approach of structuring the sensitivity assessment around the different vegetation groups and existing knowledge of how they may respond to the pipeline construction and operation under different environmental conditions and what the consequences of that could be.

This assessment relies greatly on the thoroughness of the compilers of these conservation plans, i.e. that they already have taken all the relevant information on conservation features into account in their plans. Based on what they describe in their reports and knowledge of their work, that appears to be a reasonable assumption. However, the datasets are still subject to the limitations described above. This, in turn, means that there are significant limitations and uncertainties in the assessment of the sensitivities and even more so, the risks. In particular, the level of confidence in statements about whether the risks can be mitigated is very low for most species.

As argued above, the variety and heterogeneity of the features being grouped into sensitivity classes already make a single sensitivity rating problematic. When this is combined with the range of environments which these pipelines potentially will traverse, from very low to very high rainfall, with varying rainfall reliability in all kinds of terrain, such a sensitivity rating needs to be interpreted with great caution. It is vital that those who will use this information understand and appreciate these issues when taking it into account in making decisions about the routes of the pipelines.

3.3 Relevant Regulatory Instruments

Table 2: Regulatory instruments relevant to the Fynbos biome.

Instrument	Key objective	Feature
International Instrument		
World Heritage Convention as recognised in the World Heritage Convention Act No 49 of 1999	Recognising that the cultural heritage and the natural heritage are among the priceless and irreplaceable possessions, not only of the Republic, but of humankind as a whole. Acknowledging that the loss, through deterioration, disappearance or damage through inappropriate development of any of these most prized possessions, constitutes an impoverishment of the heritage of all the peoples of the world and, in particular, the people of South Africa.	For natural heritage sites: natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view, geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation, natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.
National Instrument		
National Environmental Management Act (Act 107 of 1998).	The National Environmental Management Act of 1998 (NEMA), outlines measures that….”prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.”	The protection of all natural features, including from inappropriate development.
National Environmental Management: Protected Areas Act, 2003	No development, construction or farming may be permitted in a national park or nature reserve without the prior written approval of the management authority (Section 50 (5)). Also in a ‘protected environment’ the Minister or MEC may restrict or regulate development that may be inappropriate for the area given the purpose for which the area was declared (Section 5).	Providing for the protection of all natural features in Protected Areas, including from inappropriate development.
National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004)	The National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) provides for listing threatened or protected ecosystems, in one of four categories: critically endangered (CR), endangered (EN), vulnerable (VU) or protected. Listing Notice 3 (Government Notice R324 of 2017 (2014 EIA Regulations, as amended)) Activity 12 relates to clearing of 300 m^2 or more of vegetation, within Critical Biodiversity Areas.	Providing for the protection of South Africa’s unique biodiversity through various measures. Different sorts of activities are listed as environmental triggers which determine the different levels of impact assessment and planning required. They also set out the procedures to be followed for basic or full environmental impact assessments. DEA’s intention is to include Strategic Water Source Area requirements in the listing.

Instrument	Key objective	Feature
	The Act and Regulation 598 of 1 August 2014 require the control of listed invasive alien species, including plants on all land.	
National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) Threatened or Protected Species Regulations, Notice 255 of 2015, Government Gazette No 38600, March 2015	Regulations protecting and regulating the use of threatened species through permits and restrictions on activities.	Provides for the protection and survival of threatened species in the wild, give effect to international obligations to regulate trade, ensure that the utilisation of biodiversity and threatened or protected indigenous species is sustainable.
Conservation of Agricultural Resources Act (Act No. 43 of 1983) and associated regulations	This Act provides for, inter alia, restrictions on the cultivation of land, the protection of soils and water courses, the combating and prevention of erosion, and the prevention of the weakening or destruction of water sources on agricultural land.	One of the provisions of the Act is measures to protect wetlands and watercourses by maintaining uncultivated buffers along water courses and around water bodies to reduce sedimentation and for reducing agro-chemical pollution.
Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)	The Mineral and Petroleum Resources Development Act governs prospecting, mining, exploration and production in South Africa.	In terms of Section 49 of the Act, the Minister may restrict or prohibit the granting of prospecting or mining, exploration or production rights in respect of specified geographical areas if such restriction or prohibition is necessary to promote the sustainable development of South Africa's mineral or petroleum resources.
NEMA - Threatened or Protected Species Regulations of 2013 (ToPS)	Protection of threatened or protected species	The TOPs relates to Section 56 of NEMBA. Species categorised as CR, EN, VU or Protected require permits for activities relating to any form of capture or harvesting of part or all of an organism, possession, propagation or transport.
NEMA EIA 2014 Regulations, as amended (Government Gazette 40772, Government Notice 326 (April 2017))	These regulations provide a list of activities that require environmental authorisation prior to development because they are identified as having a potentially detrimental effect on natural ecosystems, including freshwater ecosystems.	Restricts development and land-use activities depending on the characteristics and attributes of the features.
NEMA Bioregional Planning regulations (Government Gazette No. 32006, 16 March 2009)	Guideline regarding the Determination of Bioregions and the Preparation and Publication of Bioregional Plans. April 2008.	Sets out the standards for Bioregional Planning including systematic conservation plans such as those consulted for this assessment.
Spatial Planning and Land Use Management Act (No 16 of 2013)	Provides for a uniform, effective and comprehensive system of spatial planning and land use management	The Act recognizes that development be sustainable and aligned with everyone's right to have their environment protected. It also requires all levels of government to work together to realise these outcomes.
Provincial Instrument		
Nature Conservation Laws Amendment Act of 2000 (an amendment of the 1994 Cape ordinance	Protection and conservation of threatened flora and fauna and provincial conservation areas	This ordinance is applicable in the Western Cape and Northern Cape. It provides measures to protect the natural flora and fauna, lists nature reserves and endangered flora

Instrument	Key objective	Feature
		and fauna
Eastern Cape Nature and Environmental Conservation Ordinance (19/1974)	Protection and conservation of threatened flora and fauna and provincial conservation area. Much of the Eastern Cape legislation relies on the pre-1994 legislation of the Eastern Cape, Transkei and Ciskei.	This Ordinance is applicable to the Eastern Cape. It includes regulations for conservation areas, and enables the protection of wild animals and plants including lists of protected species.
Mountain Catchment Areas Act	To provide for the conservation, use, management and control of land situated in mountain catchment areas, and to provide for matters incidental thereto.	Originally a national instrument but assigned to the Provinces in 1995. Only really used in the former Cape Province. Intended to restrict land-management practices to those that were compatible with maintaining the ecosystem in good condition to protect water source areas. No regulations were ever created to give this intent effect.
Local Government		
Local Government: Municipal Systems Act (Act No. 32 of 2000; RSA, 2000)	Requires municipalities to develop Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs).	The IDP is a comprehensive five-year plan for a municipal area that gives an overall framework for development, land use and environmental protection. The SDF is a compulsory core component of an IDP that must guide and inform land development and management by providing future spatial plans for a municipal area. The SDF should be the spatial depiction of the IDP, and should be the tool that integrates spatial plans from a range of sectors.
Regulations 21 (published in terms of Section 120 of the Municipal Systems Act)	Municipal Planning and Performance Management standards require SDFs to include a Strategic Environmental Assessment which must be aligned with those of neighbouring municipalities	A municipal SEA identifies spatial constraints on developments and highlights sensitive areas for inclusion of detailed spatial information and policy guidelines for incorporation into a Strategic Environmental Assessment map.

4 KEY ENVIRONMENTAL ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREAS

The Fynbos Biome is globally recognised for its high diversity of plant species with about 7 500 species, 69% of which are endemic (Bergh et al., 2014; Rebelo et al., 2006) and 1 889 are listed as threatened (Turner, 2017). The biome is centred in the south-western part of the Western Cape with areas extending north-westwards for about 650 km, almost to the Orange River, and eastwards for 720 km to the Kap River mountains east of Grahamstown. Fynbos is closely associated with the north-south and east-west ranges of mountains comprising the Cape Folded Belt mountain ranges, some inselbergs, the lowlands between the coast and the coastal ranges and also the wetter inland valleys. It also occurs inland on the Roggeveld mountains that are part of the Great Escarpment. The mountains are dominated by the quartzitic sandstones of the Table Mountain Group (TMG) which give rise to sandy soils that are low in nutrients (Bradshaw and Cowling, 2014; Rebelo et al., 2006). The lowlands and the Roggeveld are underlain by shales which give rise to more fertile clay-loam soils and granites with more fertile, sandy soils which also support Fynbos in places. Parts of the lowlands have deep, infertile sandy soils particularly the west coast and parts of the southern coast that support Fynbos.

On the inland side and in the drier valleys in the western part of the biome the Fynbos adjoins the Succulent Karoo, southern part Succulent Karoo and Albany Thicket in the inland valleys, and in the east Albany Thicket in low rainfall areas and Grasslands in high rainfall areas. Both the Succulent Karoo and the Albany Thicket biomes are fire sensitive and the boundaries appear to be largely fire-maintained. There are numerous patches of Afromontane Forest in fire-protected kloofs throughout the Fynbos with extensive areas of forest on the coastal slopes in the Outeniqua-Tsitsikamma region (Geldenhuys, 1994; Mucina et al., 2006). The Forests embedded within the Fynbos are excluded from this analysis as they are considered no-go areas.

The western part of the biome receives its rainfall primarily in the winter months (June to August) and the eastern part has peaks in the spring and summer with some rain every month (Bradshaw and Cowling, 2014; Rebelo et al., 2006). The temperatures are hot in summer and cold in winter, especially when there is snow. The summers are also characterised by strong, desiccating, south-easterly winds and the winters by the passage of cold fronts with north-westerly and south-westerly winds. Warm to hot berg winds occur when warm air drains from the interior prior to the passage of cold fronts and can lead to fires (Geldenhuys, 1994; Heelemann et al., 2008). The hot, dry conditions in summer dry out plant litter and dead fuels, creating high-fire danger conditions in the west but in the east, large fires can occur at any time of the year (Kraaij et al., 2013b; Kraaij and Wilgen, 2014). Lightning strikes are infrequent, around 1 per km^2 per year but were, historically the main cause of fires; most fires are now caused by people (Van Wilgen et al., 2010).

The vegetation types in the Fynbos can be divided into three major types (Bergh et al., 2014; Rebelo et al., 2006) (Figure 1): (a) the typical Fynbos vegetation on the nutrient poor soils which is a mixture of reeds (Restionaceae), sedges and grasses (Cyperaceae, Gramineae), ericoid (fine-leaved) shrubs (e.g. Ericaceae, Asteraceae) and an overstorey of broad leaved shrubs (e.g. Proteaceae); (b) Renosterveld vegetation on more nutrient-rich soils with a mixture of evergreen fine leaved shrubs, mainly Asteraceae and herbaceous species including a rich flora of geophytes; and (c) Western Strandveld with a dense overstorey of evergreen shrubs and herbaceous species in the gaps. Fynbos is found in two main settings on the shallow, rocky soils of the TMG sandstones of the mountains and foothills (montane Fynbos) and on the deep, leached sands of the lowlands and wetter inland valleys (sand plain Fynbos). Renosterveld is found on the shale-derived soils of the lowlands, the dry lower slopes and valleys, including the Roggeveld mountains. Strandveld generally occurs near the coast on more calcium-rich deep sands and on limestone soils.

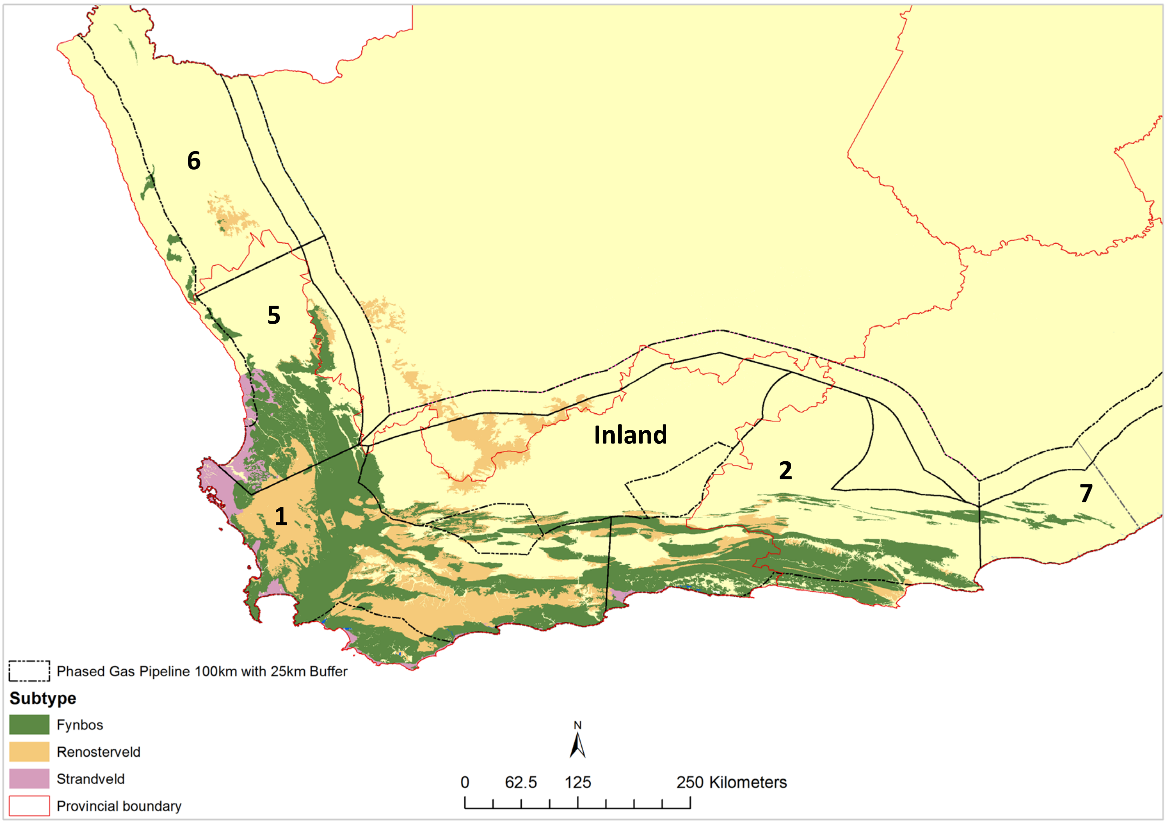

Figure 1: The Fynbos Biome showing the extent of the three main vegetation categories in relation to the Phased Gas Pipeline corridors and their buffers.

The ecology of these major vegetation types differs as well. Sandstone, Granite, Shale, Limestone and Sand Plain Fynbos all require fires at intervals of 10-30 years to maintain their biodiversity and ecosystem functioning (Kraaij and Wilgen, 2014; Le Maitre et al., 2014). Many species' seeds will only germinate after fires and many species require fires to flower, produce seed and reproduce. The fire-ecology of Renosterveld is less well understood than that of Fynbos. Fires do stimulate regeneration in the Renosterveld, which is dominated by sprouting species, lacks slow-maturing species, and has some species whose seeds require fire to germinate (Kraaij, 2010; Kraaij and Wilgen, 2014). Yet it is able to persist for decades without fires, especially in the drier areas such as the inland slopes of the mountains and the Roggeveld escarpment. Fires in western Fynbos and Renosterveld occur primarily in the dry summer months but fires can occur at any time, including winter in the southern and eastern parts of the biome (Kraaij et al., 2013b; Kraaij and Wilgen, 2014). In the western and southern Fynbos, fire season has a marked impact on the regeneration of non-sprouters such as the Proteaceae, being most successful after fires in summer and autumn and least successful after fires in late-winter or spring (Bond et al., 1990; Kraaij et al., 2013d; Kraaij and Wilgen, 2014; Le Maitre et al., 2014). In the eastern Fynbos fire season has relatively little impact. Fire return intervals need to be long-enough for slow-maturing, non-sprouting species like many Proteaceae to produce sufficient seeds to maintain their populations; this typically requires fire return intervals of at least 10-12 years, preferably longer (Kraaij and Wilgen, 2014; Van Wilgen et al., 2010). Strandveld rarely burns but can do so under extreme fire conditions and regeneration apparently is not fire-dependent.

All forms of Fynbos are susceptible to invasion by alien (introduced) tree species, notably the Australian *Acacia* (wattle), *Hakea* and *Leptospermum* species, and *Pinus* species (pines) (Wilson et al., 2014). Sand-plain Fynbos is also very prone to invasion by alien herbaceous species, particularly grasses, and so is Renosterveld. Some of the grass invasion may be due to soil enrichment by the nitrogen-fixing *Acacia* species (Heelemann et al., 2010; Krupek et al., 2016; Le Maitre et al., 2011; Musil et al., 2005; Visser et al., 2017).

The diversity and endemism of the terrestrial fauna in Fynbos is not particularly high except for certain groups such as amphibians (60 species in the Western Cape, 36 endemic and 15 threatened), reptiles (146 species, 18 threatened), fossorial mammals (moles) and invertebrates (particularly butterflies, dragon flies, long-tongued flies, beetles) (Anderson et al., 2014; Colville et al., 2014; Turner, 2017). Many of the Fynbos shrub species are known to be deep rooted and the pipeline servitude would have to be kept clear of these plants. The loss of these plant species will change the habitat suitability for fauna that live or feed on, shelter under, or otherwise use or depend on them, so that areas without them may become a barrier to the movement of some terrestrial fauna, notably reptile and invertebrate species.

Biotic interactions are essential for the pollination of many species and many species depend on ants for seed dispersal (myrmecochory) (Anderson et al., 2014; Rebelo et al., 2006). Ant seed dispersal is disrupted by the Argentinian ant which is able to invade disturbed areas and care will be needed to ensure that invasions by this ant species are not facilitated by, for example, ensuring that construction material does not contain colonies of this species (Anderson et al., 2014; Bond and Slingsby, 1990; Wilson et al., 2014).

Arid Fynbos, as found in corridor Phases 5 and 6, especially on the deep sands of the Sandveld, would be expected to require fire, but fires are very infrequent in these Fynbos types. Only single occurrences of fires have been detected in the past 16 years and these affected <1% of the Fynbos in the area, with the largest fire being in the Kamiesberg (unpublished data, Advanced Fire Information System, Meraka Institute, CSIR). There have not been any studies of the effects of fire on these Fynbos vegetation types to assess the modes of regeneration (e.g. sprouting and non-sprouting, fire stimulated seed germination or flowering, seedling establishment) or of the time required for species to reach reproductive maturity. The low frequency of fires suggests that fire may not play a significant role in maintaining these communities so they may not require fire to maintain themselves.

There is a growing body of research on the restoration of Fynbos, but it is still a developing science (Gaertner et al., 2012a, 2012b, Heelemann et al., 2013, 2012; Holmes, 2008). There are some guides for restoration in books on the management of the Fynbos and Karoo but mainly developed for higher rainfall areas or the Nama Karoo (Esler et al., 2014, 2010; Esler and Milton, 2006; Krug, 2004). It is clear that removing the upper few centimetres of the topsoil and returning with minimal storage, and the use of treatments to stimulate seed-germination can facilitate recovery, but this it still the subject of active research (Hall et al., 2017). Most of this work and experience has been gained in the higher rainfall parts of the biome and there is little experience in the arid areas. Much of the Fynbos vegetation in Phase 5 and, particularly, Phase 6 is at the limits of the climatic tolerance which means that recovery after disturbance could be slow, with a high risk of failure, and probably will require active restoration, as demonstrated by experience at the Namaqua Sands mine in Strandveld vegetation (Blignaut et al., 2013; Pauw, 2011) which is in an area with higher and more reliable rainfall. There has been research on restoration in Namaqualand but the studies have been located in the Strandveld or Succulent Karoo and not in the Fynbos (Carrick et al., 2015; Carrick and Krüger, 2007; James and Carrick, 2016; Todd, 2008). The uncertainties about the role of fire and the poor understanding of the potential for restoring Fynbos in these areas are strong rationales for making every effort to avoid Fynbos in arid areas when selecting the final gas pipeline routes. Disturbance also facilitates invasion so regular monitoring and control operations will be required as part of the Environmental Management Plans (EMPs).

Many vegetation types (e.g. forests) follow the classical succession model where certain species will regenerate or colonise after a disturbance creates an opening. These initial or pioneer species will then create an environment which can be colonised by other species before they die off and so species replace each other. In Fynbos and Renosterveld all the species re-establish themselves after a fire (disturbance) from seeds or by sprouting, but different growth forms tend to recover at different rates so their prominence and the structure changes over time, creating an apparent succession (Kraaij and Wilgen, 2014; Kruger and Bigalke, 1984). The long evolutionary history of the dominance of regeneration from *in situ* sources in Fynbos after fires, combined with the stable soils, seems to be why Fynbos lacks a typical pioneer flora capable of colonising sites where the top soil (essentially the upper 50-100 mm) has been removed or markedly disturbed. A long period of dense invasion by alien plant species can also result in the loss of the seed banks and re-sprouting species (Holmes, 2005; Holmes et al., 2000; Holmes and Cowling, 1997). This means that successful recovery on such sites typically requires the reintroduction of seeds or plants. Fynbos and Renosterveld also have a remarkable flora of geophytic species, only a few of which seem to be able to survive soil disturbance. They may also not be well-dispersed and would need to be reintroduced during the rehabilitation of the pipeline corridor and construction areas.

Although much has been said about the uniqueness of Fynbos and its high plant biodiversity, Fynbos has many other values which generally are not adequately appreciated by the public. These include the benefits derived from the sustained flows of high quality water from Fynbos catchment that support cities and towns and their economies and are used for the production of irrigated crops. Other benefits include species with commercial value in the form of flowers or herbal teas and medicinal products, fibre and thatch, crop pollination, and landscapes that attract tourists (Turpie et al., 2017, 2003). The impacts of unwise developments on the commercial benefits provided by these ecosystems also need to be taken into account.

4.1 Corridor Descriptions

Only the portions of the proposed Gas Pipeline Phases or corridor sections which include fynbos are assessed (Table 3). The routing of all the pipelines will be such that they are likely to cross faunal migration routes between the coast and interior. They will also cross climate adaptation corridors designed to allow for vegetation movements and migration in response to changes in climatic conditions that are predicted by climate change models (Davis-Reddy and Vincent, 2017; DEA, 2015; Midgley et al., 2006, 2005; Midgley and Thuiller, 2011; Rutherford et al., 1999). These areas are identified as CBAs and are rated as highly sensitive in the sensitivity assessments.

Table 3: Summary of the Fynbos biome environmental description for the proposed Gas Pipeline Phases.

Site	Brief description
Phase 1	The corridor covers the southwestern corner of South Africa and is located mainly in the Western Cape, just extending into the Northern Cape at its northern most point. It extends southwards from Cape Columbine along the West Coast to Cape Point, then eastwards to Vleesbaai near Mosselbay, northwards to near Prince Albert, then south-westwards past Ladismith before turning northwest past Touwsriver into the Tanqua Karoo - in this last section it meets the Inland corridor. Then it turns southwest to Hopefield and northwest back to Cape Columbine – this section adjoins Phase 5. In the East it connects with Phase 2. A prominent feature of this corridor is the rugged Cape Folded Belt mountains extending roughly north-south from the northern Cederberg to Cape Hangklip, the Kouebokkeveld and Hex inland, and the Riviersonderend, Langeberg, and Swartberg which run more or less east-west. The rainfall falls primarily in winter in the west and centre but becomes bimodal with spring and ranges from about 400 mm in the northwest to over 2 500 mm in the Boland mountains. The summers are warm and dry, with strong, desiccating south-easterly winds. The rainfall is lower on the inland mountains and east-west ranges but exceeds 1 000 mm in the central Langeberg. These mountain ranges are important water sources for the rivers and streams that flow into the adjacent lowland and nationally significant Strategic Water Source Areas (SWSAs) (Nel et al., 2017, 2013). This corridor covers the core area of the Fynbos Biome, as well as some of the most transformed portions, and so includes a large number of threatened ecosystems and a high proportion of the threatened species in the biome. The entire corridor falls within the biome except for the areas of the Succulent Karoo in the drier inland valleys, islands of Afromontane Forest, and some small areas of Albany Thicket in river valleys both on the coastal lowlands and in inland valleys. The corridor overlaps with a total of 113 vegetation types, including 86 from the Fynbos Biome. Of these, 18 are rated Critically Rare, 14 Endangered and 15 Vulnerable, making a total of 54% threatened. All of the Sand Fynbos, 78% of the Renosterveld, 50% of the Strandveld and 44% of the other Fynbos vegetation types are considered threatened. Threatened flora and the full range of threatened terrestrial fauna are found in the CBA areas within the corridor, especially in the lowlands. The western part of this corridor is dominated by the sandy plains and granite and shale hills of the West Coast and the Swartland with sandstone inselbergs. *The West Coast National Park* (NP) and adjacent CBAs form a block that extends right across the corridor at this point, forming a pinchpoint. The coastal mountain chain is almost unbroken from Piekenierskloof in the north to Hangklip in the south, with only a narrow gap formed by the Klein Berg River valley (Nuwekloof Pass). These ranges are either in Nature Reserves, Mountain Catchment Areas or Informal Protected Areas. The inland mountain chain from the Cederberg to the Langeberg is also only broken by narrow river valleys. The remaining natural vegetation adjoining these protected areas is all in CBAs or ESAs. The Hex River mountains extend inland from this mountain chain to the inland boundary of this corridor. There is a pinch point near Robertson and routes over the north-south oriented river systems between Swellendam and Mosselbay (e.g. GouKou, Duiwenhoks, and Gouritz) will have to be chosen with care as these are also climate change adaptation corridors. There are some extensive Azonal vegetation types in this corridor but they are mainly wetlands (e.g. the reed beds and salt marshes in the Langebaan Lagoon and the Breede River floodplain) and so fall outside the scope of this assessment. The Cape mountains are important water sources for the rivers and streams that flow into the adjacent lowlands. The ranges from the Cederberg to the Langeberg and south to Cape Hangklip, and Table Mountain all being SWSAs (Nel et al., 2017, 2013). There are also extensive SWSAs for groundwater in this area including the West Coast aquifer and the Sandveld aquifer, as well as in the inland valleys. These findings clearly highlight the extensive transformation of the lowland vegetation types and that all their natural remnants are considered highly or very highly sensitive. So, even if the lowlands look like the best options for a route, some careful routing will be needed to minimise impacts.

Site	Brief description
Phase 2	This corridor covers the southern or middle portion of the Fynbos Biome between Phase 1 in the west and Phase 7 in the east. It extends from a line roughly between Vleesbaai and Prince Albert in the West (i.e. at Mossgas) to a line between Coega and Somerset-East in the east. The coastal boundary excludes the area between Plettenberg Bay and St Francis and the Tsitsikamma Mountains. The inland boundary is generally inland of the Fynbos Biome and so is not included in this assessment. The climate is characterised by mild temperatures, except in the interior valleys, and evenly distributed rainfall with spring and autumn peaks. Berg winds are common in the winter and are often associated with fires (Geldenhuys, 1994; Kraaij et al., 2013a). A prominent feature is the east-west mountain ranges, with the Huisrivier-Outeniqua-Tsitsikamma-Kouga-Baviaanskloof in the south and the Swartberg, Groot and Klein Winterhoekberge-Suurberg inland in the north. The Kammanassie Mountains in the western part of the corridor form a link between the inland and the coastal ranges at the eastern end of the Little Karoo. The mountain ranges with their protected areas have extensive ESA and CBA areas adjoining them. The intensively farmed and developed coastal lowlands from Mosselbay to Plettenberg Bay have a fine-scale mosaic of CBAs including the remnants of these coastal vegetation. The same applies to the Langkloof and the Humansdorp Plains. The complicated mosaic of Fynbos and Forest in the area between Wilderness and Plettenberg Bay will have to be treated as special a unit in the routing assessment should the construction be authorised. The best option is probably the inland through the Little Karoo and Langkloof but the pinch points at the feasible passes from the coast inland are a problem. There are also pinch points between about Joubertina and Kareedouw and between there and the Gamtoos River valley. Another option is to avoid the Langkloof and go via Uniondale, Willowmore and, Steytlerville to Coega. Most of this route is through Succulent Karoo and Albany Thicket whose sensitivity is assessed in separate studies (Appendix C.1.4 and Appendix C.1.5 of the Gas Pipeline SEA Report, respectively). In the Western Cape portion, the corridor includes 50 vegetation types with 34 of these being Fynbos, 4 Forest, 4 Succulent Karoo and 7 Azonal. Thirteen (38%) of the Fynbos vegetation types are threatened based on the WCBSP data. Based on the 2011 Threatened Ecosystems listing, there are six threatened (two CR) Fynbos vegetation types in the Eastern Cape which is 15% of the vegetation types; five of these extend into the Western Cape. Most of these threatened vegetation types are found on the intensively developed coastal lowlands between Mosselbay in the west and Humansdorp in the east. The full range of threatened terrestrial fauna can be found in the CBA areas. There are some extensive Azonal vegetation types in the corridor such as river floodplains and the Wilderness Lakes and wetlands which are covered in a separate specialist study (Appendix C.1.7 of the Gas Pipeline SEA Report). The Cape mountains are important water sources for the rivers and streams that flow into the adjacent lowland with the Huisrivier-Outeniqua-Tsitsikamma-Kouga and Swartberg all being SWSAs (Nel et al., 2017, 2013). There are also extensive SWSAs for groundwater in this area, including the West Coast aquifer and the Sandveld aquifer, as well as in the inland valleys.
Phase 5	The corridor is situated on the west-coast of South Africa and forms a link between Phase 1 in the south-west and Phase 6 in the north-west. It extends about 220 km from near Piketberg in the Swartland to near Bitterfontein in Namaqualand. The rainfall falls mainly in the winter months and the summers are hot and dry with strong, drying winds. The rainfall decreases from about 400 mm on the coastal lowlands in the south to 200 mm in the north, and reaches about 800-1 000 mm on the Piketberg, Piekenierskloof and Cedarberg mountains. The northern and inland parts of the corridor fall primarily into the Succulent Karoo Biome and the south-western and southern part in the Fynbos biome. Fires occur at intervals of 8-15 years in the mountain Fynbos but at longer intervals in the Renosterveld and sand plain Fynbos of the lowlands. The rainfall is too low for cultivation in the north and the vegetation is fairly intact and used as rangelands. The extent of the cultivated dryland areas increases south of Vredendal

Site	Brief description
	as do cultivated areas on the Nieuwoudtville plateau and the Gifberg. Almost all of the Swartland is under cultivation. Areas under irrigation are found along the Olifants River, in the Sandveld and along the Berg River southwards to Hopefield. The extent of vegetation transformation has resulted in 11 of the 14 Fynbos vegetation types in this part of the corridor being classified as threatened (6 Vulnerable, 4 Endangered, 1 Critically Rare) due to habitat loss in the Western Cape Biodiversity Spatial Plan (Pool-Stanvliet et al., 2017). All of these are lowland vegetation types with the Swartland Shale Renosterveld (CR) having only 6.3% of its original extent and every remnant classified as a CBA 1 (Very high sensitivity). The high degree of transformation means that every remnant that can form part of a corridor is a CBA 1, resulting in a nearly continuous CBA 1 from the coast to the inland mountains north of the Piketberg. The Niewoudtville-Gifberg plateau in the Northern Cape also is an extensive area where all natural vegetation is categorised as CBA 1. At the scale of this map many of the small CBA 1s in highly transformed areas like the Swartland are not visible but minimising impacts on them will be critical at the route planning stage. The main pinch point is from the Piketberg through the Sandveld to Graafwater. The route westwards into the Olifants River valley also is through high sensitivity areas and difficult terrain. The extensive Azonal vegetation types are primarily salt marshes and wetlands associated with estuaries (e.g. The Berg and Olifants Rivers) and river floodplains. The Cape mountains are important water sources for the rivers and streams that flow into the adjacent lowland with the Cederberg, Piekenierskloof and Kouebokkeveld forming part of the Groot Winterhoek SWSA (Nel et al., 2017, 2013). There are also extensive SWSAs for groundwater in this area and in the inland valleys.
Phase 6	This corridor is situated on the arid north-west coast of South Africa. The annual rainfall ranges from <50 mm in the Orange River valley to 100-200 mm over the lowlands and more than 400 mm in the Kamiesberg and is supplemented by fog along the coast. The rain falls mainly in the winter months. The summers are hot and dry. The temperatures are moderated by the typically strong winds but these winds also have a drying effect, creating harsh conditions for plants and animals. The corridor extends about 100 km inland from the West Coast and is about 375 km in length. The southern boundary is near the town of Nuwerus and the northern boundary is the Orange River and border with Namibia. Four biomes are found within the corridor, Succulent Karoo, Nama Karoo, Desert and Fynbos and there are extensive areas of Azonal vegetation along rivers and along coast. The Fynbos Biome in the corridor comprises four vegetation types: Namaqualand Granite Renosterveld, Kamiesberg Granite Fynbos, Namaqualand Sand Fynbos, Stinkfonteinberge Quartzite Fynbos (Rebelo et al., 2006). No Azonal vegetation types occur in the areas of the Fynbos vegetation types in the corridor. Namaqualand Granite Renosterveld and Kamiesberg Granite Fynbos are found on the upper slopes and peaks of Kamiesberg Mountains with the latter confined to the highest peaks in the area. Stinkfonteinberge Quartzite Fynbos is only found on the upper slopes and peaks of some of the Vandersterrberg range in the Richtersveld. They are all endemic to the corridor. Namaqualand Sand Fynbos is found on the leached, deep sands on the coastal plain where the patches are embedded in and grade into the Strandveld vegetation types, which are part of the Succulent Karoo Biome. Most of this vegetation lies to west of the corridor with small portions extending into it. None of these vegetation types were considered threatened in the 2011 National Biodiversity Assessment (Driver et al., 2011). Many of the plant species are endemic to these vegetation types, especially in the Kamiesberg and Richtersveld (Rebelo et al., 2006). In the 2016 Northern Cape CBA plan, the Kamiesberg Granite Fynbos is considered a CBA1 because of its extreme rarity and endemism (with less than 5000 ha of the original area remaining) and because it is confined to the Northern Cape province (Holness and Oosthuysen, 2016). Most of the Namaqualand Granite Renosterveld and Namaqualand Sand Fynbos fall into areas which are CBA1 or CBA2. None of the Namaqualand Sand Fynbos in the Western Cape extends into the corridor.

Site	Brief description
	The northern section of the Stinkfonteinberge Quartzite Fynbos falls within the Richtersveld NP and the southern portion within the Richtersveld World Heritage Site. There are no protected areas in the Namaqualand Granite Renosterveld, Kamiesberg Granite Fynbos or the portions of Namaqualand Sand Fynbos that fall into the corridor. The Richtersveld NP and World Heritage site form an extensive protected area in the north, and the Namaqualand NP forms a link between the coast and the Namaqua Highlands. Linking this park to the Kamiesberg is seen as a very high conservation priority. The Kamiesberg is an important water source area at the local level but not at the national level.
Phase 7	Phase 7 extends eastwards from a line roughly between Coega and 100 km inland towards Somerset east, where it adjoins phase 2, to KwaZulu-Natal. The Fynbos Biome only extends into the western end of this corridor to about 27°E, so that section is the focus of this assessment. Only montane Fynbos occurs in this area, being found on the Suurberg, Swartwatersberg, Grahamstown Height and Kapriviersberge. The climate is variable and can be very hot in summer and very cold in winter with snow falls. The mean annual rainfall is about 500-550 mm with slight peaks in spring and autumn. Only two Fynbos vegetation types shave been mapped in this area: Suurberg Quartzite Fynbos and Suurberg Shale Fynbos the latter being found mainly as patches embedded within the former which is more continuous. Neither is considered threatened. They form complex mosaics with the Grassland Biome in the higher rainfall areas and the Albany Thicket Biome in the lower rainfall areas. Grasses and reeds (Restionaceae) are a prominent component in these vegetation types and seed-regenerating shrubs tend to be found in localised and often rocky patches on southern slopes (Rebelo et al., 2006). The ecology and biodiversity of the Fynbos in these eastern areas is not well documented (Kraaij and Wilgen, 2014; Martin, 1987; Richardson et al., 1984). Fire regimes do play an important role especially in the interfaces with the grasslands where fires can be too frequent for the survival of seed regenerating species (Kraaij et al., 2013c; Kraaij and Wilgen, 2014) but fire season seems to be less important (Heelemann et al., 2008). In some areas fires can be very frequent, for example south of Grahamstown where they reach 6 fires in 16 years. These mountains are locally important as water source areas but not at the national level.
Inland Phase	In the north, this corridor extends from the Tankwa Karoo north-eastwards to just north of Victoria West and then south-eastwards to near Somerset East. In the southwest it adjoins Phase 1 and in the south-east Phase 2. It overlaps with the Fynbos Biome only in the south-west and centre where it adjoins Phase 1 and in the Roggeveld mountains. Fynbos Biome vegetation is found on the inland slopes of the mountains from the Skurweberge to the Swartberg and on the Roggeveld escarpment. The climate is marked by hot summers and cold winters and the rainfall of about 300-400 mm per year occurs mainly in the winter months. Fires are rare on the Roggeveld Escarpment but more frequent on the northern slopes of the Swartberg and the Bontberg near Touwsriver based on fire occurrence records (Unpublished data, Advanced Fire Information System, Meraka Institute, CSIR). Sixteen Fynbos Biome vegetation types are found in this corridor, with half being Fynbos and half Renosterveld, with one being Endangered and two Vulnerable. About 60% is Roggeveld or Central Mountain or Matjiesfontein Shale Renosterveld. The threatened vegetation types are found mainly in the intensively cultivated Ceres and Kouebokkeveld areas. The Roggeveld escarpment is seen as a key area for the expansion of the Tankwa Karoo National Park (Pool-Stanvliet et al., 2017; SANBI, 2009). This is another part of the biome whose diversity and ecology is poorly documented and understood. Fires can play a role in regenerating the Renosterveld vegetation (Van der Merwe et al., 2008; van der Merwe and van Rooyen, 2011) but are actively suppressed by the farmers (David Le Maitre pers. obs.). The inland mountains, including the Roggeveld are important water source areas at the local level.

4.2 Feature Sensitivity Mapping

This section deals with the biodiversity and conservation features where biodiversity features are those that capture aspects of the biodiversity (e.g. endemic species, threatened species and ecosystems), and conservation features are those that have been developed by people to conserve biodiversity and other natural features (e.g. protected areas). The intention was to include information on the threatened Fynbos species which occur in the corridor so they can be flagged for special attention. However, the lists of names, especially for plants, are so extensive that this provides to be impractical and only the maps with information on high level taxonomic groups are shown.

4.2.1 Identification of feature sensitivity criteria

This assessment has relied primarily on the most recent conservation plans for the areas concerned because they already include all the relevant layers of information such as threatened vegetation, threatened vertebrates, protected area expansion strategies and climate adaptation corridors in their CBAs and ESAs and the latest information on the protected areas (PAs).

In the WCBSP (Pool-Stanvliet et al., 2017), the category CBA is reserved for areas that are required to meet biodiversity targets for species and ecosystem pattern (i.e. composition and spatial distribution) or ecological processes and infrastructure (Table 4). These include Critically Endangered (CR) ecosystems and all areas required to meet ecological infrastructure targets for sustaining the existence and functioning of ecosystems and the delivery of ecosystem services. They also include the corridors required to maintain landscape connectivity and allow communities to respond to climate change. A CBA 1 is for ecosystems in natural or near-natural condition and a CBA 2 comprises ecosystems that are degraded and can and should be restored. The category ESA is used for areas which are important for sustaining the functioning of PAs or CBAs, and can deliver important ecosystem services, and remnants of endangered vegetation types (Pool-Stanvliet et al., 2017). They provide connectivity, and so improve the potential to adaptation to climate change. So they include corridors, water source and groundwater recharge areas, azonal habitats along rivers and around wetlands. Every individual CBA and ESA is provided with a “reason” or rationale which takes one or more features into account. These reasons include threatened vegetation types and vertebrates, ecological processes and specific habitat types. The “reasons” given often include both terrestrial and aquatic systems in the same CBA which makes it difficult to differentiate. Other Natural Areas (ONAs) have not been identified as a priority in the current biodiversity spatial plan but retain most of their natural character, biodiversity and ecological functions and are still important. Rather than include PAs in their CBA classes they were retained as separate, but with land-use practices in the PAs and buffer areas tightly restricted by guidelines in the protected area plan, as prescribed in the NEM: Protected Areas Act (Table 5). In essence this amounts to treating them as having very high sensitivity and equivalent to a CBA 1 and this is what is shown in the sensitivity maps.

The 2016 Northern Cape CBA plan CBAs took four features into account: ecosystem threat status, rarity, endemism and ecosystem process importance (Holness and Oosthuysen, 2016) (Table 4). Threatened species of plant, butterfly, and reptile locations based on data from SANBI and the province were included in the Northern Cape as CBA 1 minimum. All protected areas in the Northern Cape were given a 5 km buffer and National Parks a 10 km buffer based on “Listing Notice 3”[3] under NEMA (Act 107 of 1998) Act (Table 5) and rated CBA 2 minimum (Holness and Oosthuysen, 2016). The PA expansion areas were also categorised as CBA 2. ESAs are areas which are important for sustaining the functioning of PAs or CBAs, deliver important ecosystem services, include special habitats, provide connectivity and thus include corridors for improving resilience to climate change. Other Natural Areas have not been identified as a priority in the current biodiversity spatial plan but retain most of their natural character, biodiversity and ecological functions and are still important.

[3] Environmental Impact Assessment Regulations, Government Notice No. R34 in Government Gazette 40772 of 7 April2017

The Eastern Cape Biodiversity Conservation Plan includes all categories of Protected Areas (State) and Conservation Areas (private) (Table 4) and their buffers (Table 5). State includes Biosphere Reserves, World Heritage Sites, State-owned (National Park, Nature Reserve) and Protected Environments as category PA. Private Nature Reserves (PNR) and *De Facto* PNR were categorised as CBA 2, and DAFF Forest Reserves as CBA 1. National threatened ecosystems (Critically Rare (CR) and Endangered (EN)) were included as CBA 1 and VU types were added to meet targets. Irreplaceable sites and Planning Units selected to meet targets for vegetation types, species points and expert areas were included in the category CBA 1. Best Design sites and Planning Units selected to meet targets for vegetation types, species points and expert areas were included in category CBA 2. Other sites required to complete the network were classed as ESA 1 together with selected cliffs and their buffers, Eastern Cape Corridors, climate change refugia and climate change resilience areas. Some Other sites were made ESA 2 as were some Best Design corridor sites.

The buffering is designed to prevent protected areas becoming surrounded by developments that transform the land, such as extensive cultivation and urban developments. The buffer widths for different protected areas were specified in Listing Notice 3 of the 2014 EIA regulations[3] and have not been altered in any of the subsequent amendments Act (Table 5). The buffering only affects the sensitivity maps as the actual boundaries are shown in the feature maps. Such areas are not necessarily no-go areas for a linear development such as this pipeline but, as with any other CBA areas, they should be avoided, wherever possible, at an early stage of the planning (Sahley et al., 2017).

Table 4: Spatial data used for the sensitivity analysis.

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors
Protected Areas	Data supplied by SANBI in January 2018 from the South African Protected and Conservation Areas Database with permission from DEA	Protected areas divided into sensitivity categories: • Very High (National Parks, nature reserves, World Heritage Site core, Special Nature Reserves) • High (Mountain Catchment Areas, Protected Environment) • Moderate (Nature Reserve and National Park Buffers, Biosphere (unprotected)) • Low (not used in this assessment)	All phases assessed in this Fynbos Biome Assessment
	2016 Northern Cape CBA Plan (Holness and Oosthuysen, 2016)	All protected areas in the Northern Cape were given a 5 km buffer and National Parks 10 km (Holness and Oosthuysen, 2016) based on "Listing Notice 3" under NEMA (Act 107 of 1998).	Phase 1, 5, 6 and Inland
	Western Cape Biodiversity Spatial Plan (Pool-Stanvliet et al., 2017)	All protected areas excluding stewardship areas. This dataset was found to be more complete than the dataset provided by SANBI in January 2018	Phases 1, 2, 5, 6 and Inland
	Eastern Cape Biodiversity Conservation Plan	All protected areas as indicated in the draft plan dataset supplied via CSIR January 2018	Phase 2, 7 and Inland
National Protected Areas Expansion Strategy (NPAES) 2016	DEA. 2016. National Protected Areas Expansion Strategy for South Africa.	Focus areas for land-based protected area expansion are large, intact and unfragmented areas of high importance for biodiversity representation and ecological persistence, suitable for the creation or expansion of large protected areas. Rated Moderately Sensitive	All phases assessed in this Fynbos Biome Assessment
CBA 1	Western Cape Biodiversity Spatial Plan	In the WCBSP in every Local Municipal dataset every individual CBA is provided with a "reason" which takes one or more features into account.	Phase 1, 2, 5, 6 and Inland
	2016 Northern Cape Critical Biodiversity Areas	Northern Cape CBAs took four features into account: ecosystem threat status, rarity, endemism and ecosystem process importance.	Phase 1, 5, 6, and Inland

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors
	Eastern Cape Biodiversity Conservation Plan	All state protected areas including Forest Reserves, national threatened ecosystems	Phase 2, 7, and Inland
CBA 2	Western Cape Biodiversity Spatial Plan	See above for WCBSP	Phase 1, 2, 5, 6 and Inland
	2016 Northern Cape Critical Biodiversity Areas	For the Northern Cape the individual CBAs did not include reasons, only the general rules applied in the development of the plan (Holness and Oosthuysen, 2016)	Phase 1, 5, 6, and Inland
	Eastern Cape Biodiversity Conservation Plan	Best Design sites and Planning Units selected to meet targets for vegetation types, species points and areas identified by experts	Phase 2, 7 and Inland
ESA 1	Western Cape Biodiversity Spatial Plan	These areas include ecosystems that range from natural to moderately degraded	Phase 1, 2, 5, 6 and Inland
	Eastern Cape Biodiversity Conservation Plan	Other sites required to complete the network were classed as ESA 1 together with selected cliffs and their buffers, Eastern Cape Corridors, climate change refugia and climate change resilience areas	Phase 2, 7 and Inland
ESA 2	Western Cape Biodiversity Spatial Plan	These areas require restoration; although they are degraded or have little natural cover they should be restored	Phase 1, 2, 5 6 and Inland
	Eastern Cape Biodiversity Conservation Plan	Other sites of conservation importance and best design sites not included above	Phase 2 and 7
ESA	2016 Northern Cape Critical Biodiversity Areas	Did not distinguish between ESA categories or give reasons for specific ESAs	Phase 1, 5, 6 and Inland
ONA	Western Cape Biodiversity Spatial Plan, 2016 Northern Cape Critical Biodiversity Areas and Eastern Cape Biodiversity Conservation Plan	Other Natural Areas (ONAs) are not a priority at present but retain a natural level of biodiversity and ecosystem functions and so impacts should be avoided or minimised in favour of transformed areas.	All phases assessed in this Fynbos Biome Assessment

Table 5: Sensitivity rating assigned to important environmental features of the Fynbos biome for all the Corridor sections covered in this assessment.

Corridor	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
All	**Protected Areas Western Cape:**		
	National Parks, Nature Reserves, World Heritage Sites	Very High	High (10 km)[4]
	Mountain Catchment Areas	High	High
	Private Conservation Areas (all types)	Moderate	Moderate (5 km)
	Protected Environment	Moderate	Moderate
	National Protected Area Expansion Strategy	Moderate	Moderate
	National Park Buffer	Moderate	Moderate
	Nature Reserve Buffer	Moderate	Moderate
	Protected Areas Northern Cape (all types)	Very High	High: in the plan all PAs were buffered by 5 km and National Parks by 10 km as CBA2 minimum
	Protected Areas Eastern Cape Biodiversity Conservation Plan:		
	World Heritage Sites, National Park, Nature Reserve, DAFF Forest Reserves	Very High	Not buffered
	Biosphere Reserves, Protected Environments	High	Not buffered
	Private Nature Reserves	Moderate	Not buffered
	Conservation categories from Western Cape Biodiversity Spatial Plan	CBA 1: Very High	Not buffered
		CBA 2: High	Not buffered
		ESA 1 and 2: Moderate	Not buffered
	Conservation categories from 2016 Northern Cape CBA Plan	CBA 1: Very High	Not buffered
		CBA 2: High	Not buffered
		ESA: Moderate	Not buffered
	Conservation categories from Eastern Cape Biodiversity Conservation Plan	CBA 1: Very High	Not buffered
		CBA 2: High	Not buffered
		ESA 1 and 2: Moderate	Not buffered
	Land Cover : Natural Area Land Cover: Transformed	Moderate Low	Not buffered
	Other Natural Areas	Moderate	Not buffered

[4] Environmental Impact Assessment Regulations, No. R. 982, 4 December 2014 as updated in Government Notices 324 to 327 in Government Gazette 40772 of 7 April 2017

4.2.2 Feature maps

The features have been presented in the maps using slightly different approaches because of the way in which they have been represented. In the Western Cape the mapping is very detailed and has a high spatial resolution so that the CBA and ESA features are accurately shown and clear in the maps. In the Eastern and Northern Cape the CBA and ESA mapping was more generalised so that the fine-scale features tend to be masked by the broad swathes that are in these categories. This was not such an important issue in the Northern Cape because the Fynbos only occupies a small proportion of the corridor so the CBA and ESA features have been included. However, they have been excluded from the features maps for the Eastern Cape so that the maps are more easily interpreted. The features maps are presented separately for each Phase (Figures 2-19). For each Phase the first map shows the protection areas and other conservation features, the second map the location of the threatened fauna and the third map the threatened flora.

In the sensitivity maps all the features have been included whether they are protected areas, threated species populations or other important conservation features. This means that the sensitivity maps give a more complete representation of the constraints on the potential routes.

4.2.2.1 Phase 1

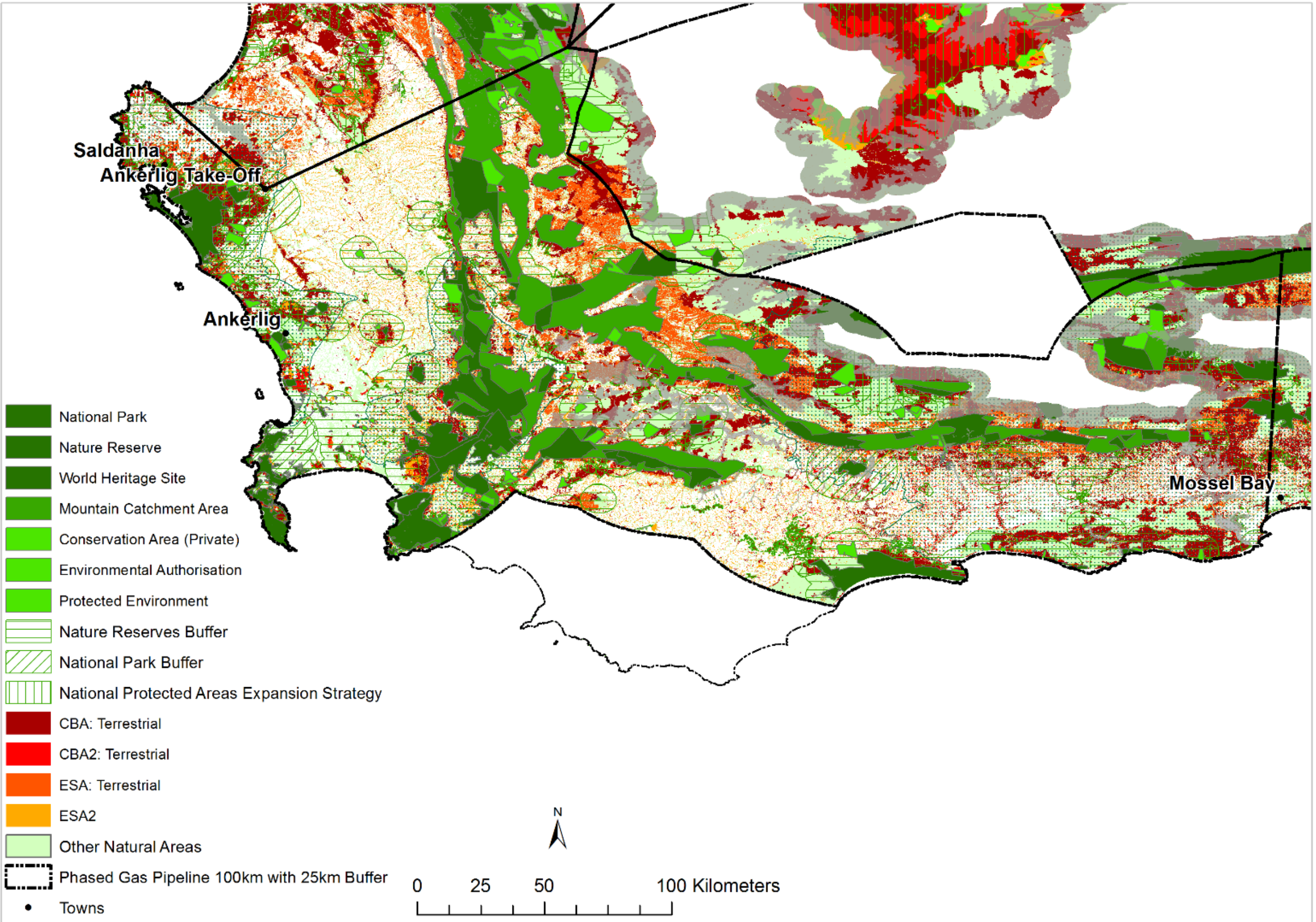

Figure 2: Gas Pipeline Phase 1 – Conservation features showing both the categories of ecosystems (CBA, ESA) and protected areas and their buffers. The Fynbos Biome units have been outlined with a 5 km external buffer in semi-transparent medium grey, and clipped to the corridors and buffers. Areas with the same level of protection status have been given the same shaded of green.

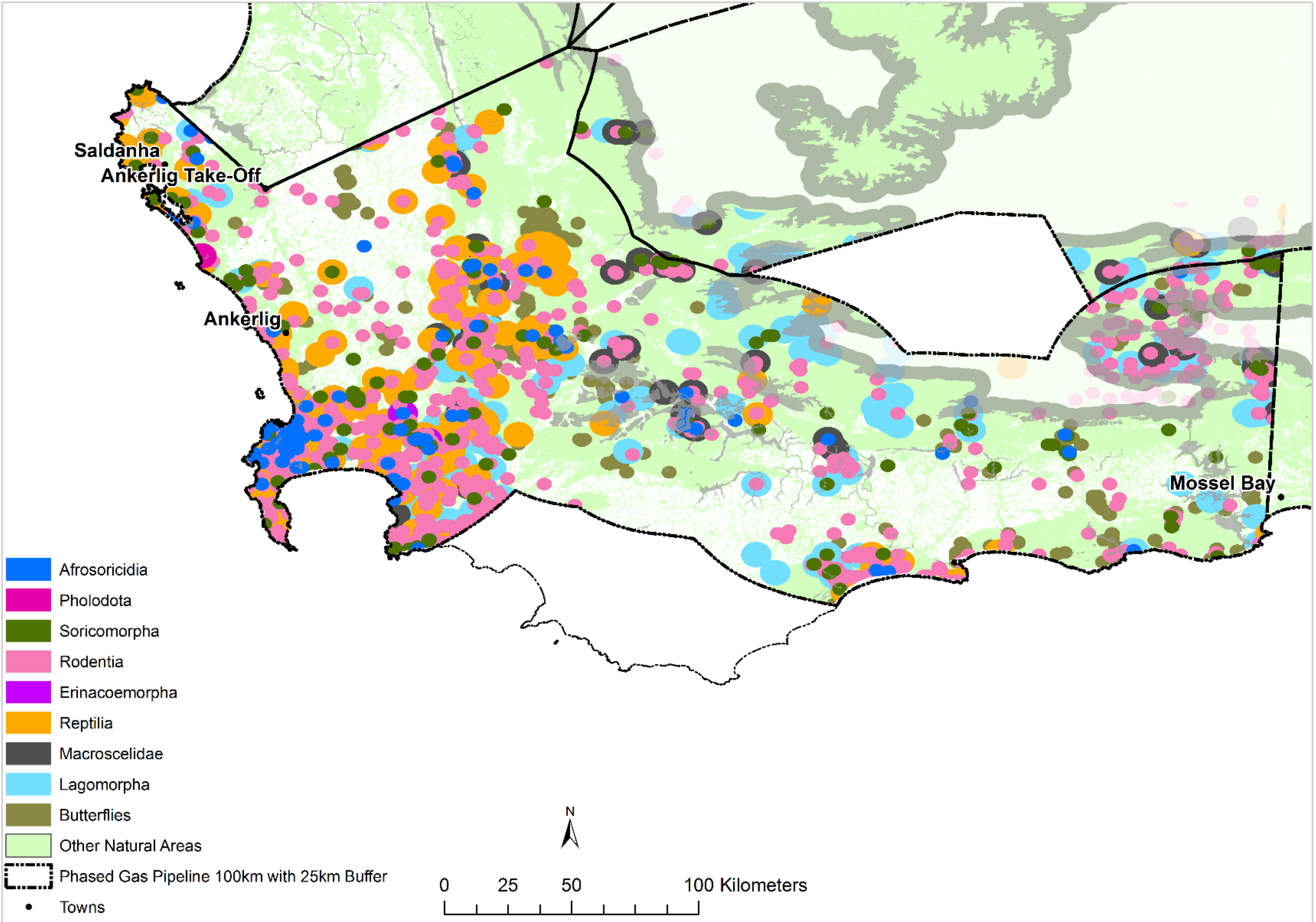

Figure 3: Gas Pipeline Phase 1 - Buffered locations of recorded threatened fauna in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with larger ranges are beneath those with smaller ranges. For information on the buffer radiuses used see the text.

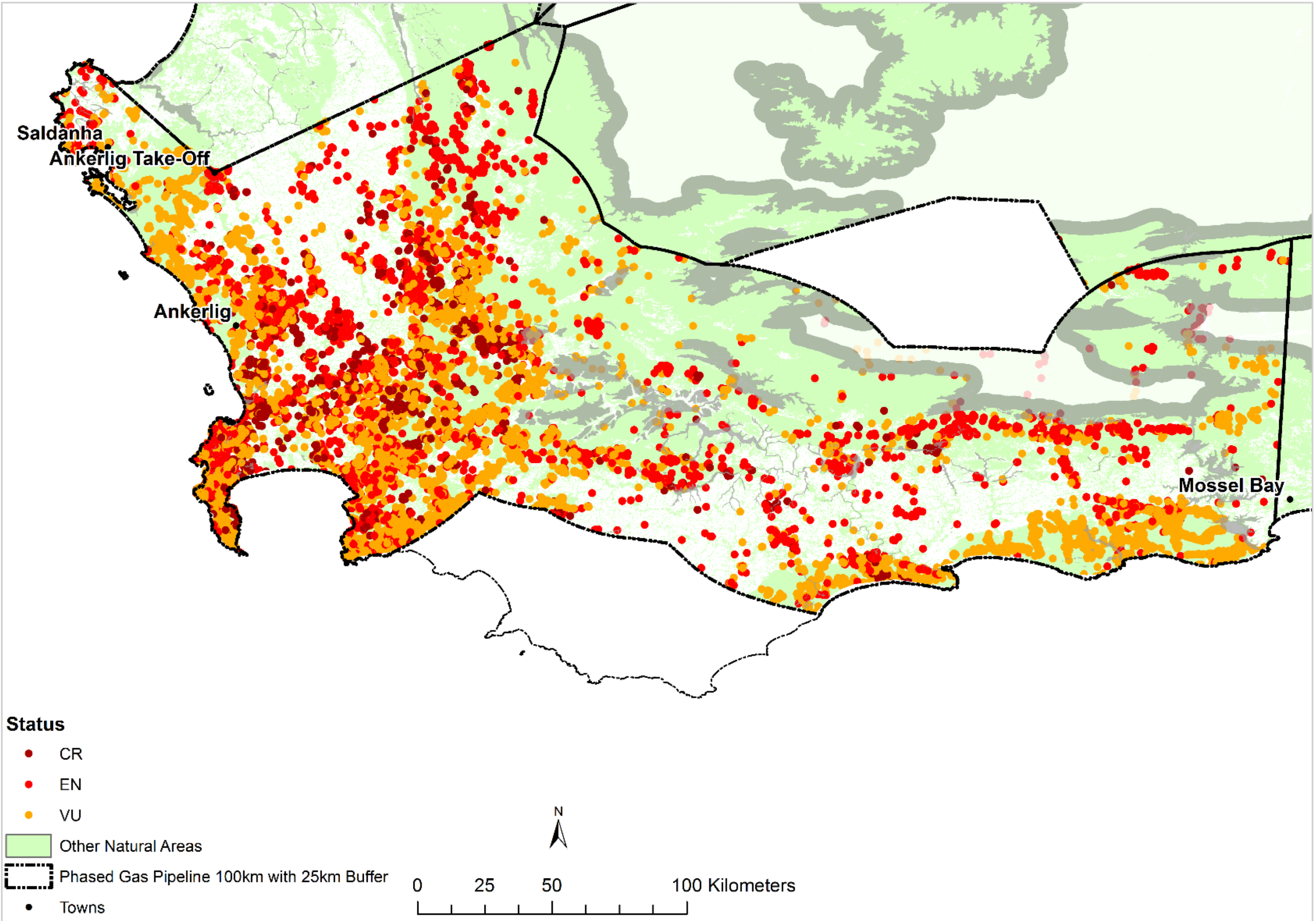

Figure 4: Gas Pipeline Phase 1 - Records of the locations of threatened plant species in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with a higher threat status are overlaid on those with a lower threat status where they overlap.

4.2.2.2 Phase 2

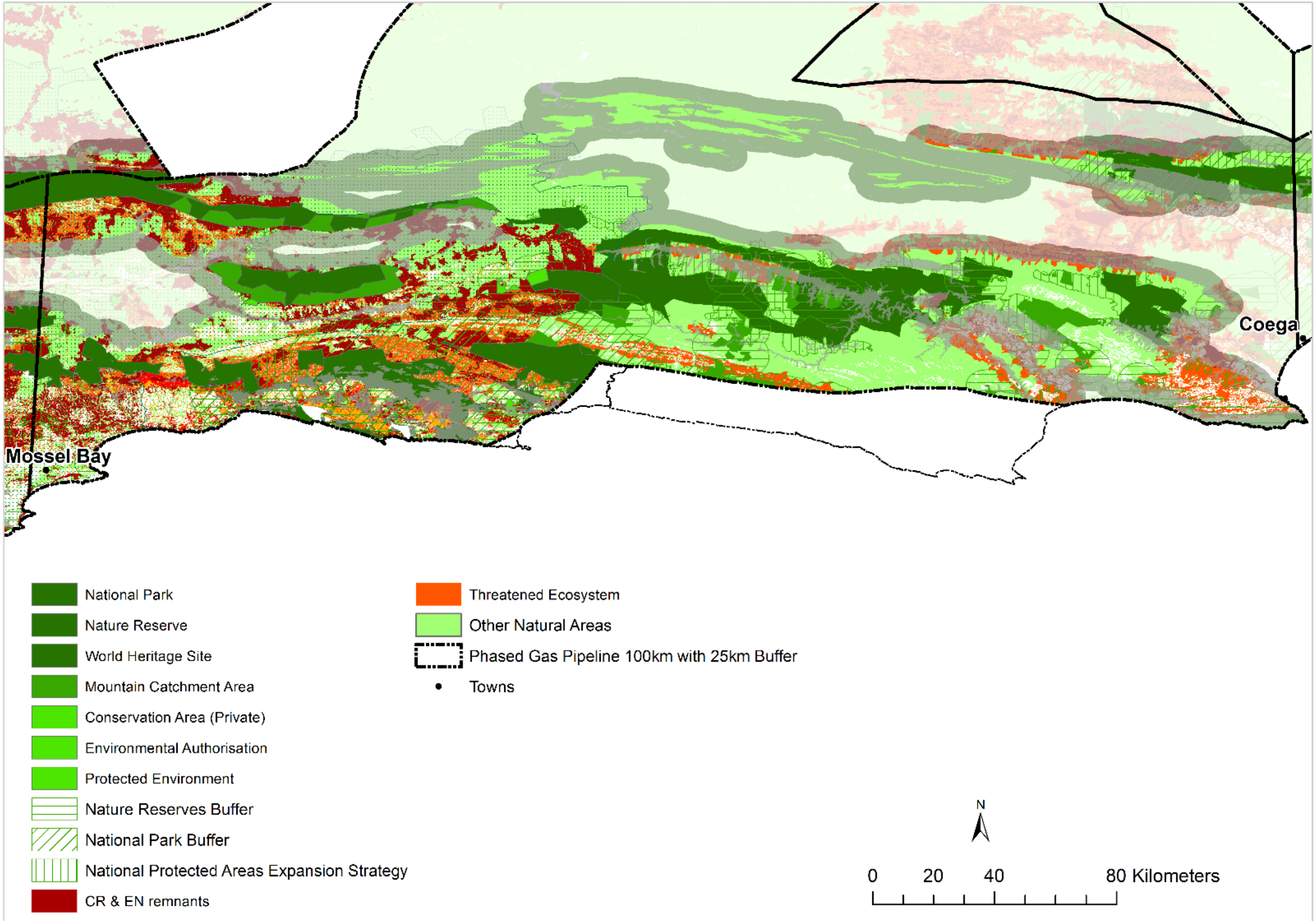

Figure 5: Gas Pipeline Phase 2 - Conservation features showing both the categories ecosystems (CBA, ESA) and protected areas and their buffers. The Fynbos Biome units have been outlined with a 5 km external buffer in semi-transparent medium grey, and clipped to the corridors and buffers. In the Western Cape threatened remnants are shown in deep red (CR, EN) and medium red (VU). Areas with the same level of protection status have been given the same shaded of green.

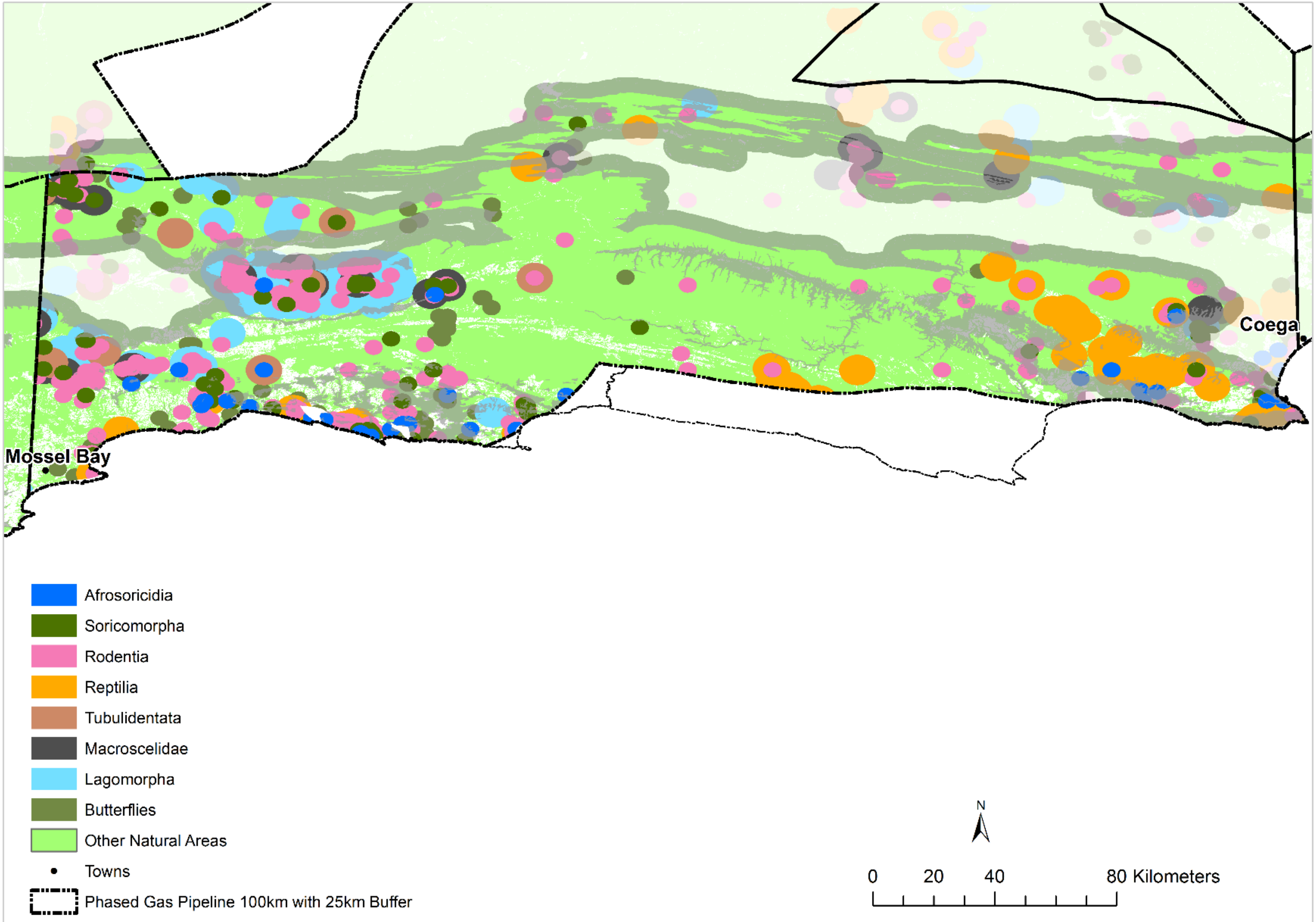

Figure 6: Gas Pipeline Phase 2 - Buffered locations of recorded threatened fauna in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with larger ranges are beneath those with smaller ranges. For information on the buffer radiuses used see the text.

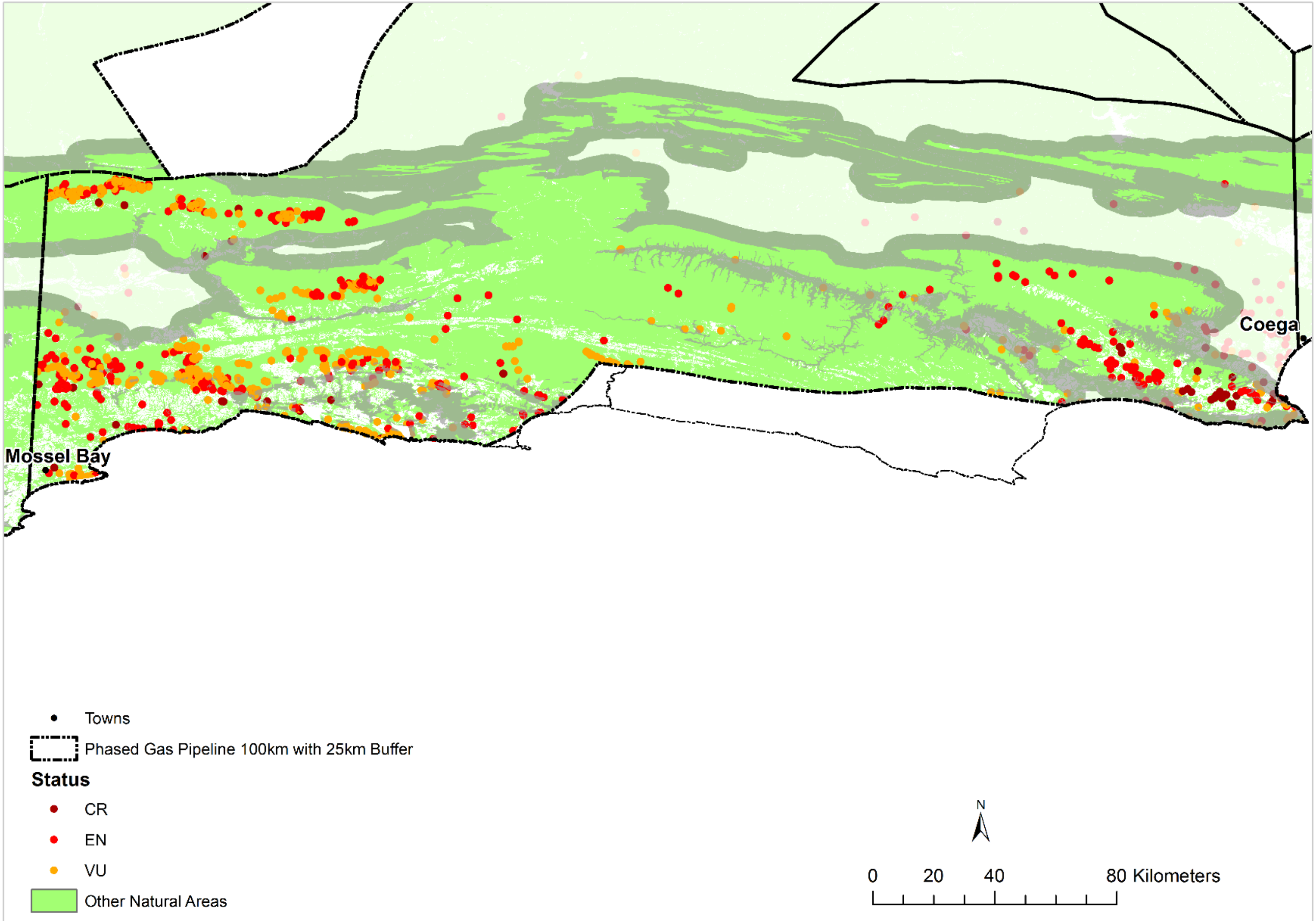

Figure 7: Gas Pipeline Phase 2 - Recorded locations of threatened plant species in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with a higher threat status are overlaid on those with a lower threat status where they overlap.

4.2.2.3 Phase 5

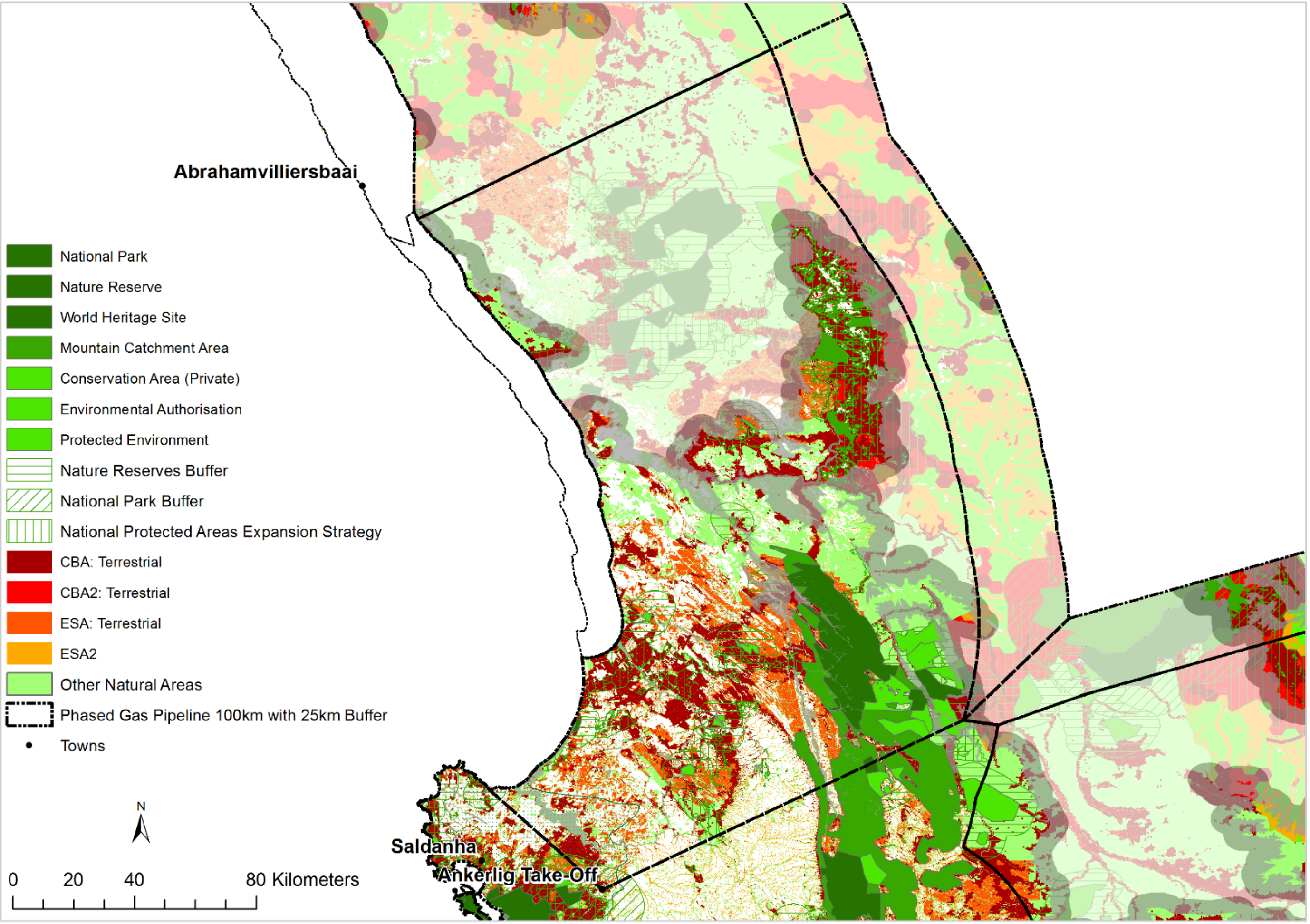

Figure 8: Gas Pipeline Phase 5 - Conservation features showing both the categories ecosystems (CBA, ESA) and protected areas and their buffers. The Fynbos Biome units have been outlined with a 5 km external buffer in semi-transparent medium grey, and clipped to the corridors and buffers. Areas with the same level of protection status have been give the same shaded of green.

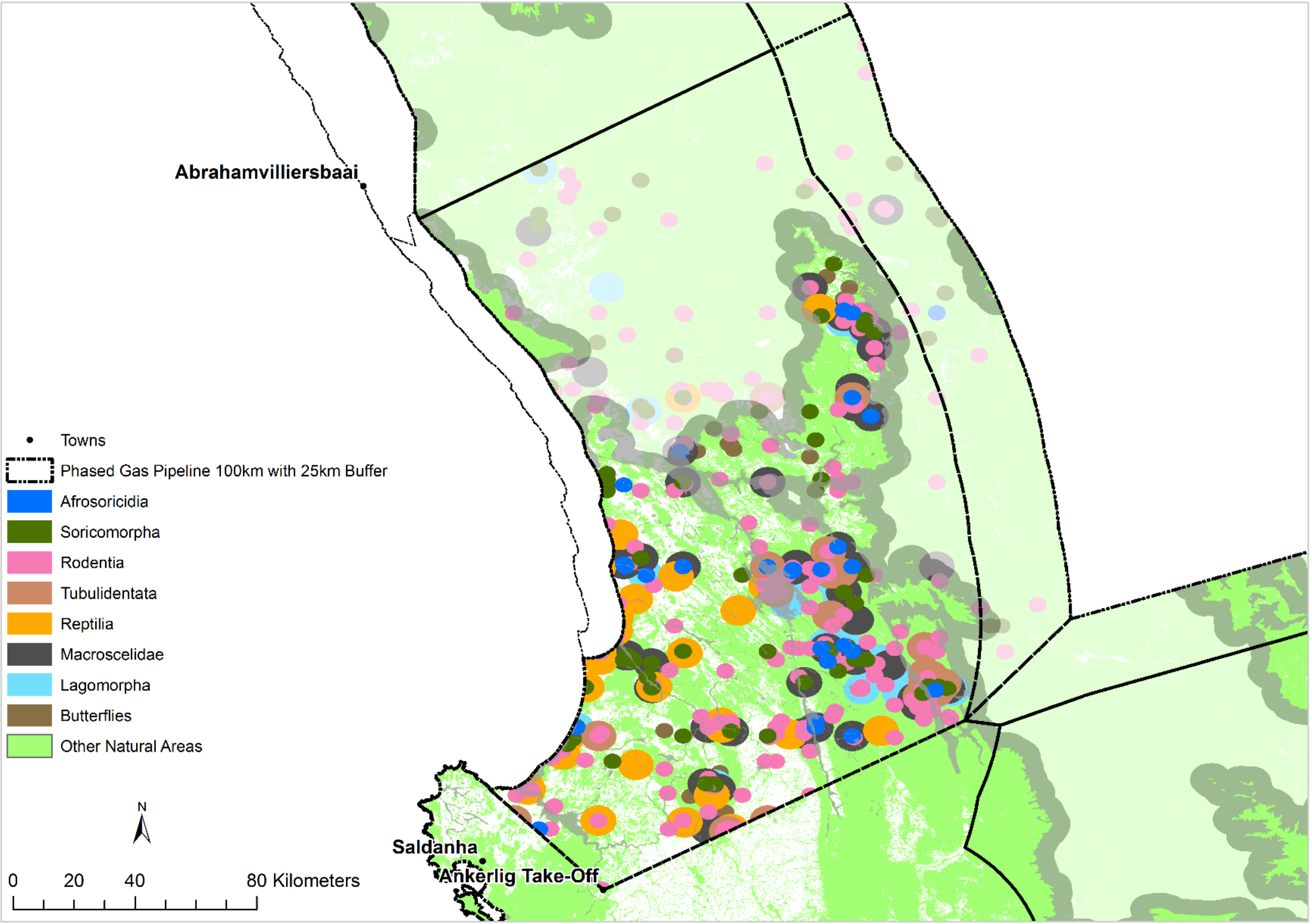

Figure 9: Gas Pipeline Phase 5 - Buffered locations of recorded threatened fauna in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with larger ranges are beneath those with smaller ranges. For information on the buffer radiuses used see the text.

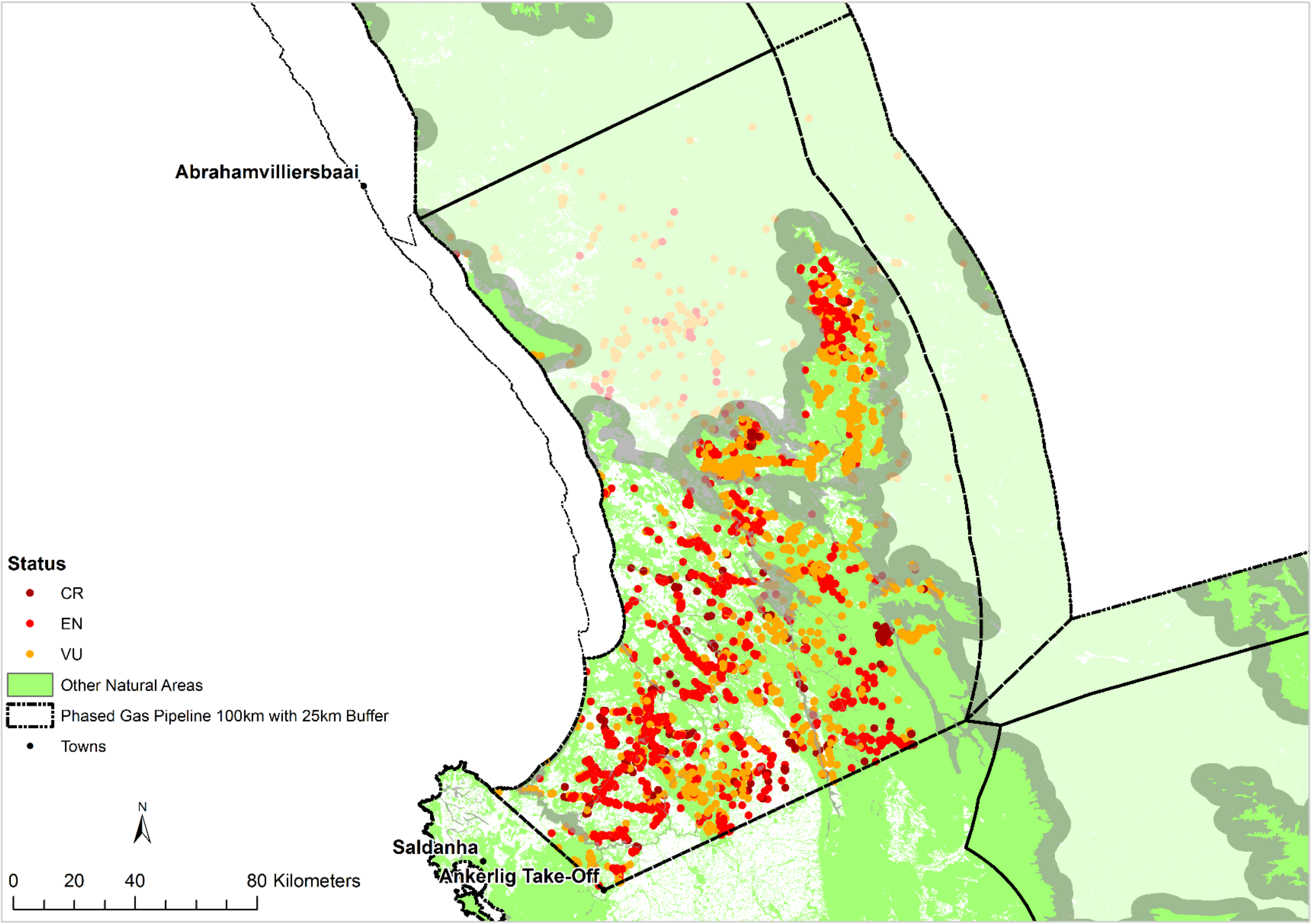

Figure 10: Gas Pipeline Phase 5 - Recorded locations of threatened plant species in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with a higher threat status are overlaid on those with a lower threat status where they overlap.

4.2.2.4 Phase 6

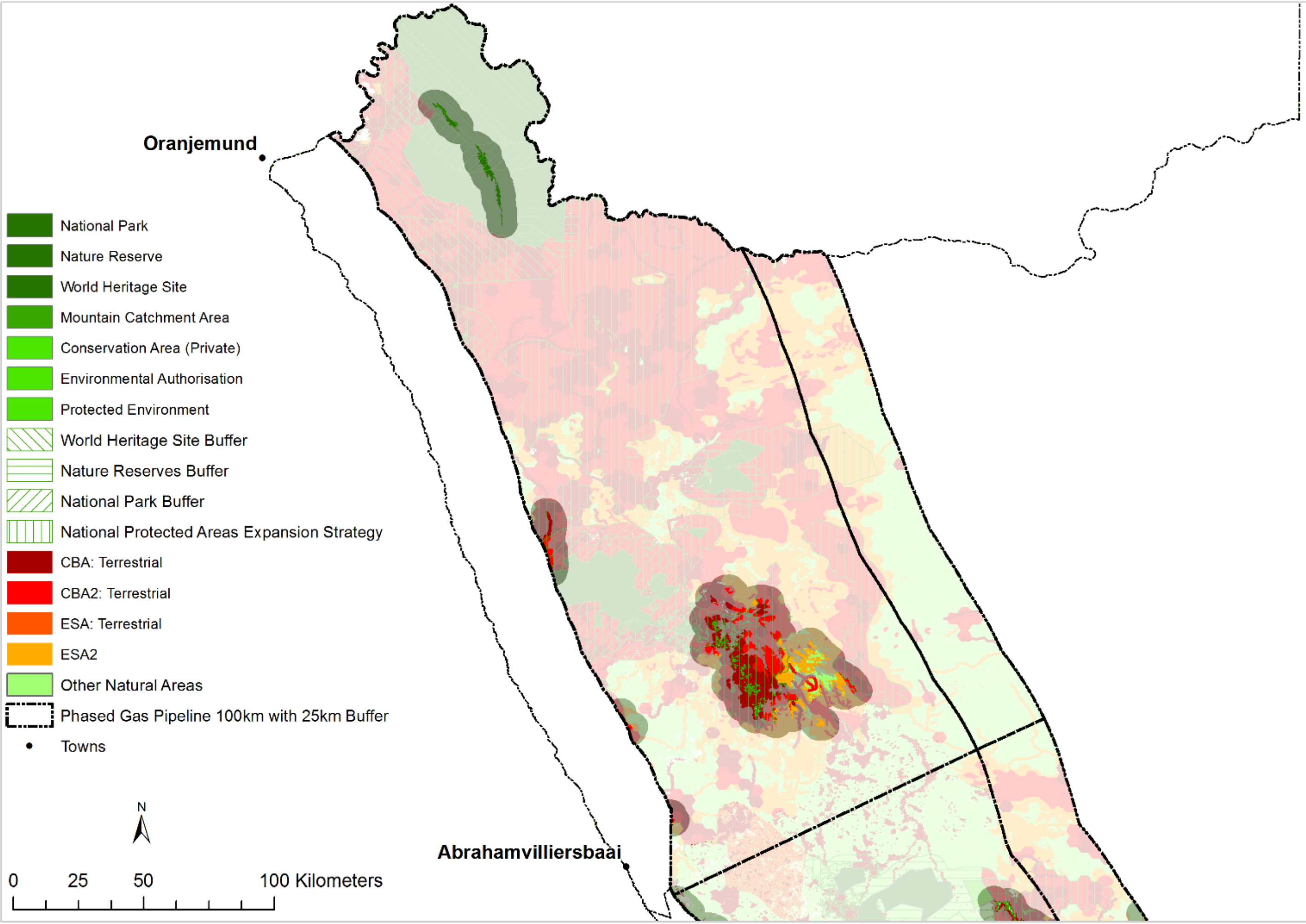

Figure 11: Gas Pipeline Phase 6 - Conservation features showing both the categories of ecosystems (CBA, ESA) and protected areas and their buffers. The Fynbos Biome units have been outlined with a 5 km external buffer in semi-transparent medium grey, and clipped to the corridors and buffers. Areas with the same level of protection status have been given the same shade of green.

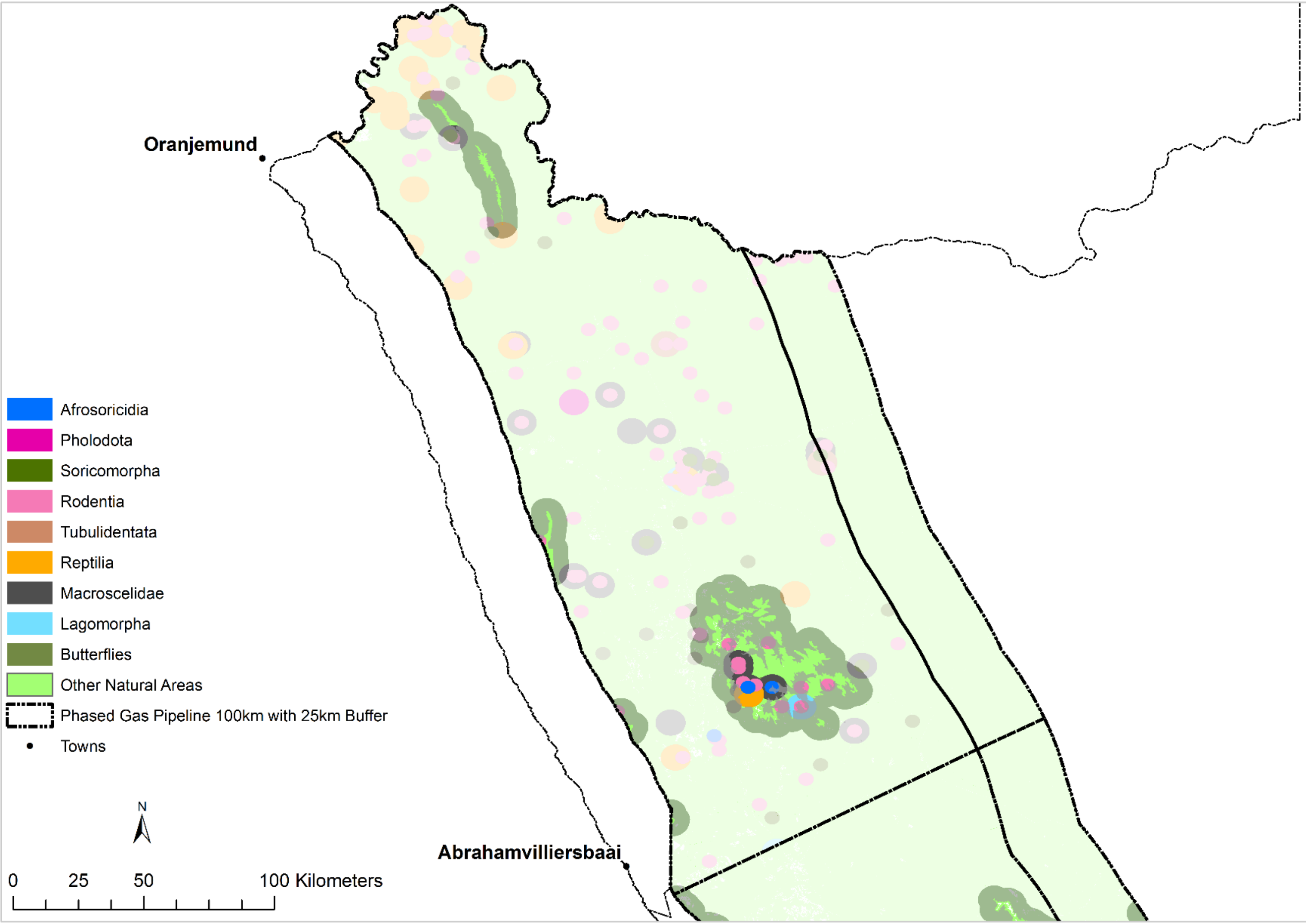

Figure 12: Gas Pipeline Phase 6 - Buffered locations of recorded threatened fauna in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with larger ranges are beneath those with smaller ranges. For information on the buffer radiuses used see the text.

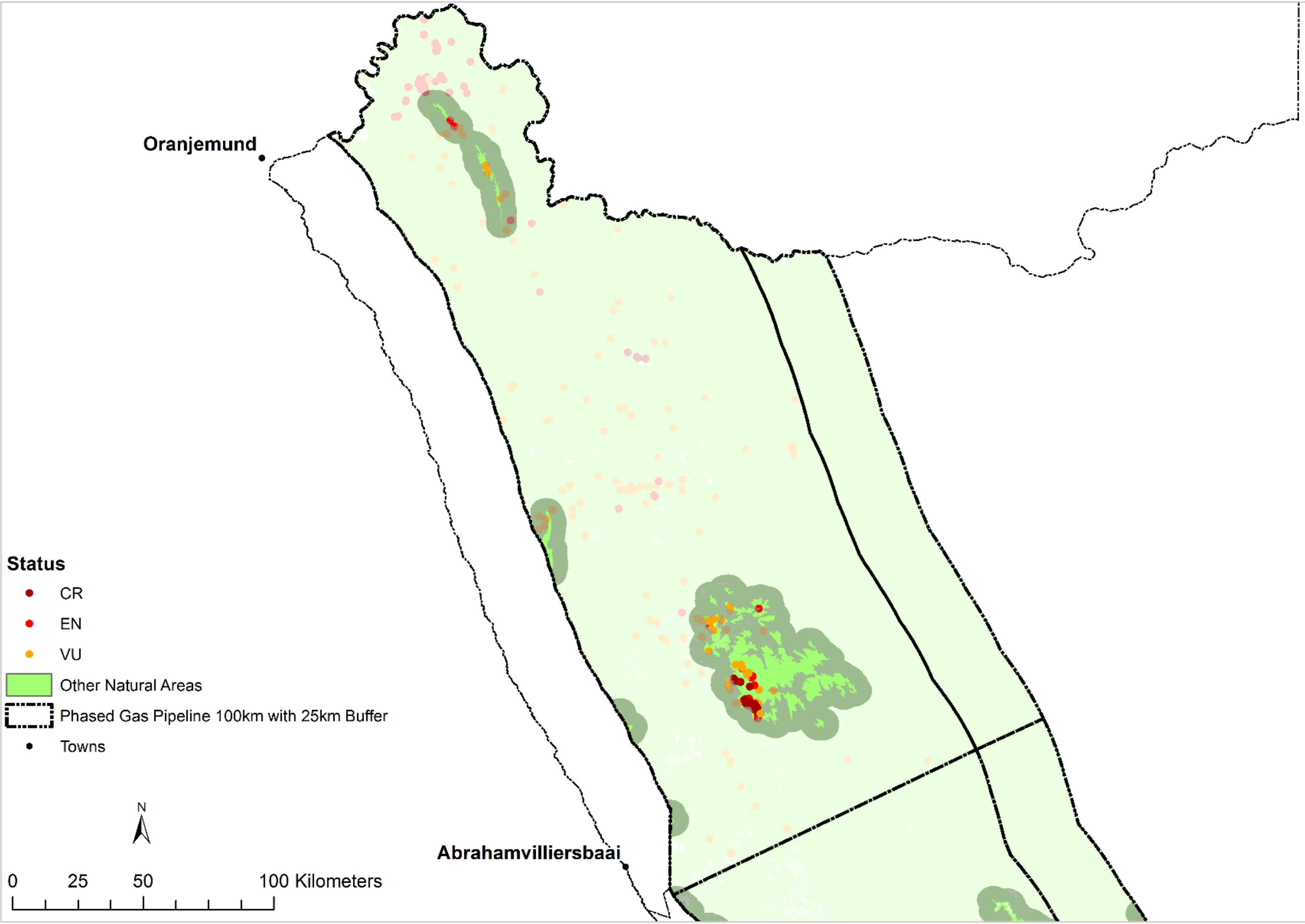

Figure 13: Gas Pipeline Phase 6 - Recorded locations of threatened plant species in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with a higher threat status are overlaid on those with a lower threat status where they overlap.

4.2.2.5 Phase 7

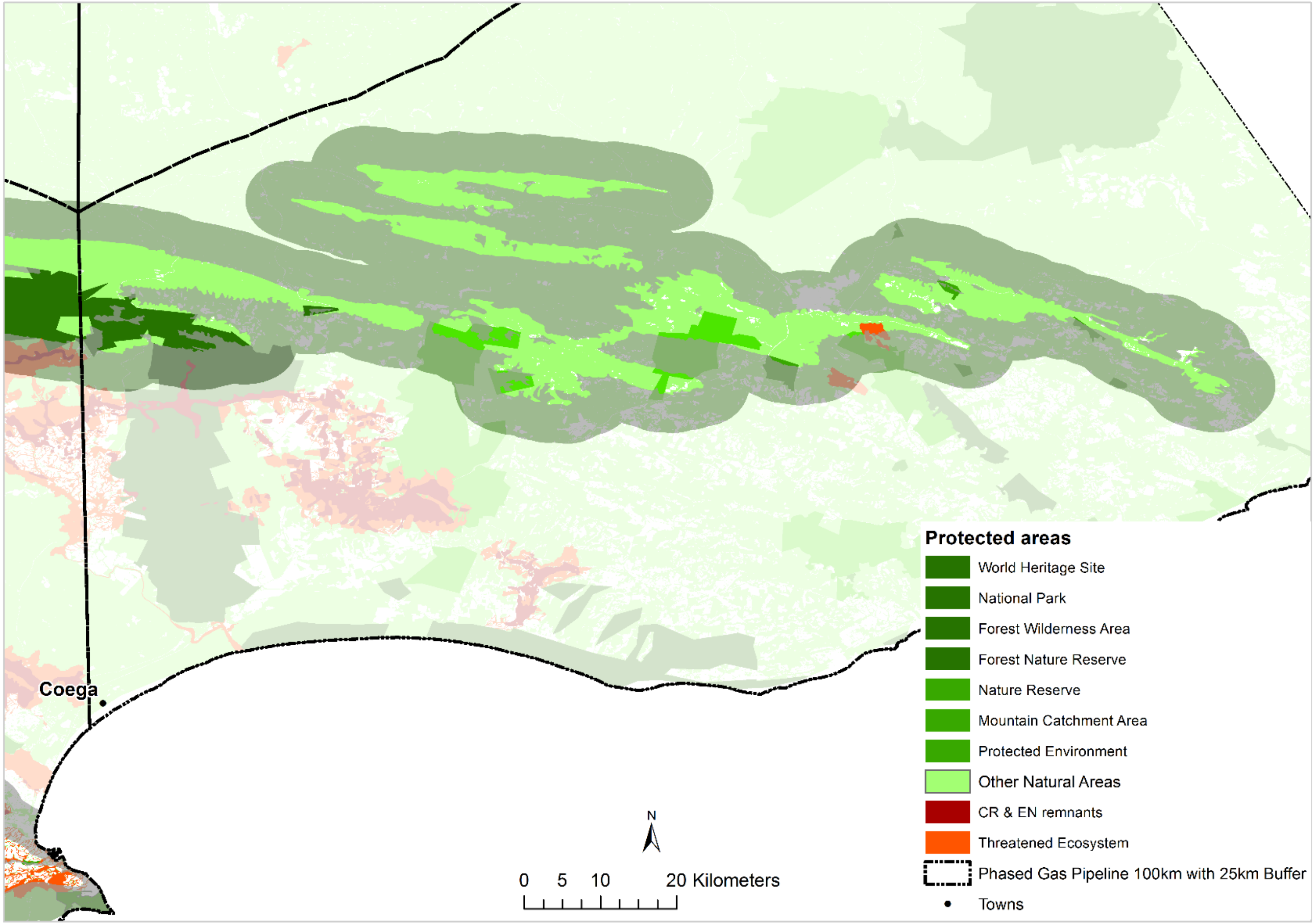

Figure 14: Gas Pipeline Phase 7 - Conservation features showing both threatened ecosystems and protected areas. The Fynbos Biome units have been outlined with a 5 km external buffer in semi-transparent medium grey. Areas with the same level of protection status have been given the same shade of green.

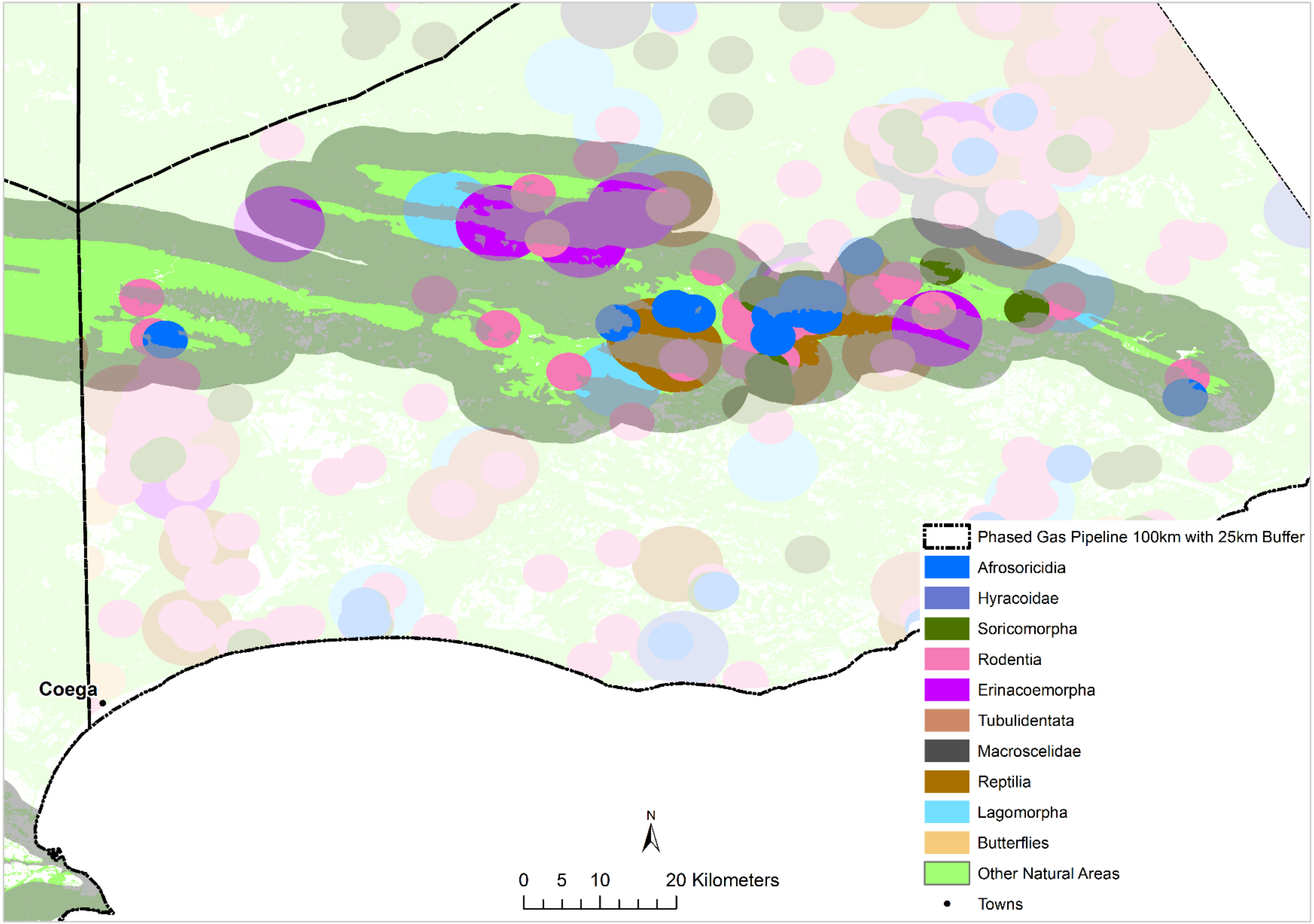

Figure 15: Gas Pipeline Phase 7 - Buffered locations of recorded threatened fauna in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with larger ranges are beneath those with smaller ranges. For information on the buffer radiuses used see the text.

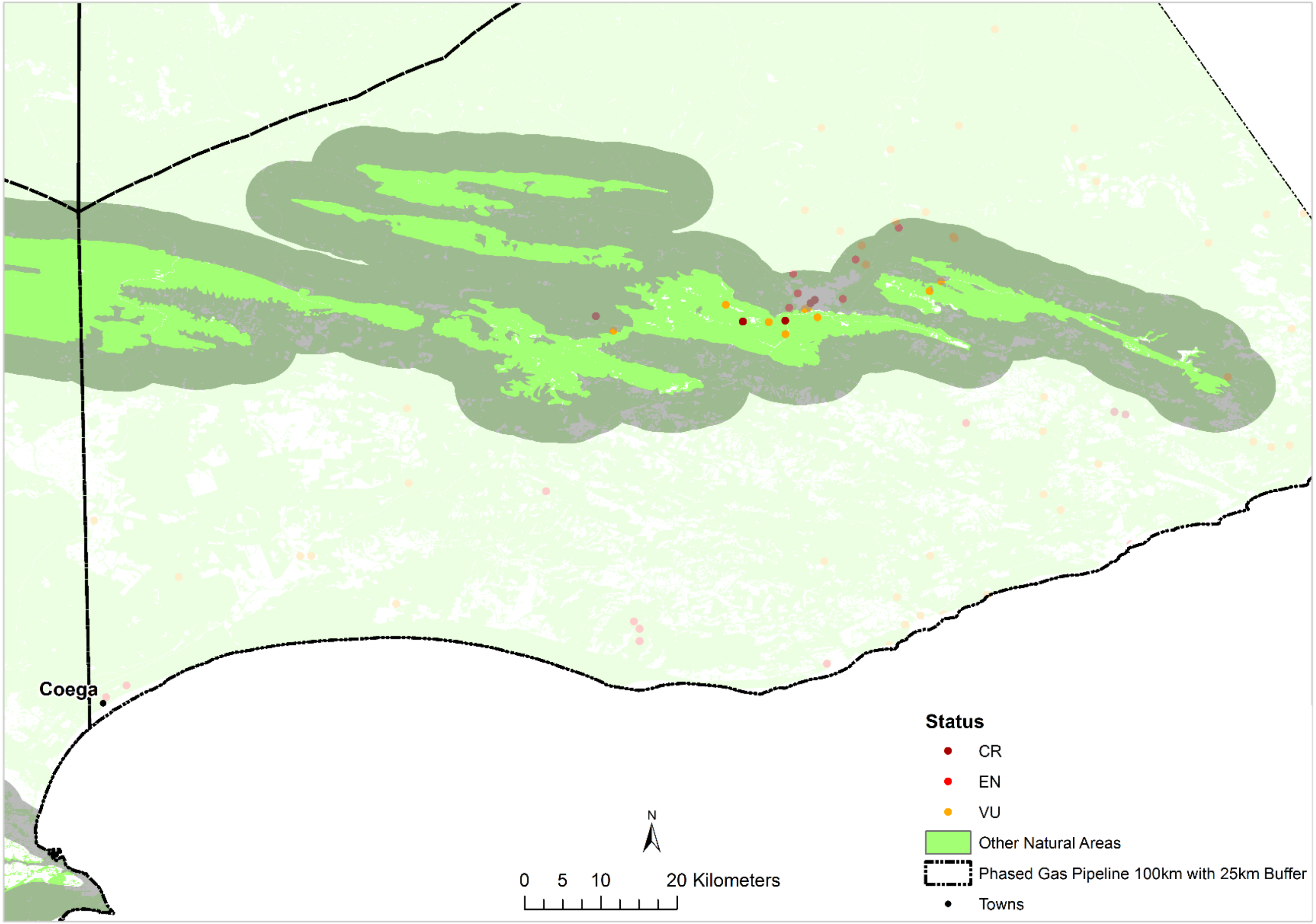

Figure 16: Gas Pipeline Phase 7 - Recorded locations of threatened plant species in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with a higher threat status are overlaid on those with a lower threat status where they overlap.

4.2.2.6 Inland

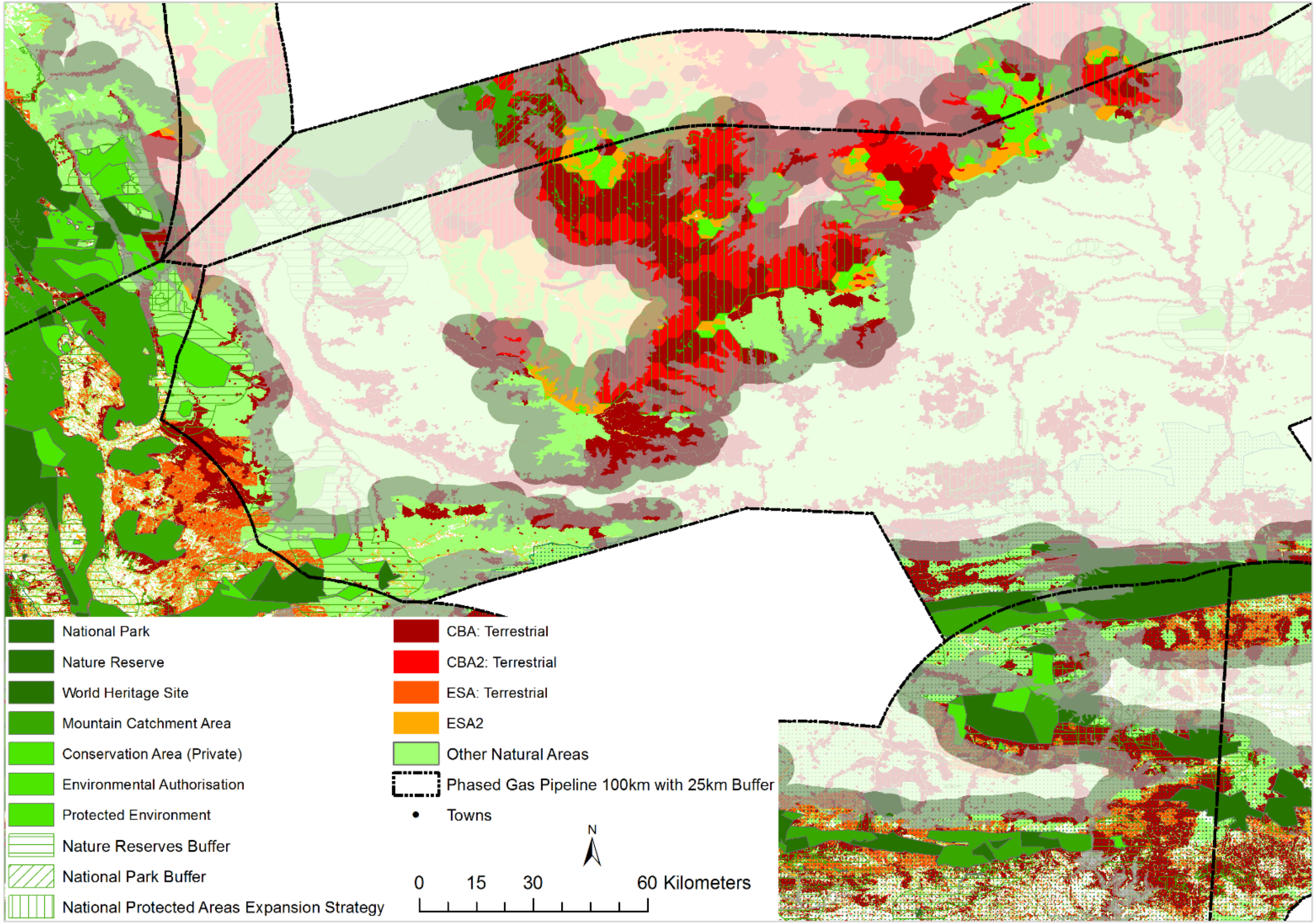

Figure 17: Gas Pipeline Phase Inland - Conservation features showing both the categories ecosystems (CBA, ESA) and protected areas and their buffers. The Fynbos Biome units have been outlined with a 5 km external buffer in semi-transparent medium grey, and clipped to the corridors and buffers. Areas with the same level of protection status have been given the same shade of green.

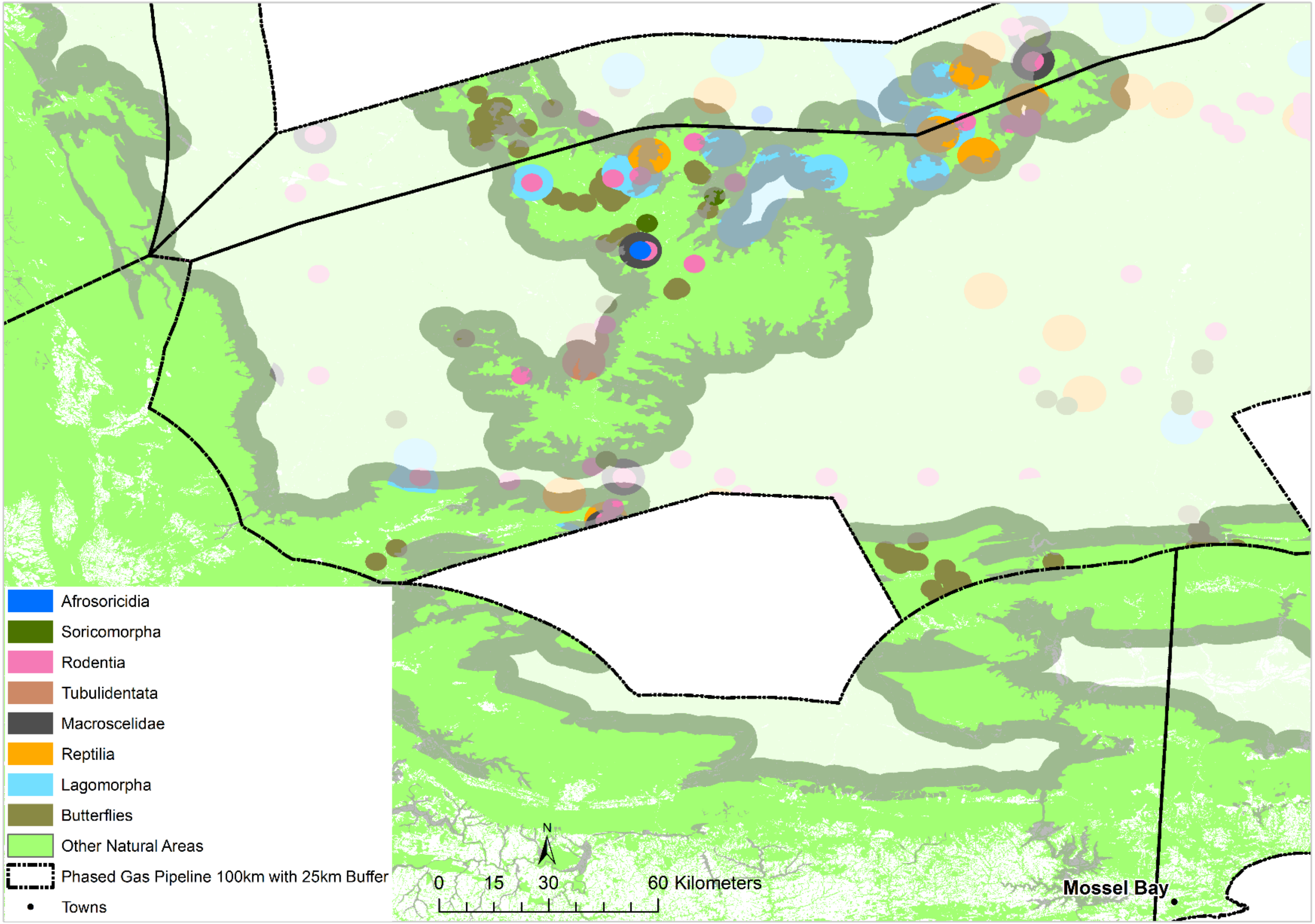

Figure 18: Gas Pipeline Phase Inland - Buffered locations of recorded threatened fauna in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with larger ranges are beneath those with smaller ranges. For information on the buffer radiuses used see the text.

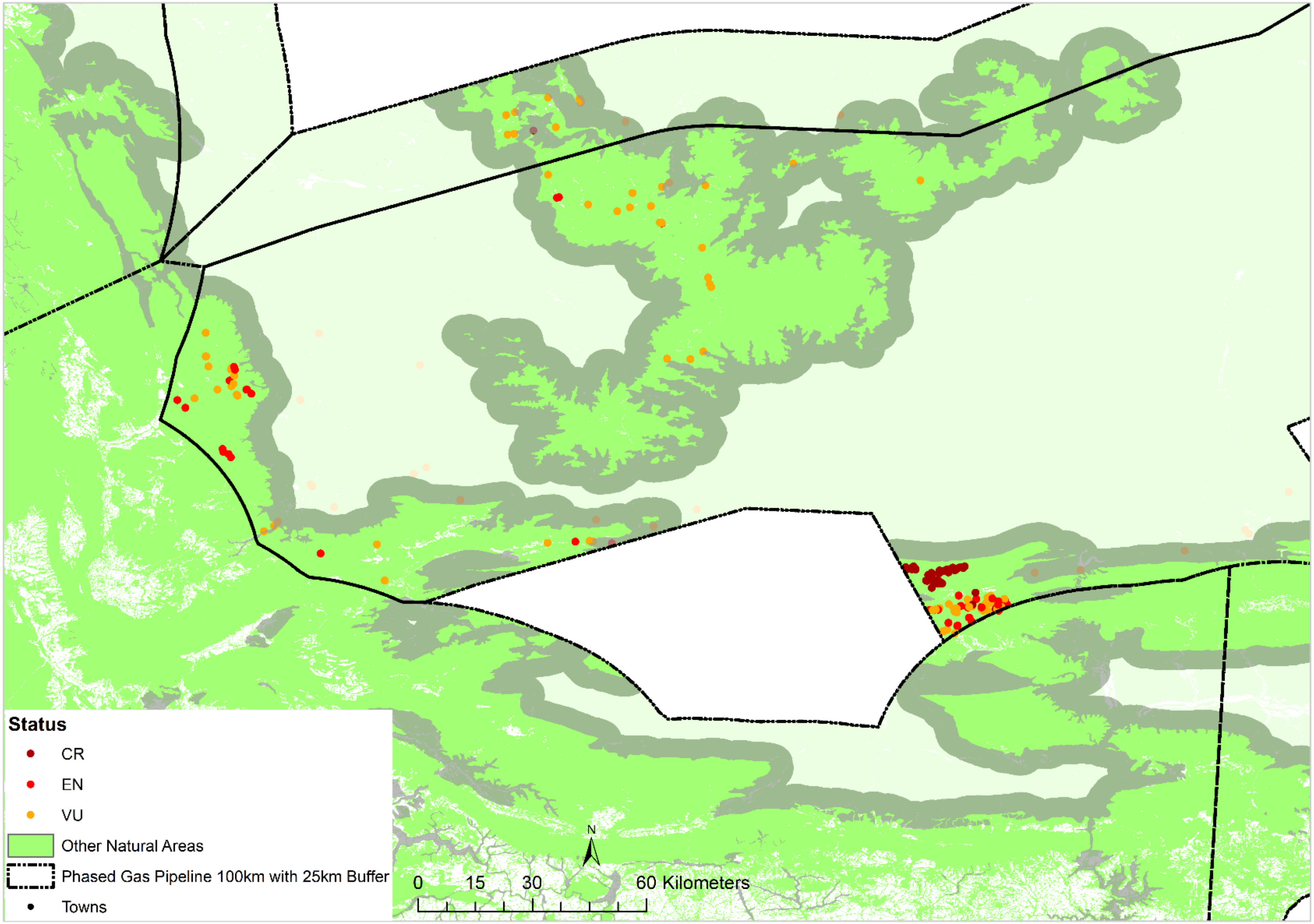

Figure 19: Gas Pipeline Phase Inland - Recorded locations of threatened plant species in the Fynbos Biome within the proposed corridor based on datasets supplied by SANBI. The taxa have been arranged so that those with a higher threat status are overlaid on those with a lower threat status where they overlap.

4.3 Four-Tier Sensitivity Mapping

The sensitivity rating followed the approach suggested for this assessment although there are shortcomings because the method combines quite disparate measures: namely biodiversity feature based values such as threatened ecosystems or species, uniqueness, with the current level of protection. Ideally the level of protection and the biodiversity measures should be related, but the original establishment of protected areas was not based on a systematic assessment of the biodiversity value. In many cases the level of protection was determined by land availability or the land was protected for other purposes (e.g. water source protection), or by the views and objectives of the body that was legislating for their protection. The resulting maps, which illustrate the spatial distribution of the relative sensitivity, are potentially misleading because the mapped sensitivity classes are not uniform but heterogeneous. To give a hypothetical example, routing the pipeline through a National Park is seen as inappropriate given that it has the highest level of protection under law and so is rated as Very High sensitivity. But the area of the park through which the pipeline is being routed may not include threatened ecosystems or any threatened species. Adjoining the boundary is a threatened ecosystem which might also contain threatened species and be a crucial link (corridor) for species movements and has been rated a CBA 1 and so the sensitivity also is Very High. The pipeline route through the park might be longer than through the CBA 1, so the choice based on them having the same sensitivity would be to route the pipeline through the CBA 1. In this hypothetical example such a decision could well do more harm to biodiversity.

In many cases such sensitivities are estimated based on assigning a numerical value and this is potentially feasible where the features being compared are in some sense commensurate, such as species or ecosystem status or even information on key processes (e.g. movement corridors). However, in this case there are both biodiversity based values - using biodiversity in the broad sense of composition, structure and function from genes to landscapes (Noss, 1996) – that are being combined with the level of statutory protection. In such cases a simple quantitative score is the best because the preferred alternative, a multi-criteria decision making approach, is best done through consultation with other experts and the scope of the present study does not allow for such detailed consultations.

Assigning a sensitivity rating requires an assessment of the vulnerability of the receiving environment to the impact (i.e. the potential magnitude of the loss) and the potential for mitigation to reduce that impact by, for example, reducing the vulnerability. The vulnerability of the feature of interest is, in turn, determined by the characteristics of the impact and those of the feature, including the specific environmental setting and context of that feature. The characteristics of the impact that are important are its timing in relation to key community processes (e.g. in winter versus summer), intensity or severity, extent, duration and likely recurrence interval. The inherent vulnerability to the impact varies between features of different types (e.g. ecosystems, species), the environmental settings (high rainfall or marginal rainfall environment, stable versus erodible soils) and the context (e.g. north versus south-facing slopes, steep versus gentle slope). In this case the sensitivity that is being rated is to the construction and operation of a gas pipeline, which amount to a severe, linearly-extensive impact of relatively short duration and of a similar magnitude everywhere. The main impact during construction phase is due to the clearing of vegetation, access for people, machines and materials, trenching, and initiating rehabilitation. All the stages, bar the rehabilitation, could be accomplished in a period of weeks or days. It is the long-term impacts that really matter in the form of the degree of recovery of the composition and structure of the regenerating community, potentially including invading alien species, and those due to the access tracks, both forming a long line across the landscape.

Figure 20 - Figure 26 present the sensitivity maps for the Fynbos Biome in the proposed gas pipeline phases.

4.3.1 Phase 1

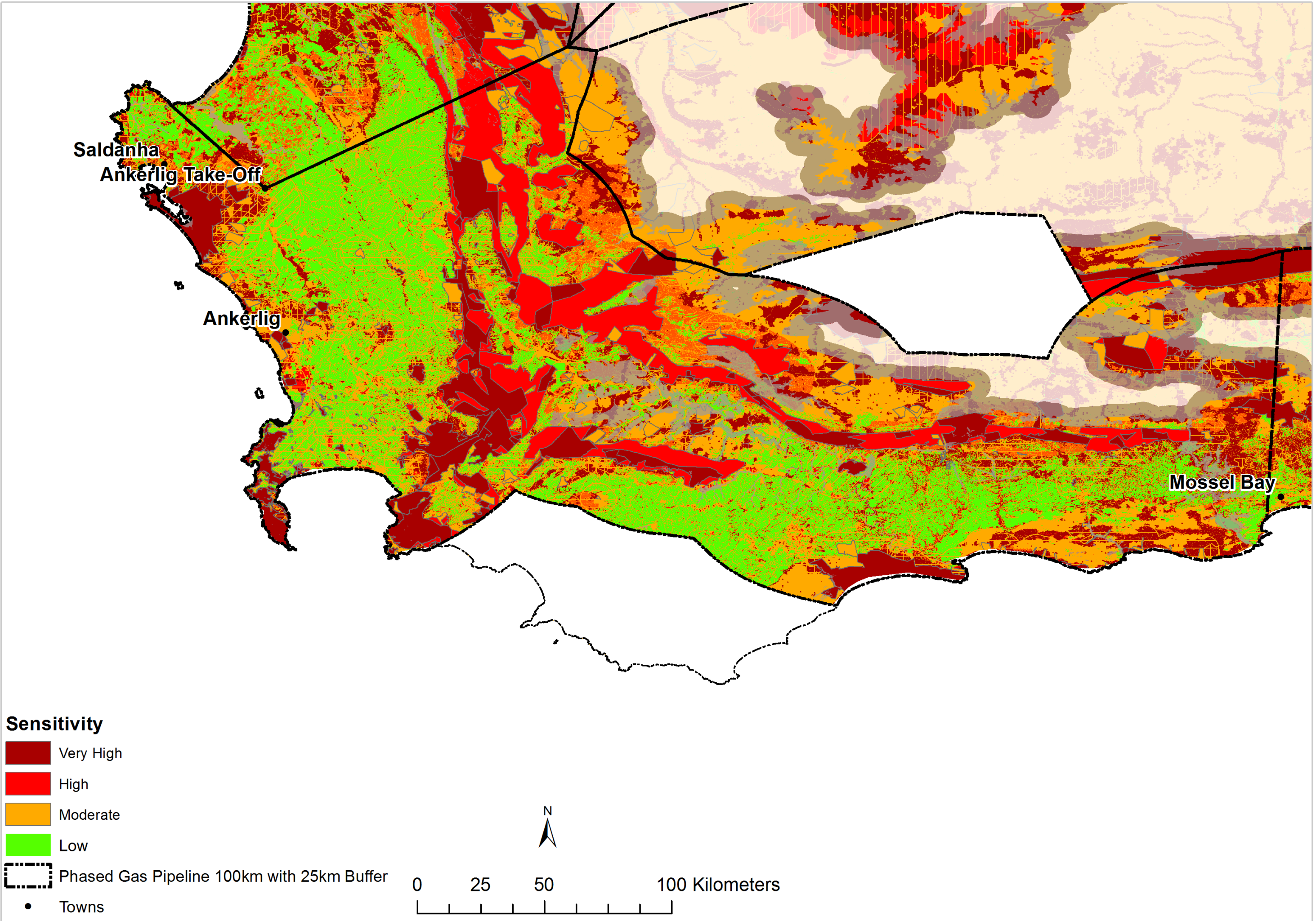

Figure 20: Gas Pipeline Phase 1 - Sensitivity map based on the sensitivity ratings of the biodiversity and conservation features.

4.3.2 Phase 2

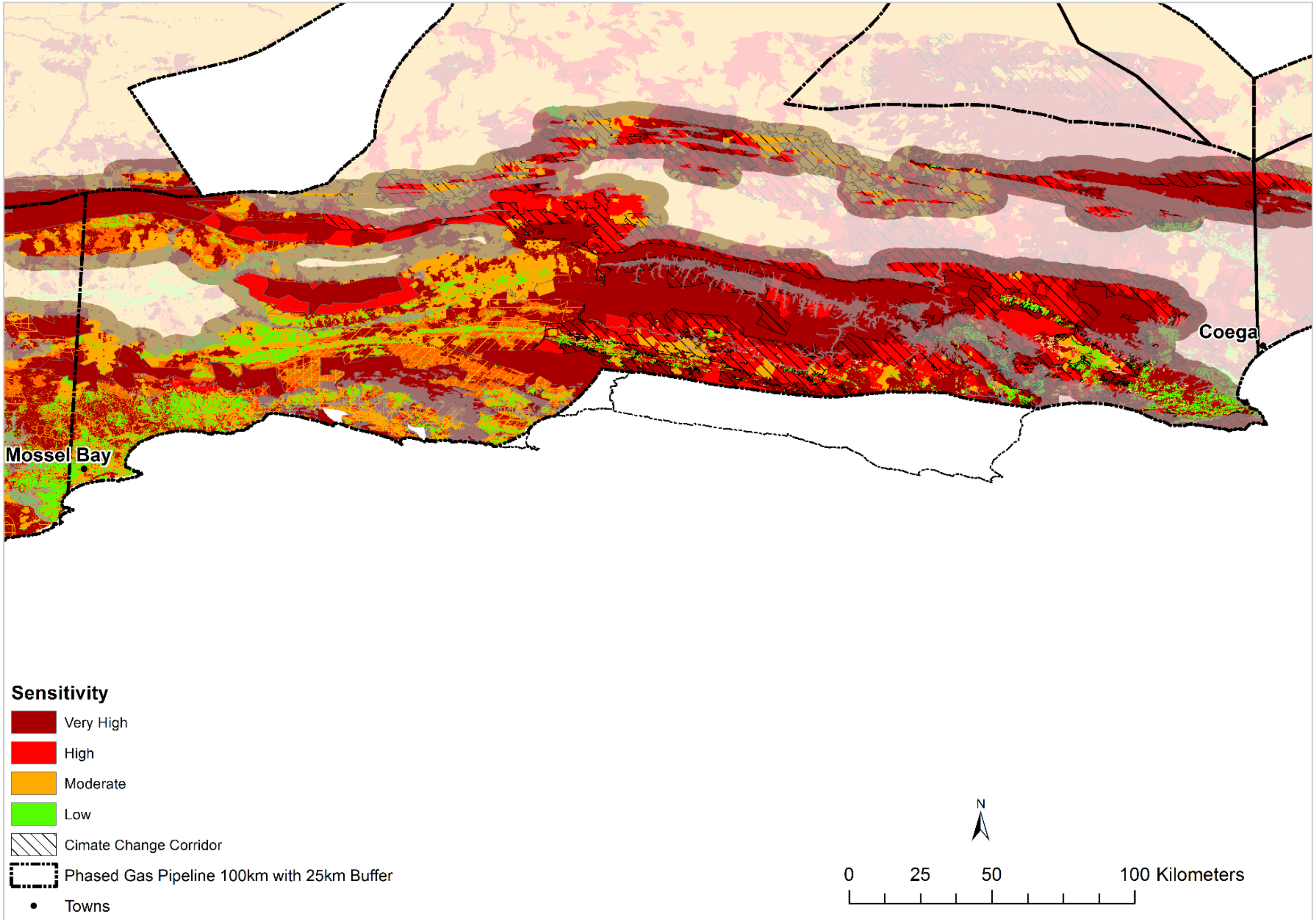

Figure 21: Gas Pipeline Phase 2 - Sensitivity map based on the sensitivity ratings of the biodiversity and conservation features.

4.3.3 Phase 5

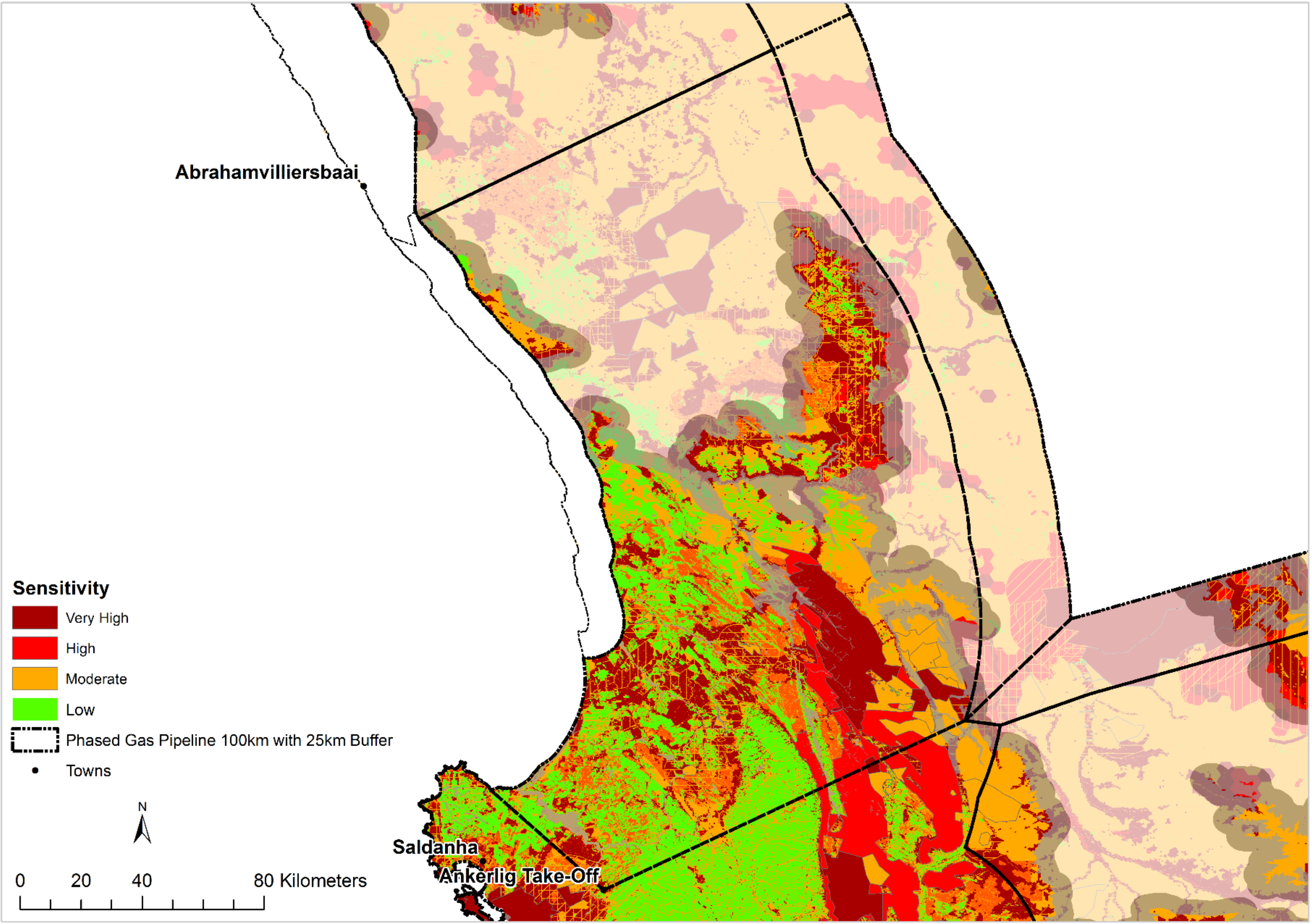

Figure 22: Gas Pipeline Phase 5 - Sensitivity map based on the sensitivity ratings of the biodiversity and conservation features.

4.3.4 Phase 6

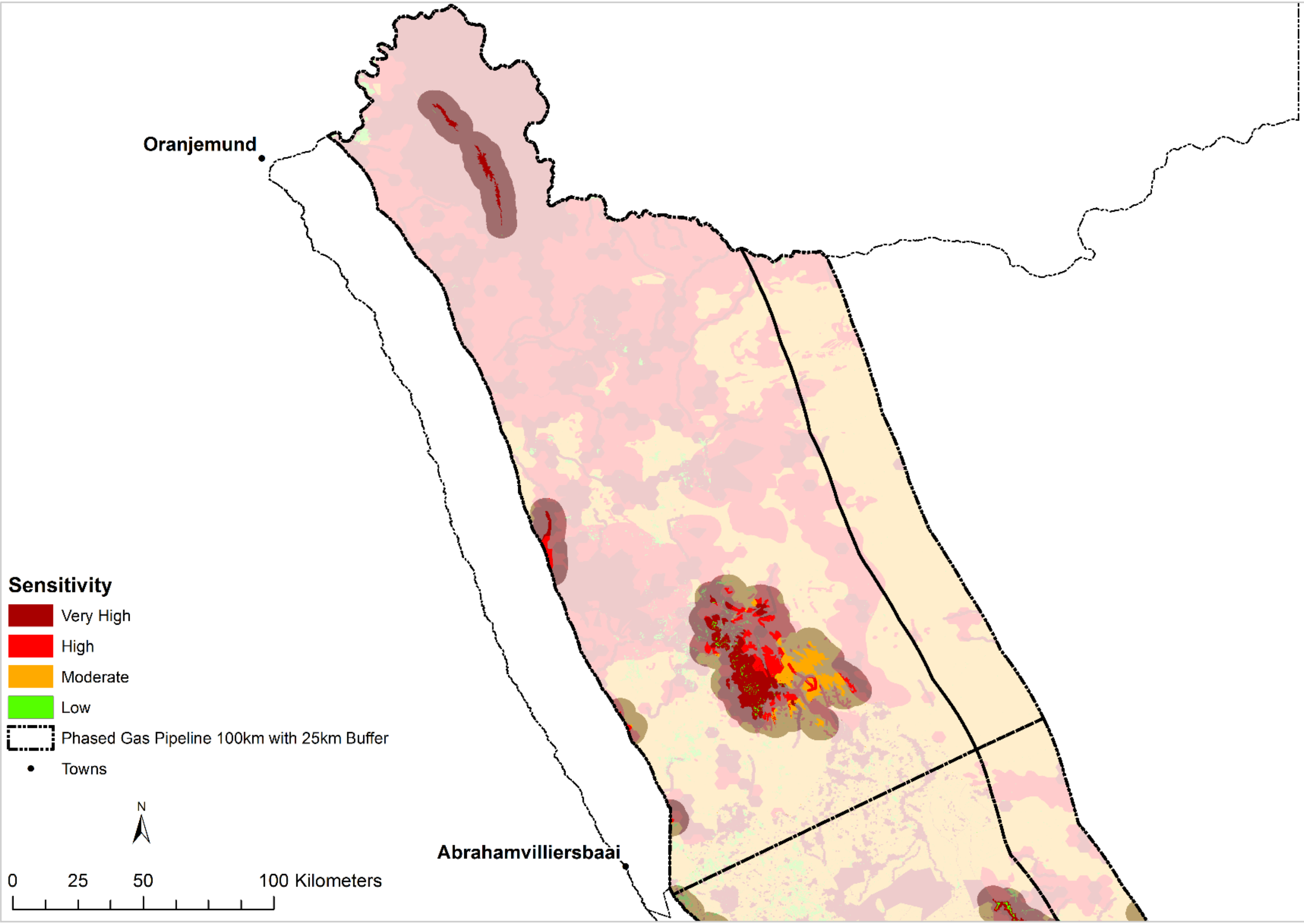

Figure 23: Gas Pipeline Phase 6 - Sensitivity map based on the sensitivity ratings of the biodiversity and conservation features.

4.3.5 Phase 7

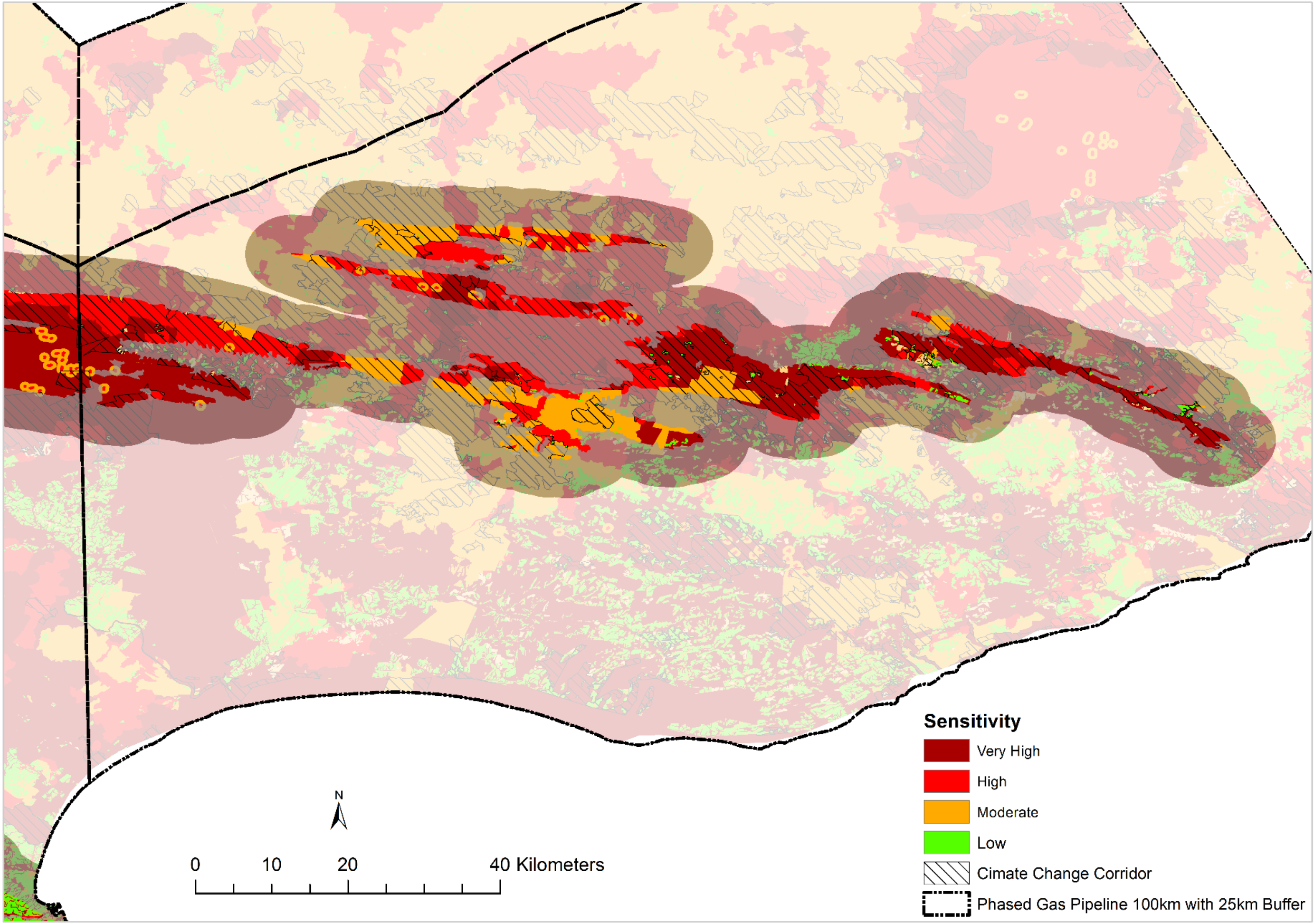

Figure 24: Gas Pipeline Phase 7 - Sensitivity map based on the sensitivity ratings of the biodiversity and conservation features.

4.3.6 Inland

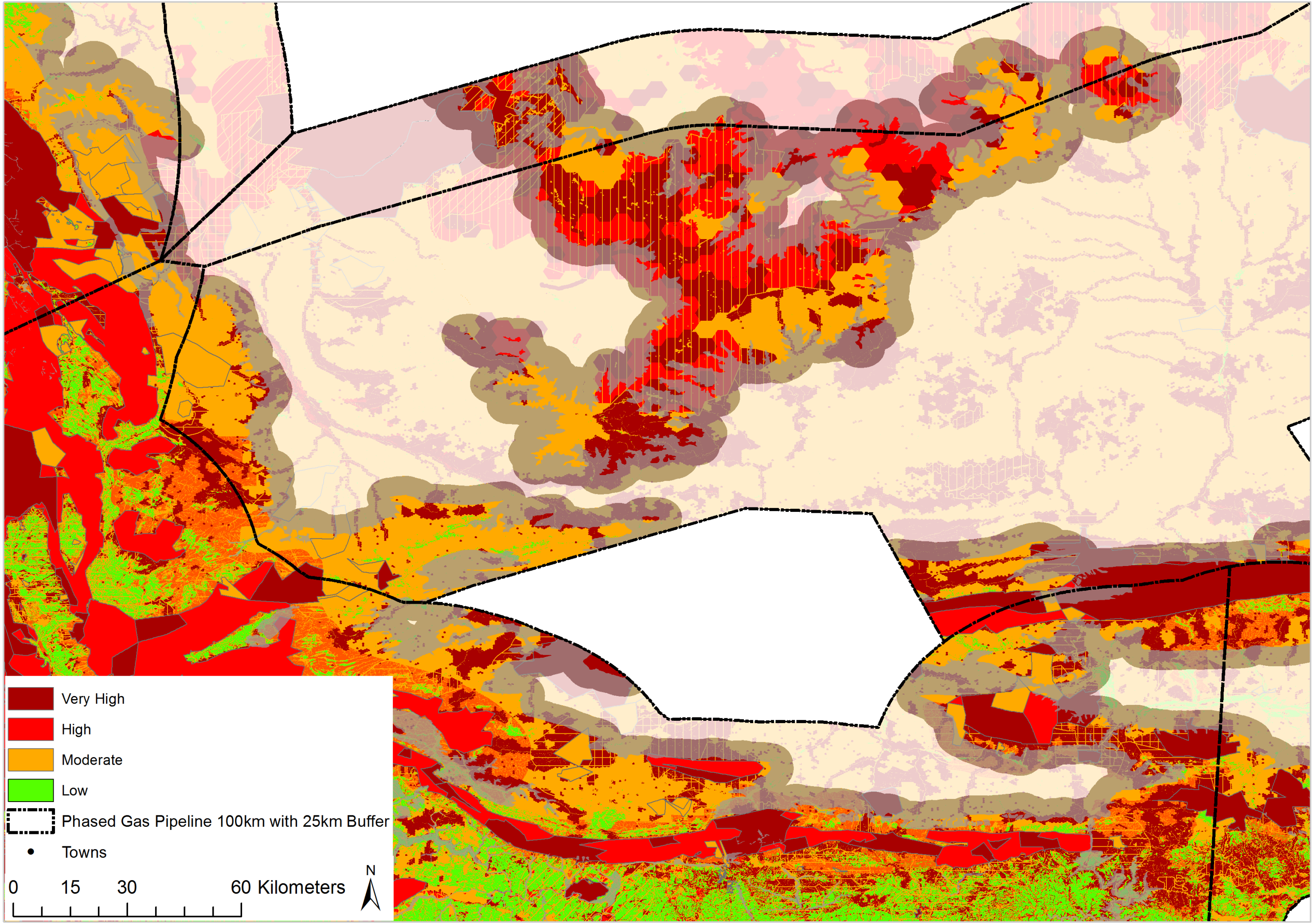

Figure 25: Gas Pipeline Phase Inland - Sensitivity map based on the sensitivity ratings of the biodiversity and conservation features.

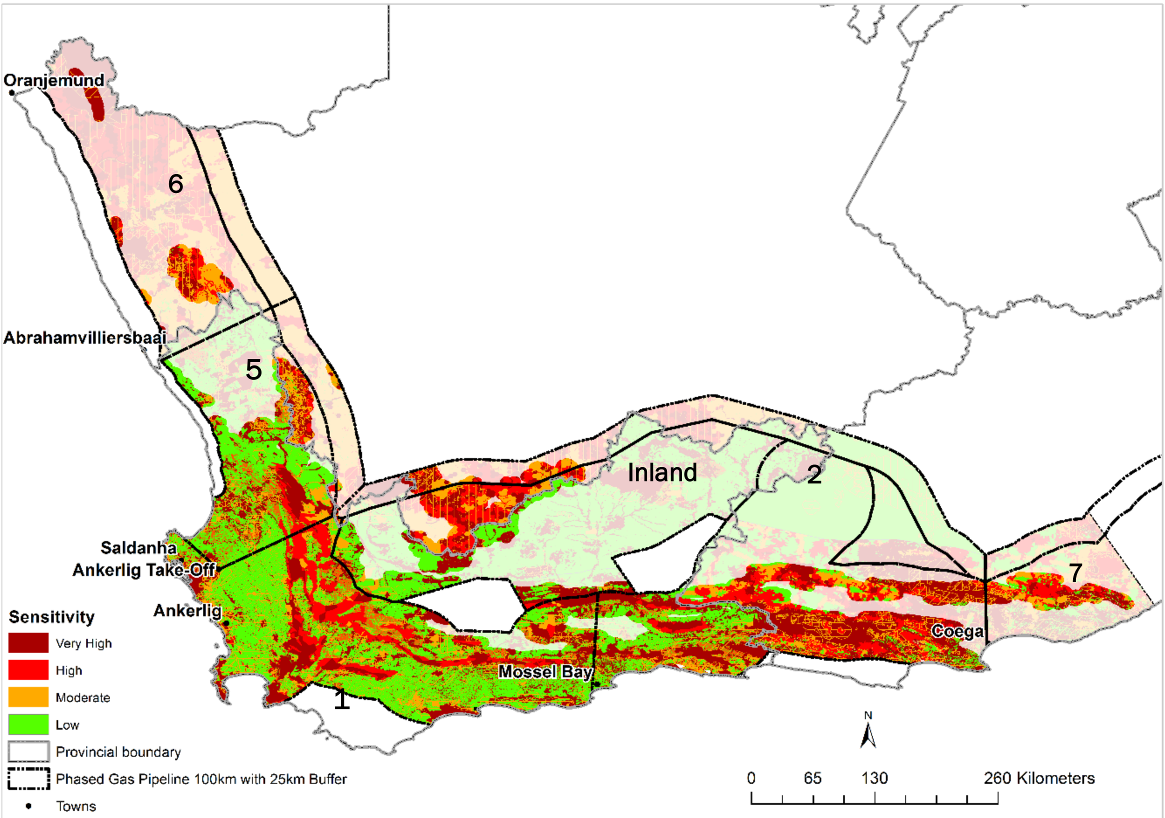

Figure 26: Sensitivity map for the Fynbos Biome based on the underlying biodiversity and conservation features.

Abrahamvilliersbaai has been identified as a key point for a land fall for the marine pipeline from the gas fields off the western coastline of South Africa. The route north to the Orange River (Phase 6) could easily be routed to avoid the limited areas of Fynbos in this section of the corridor with the actual route depending on the sensitivity of the conservation features in the Succulent Karoo. The route southwards (Phase 5, 1) is more constrained although possible routes to Saldanha and Ankerlig have already been assessed (CSIR, 2014). The critical areas lie in the southern section of Phase 5 and the adjacent area Phase 1. The high concentration of Very Highly sensitive CBA 1 features in this area, which included remnants of threatened ecosystems, threatened species and movement corridors means that any route will entail significant impacts. Essentially there are two options, one more or less parallel to the coast and one routed inland of the Piketberg, and the screening study preferred the coastal routing.

All the options for the route from the Ankerlig Take-Off to Mossel Bay (Phase 1) are problematic. They will all involve crossing the mountain ranges that extend from Piekenierskloof to Cape Hangklip. The most obvious one is to use the break formed by the Klein Berg River valley to cross over into the Tulbagh-Ashton valley and from there via Bonnievale into the eastern Overberg. All the other options also involve narrow passes and crossing higher mountain ranges. Much of this route would pass through a mosaic of Renosterveld and Succulent Karoo and route options would have to be assessed jointly.

From Mossel Bay to Coega (Phase 2) the: (a) the coast to mountain concentration of Very Highly and Highly sensitive conservation features in the Fynbos Biome, (b) the mosaic of the Fynbos and Forest Biomes, and (c) the intensive development between George and Nature’s Valley, essentially rule out a coastal route. An inland route via the southern Klein Karoo and Langkloof is an easier option but there are significant conservation features and no easy routes over the mountains into the Little Karoo.

The Fynbos Biome east of Coega (Phase 7) is confined to the mountains and higher lying areas and routing through this part of the biome would depend primarily on whether it provides an alternative to the constraints of the conservation features in the Albany Thicket.

The Inland Phase corridor does offer an alternative route inland of the Cape folded mountain ranges but would involve traversing additional mountain ranges both to get inland and then to get back to the coast. Relatively little Fynbos occurs in this Phase and so the routing would be determined primarily by the sensitivity of the conservation features in the Succulent and Nama Karoo Biomes.

5 KEY POTENTIAL IMPACTS AND THEIR MITIGATION [UNDER GAS PIPELINE DEVELOPMENT]

The construction of the pipeline will involve the stages set out in the diagram below (Figure 27) beginning with the surveying and marking out of the route, lay down areas and other facilities, followed by clearing and preparation of the access route for the pipe transport vehicles and other machines. Next will be the pipe stringing, pipe bending, alignment and welding, trenching and pipe laying. Last comes the backfilling, vegetation restoration and establishment of the permanent access route for maintenance.

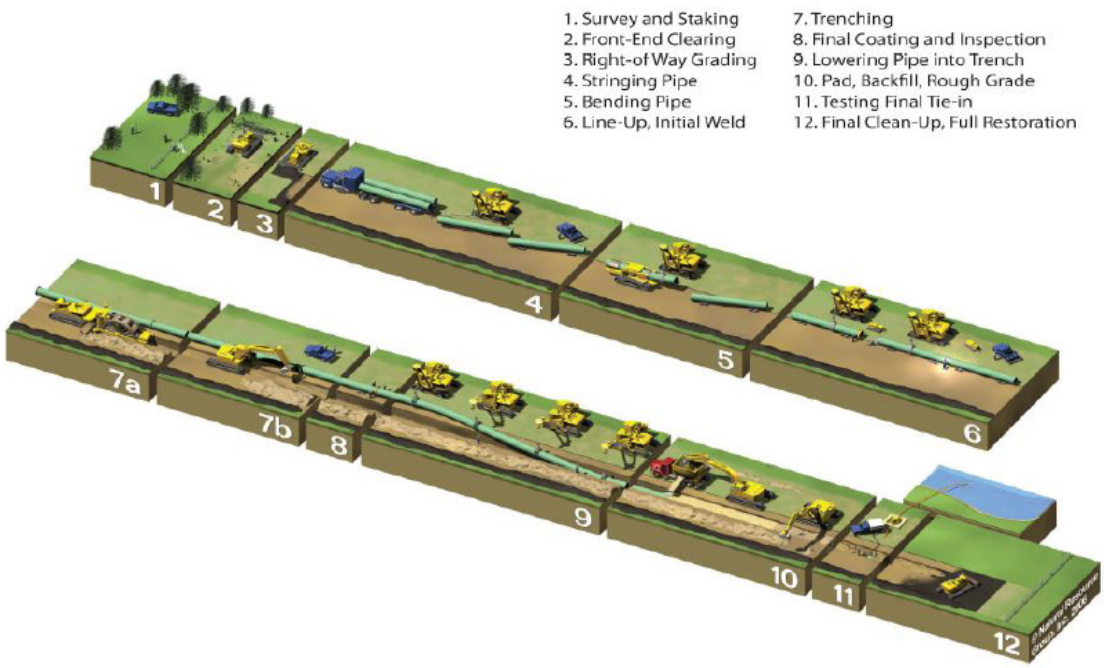

Figure 27: Typical site preparation and construction of gas pipeline infrastructure (Ephraim, 2017).

The area that is directly affected during the construction phase will typically be about 50 m wide as shown below with most of the activity being within a 40 m wide strip (20 m either side of the pipeline) (Figure 28). Where the pipeline has to traverse more rugged terrain, especially when traversing steep slopes, the width that is affected will depend in the terrain but could be substantially greater.

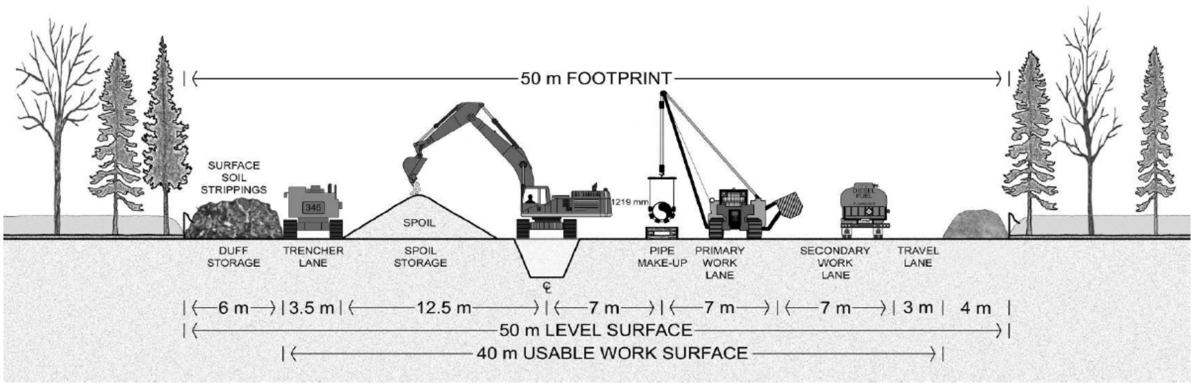

Figure 28: Typical construction footprint of gas pipeline infrastructure (Ephraim, 2017).

Access for maintenance and servicing during the operational phase will require the maintenance of access roads to at least the pigging stations. These need to be suitable for periodic use by a pickup or small truck and would need to be at least a typical two lane (wheel) track. In sandy areas and on slopes a permanent surface will be needed and will potentially involve more construction where the construction work lanes are not suitable. Access to the pigging sites will require similar road constructed to similar standards.

The key potential impacts of gas pipeline development to the Fynbos Biome may be concisely summarised as:

- Disturbance to soils, flora and fauna (incl. increased human activity, poaching, noise, dust, erosion, and oil/fuel spills);
- Introduction and establishment of alien invasive species and non-local genetic stock; and
- Habitat loss and alteration (incl. changes in ecosystem function, and local extinction or decline in populations of endemic and rare species).

The kinds of impacts on the terrestrial ecosystems can be divided up according to the stages of the pipeline construction and operation, and are unpacked in detail in Section 5.1 to 5.4 below. These impacts will be particularly important in some conservation categories (e.g. CBA1) and in protected areas. The WCBSP (Pool-Stanvliet et al., 2017) recommends some special considerations that should be applied to activities affecting threatened vegetation types or protected areas during the planning and construction stages (See Boxes 1 and 2).

5.1 Planning Stage

- **Impact 1: Final selection and laying out of the pipeline route. Disturbance and vegetation modification due to arrival and movements of people and vehicles on site (assuming untransformed communities), disturbance of soil and creation of dust**
  - Mitigation:
    - Avoid High and Very High sensitive areas during the route planning
    - Avoid crossing key migration or movement corridors for fauna during the route planning
    - Where avoidance is not possible, in areas of Moderate to Very High sensitivity undertake specialist faunal and plant species assessments to propose mitigation or recommend alternatives prior to finalising the route; and in areas of lower sensitivity specialist surveys or inspections to establish whether threatened or endemic species are present
    - If populations of threatened or endemic species are encountered and unavoidable then specialist inputs should be obtained
    - Require specialists to inspect the proposed route prior to clearing of vegetation and breaking of ground to ensure no animal burrows (e.g. porcupine, aardvark, carnivores) are harmed
    - Avoid burrows of porcupines, aardvarks and carnivores and provide sensitivity buffers where they are in the vicinity
    - Vehicle speeds must kept slow to minimise potential collisions with animals and dust creation

5.2 Construction Stage

- **Impact 2: Disturbance due to arrival of people and heavy equipment on site. Removal and disturbance of vegetation during construction resulting in the loss of foraging habitat and shelter for fauna, disturbance of soil and creation of dust.**
  - Mitigation:
    - Minimise the development footprint
    - Control dust to minimise impacts by regulating vehicle speeds and using geotextiles, particularly on soil dumps

    - Control sediments in runoff to minimise impacts on rivers and wetlands
    - Minimise the duration of the activities on site
    - Vehicle speeds must kept slow to minimise potential collisions with animals

- **Impact 3: Risk of oil and fuel spills from equipment or vehicles and their impacts on ecosystems**
  - Mitigation
    - Prevent fuel or oil leaks and make provision to contain them (e.g. in drip trays) to minimise contamination of surrounding soil and water

- **Impact 4: Dispersal of fauna due to noise and vibrations from trenching, drilling and possible blasting. Short-term impact for more mobile and resilient species but longer term or permanent for less mobile or more sensitive species.**
  - Mitigation:
    - Control dust to minimise impacts by regulating vehicle speeds and using geotextiles, particularly on soil dumps
    - Avoid construction activities in the breeding season of conservation important taxa

- **Impact 5: Harm to animals or loss/alteration of both normal and breeding habitat, including poaching. Threatened or collectable plant species theft**
  - Mitigation:
    - See Impact 1 above on selection of route for mitigation measures
    - Ensure that all staff understand that no animals may be intentionally harmed or killed for any purpose or poached

- **Impact 6: Entrapment of animals in the open trench which then could die through drowning in water puddles, dehydrate due to exposure, or starve because they have no access to food.**
  - Mitigation:
    - Minimise the physical extent of construction activities and complete them in as short a time as possible.
    - Wherever possible, time construction activities to avoid the breeding or migration periods of the threatened or important taxa that may occur along the route
    - Equip open trenches with suitable ramps or steps every 50m so that trapped animals can escape
    - In areas where there is high animal activity, fine-mesh fences should be laid out around the open section and secured to minimise the likelihood that animals will fall in

- **Impact 7: Invasive alien species, particularly plants**
  - As noted earlier, the **altered vegetation structure and access by vehicles may favour invasions by alien species**, especially plants, during the construction and operational phases. Machinery can also bring propagules onto site in the form, for example, of mud encrusted onto excavators or trucks. Construction materials, especially sand, stone and gravel from quarries can include propagules so all such materials should only be sourced from quarries or borrow pits which are free of invasive species. Many of the Fynbos invaders are woody plants which have deep roots and would have to be controlled if they occurred in the pipeline servitude. Alien grasses are particularly aggressive invaders in the Sand Fynbos and Renosterveld communities and possibly also the Strandveld communities. Studies of invasive species control measures have shown that eradication of a species cannot be achieved except in the initial stage of establishment. Therefore, effective control in this context should be that alien plant species cover within the pipeline servitude is reduced to, and maintained at, less than 5% canopy cover.

- Mitigation:
  - Incorporate, and budget for, control of invasive species in environmental management plans for the construction, operation and decommissioning phases of the pipeline
  - Identify and map invasive species along and within the planned route prior to construction
  - Prepare systematic and properly costed plans for invasive species control for sections of the proposed route
  - Carry out initial control measures prior to the construction
  - Ensure that machinery is properly cleaned before being brought onto site and also before moving it from a section of the route where invading species were controlled to a section that is free of invading species
  - Minimise imports of materials that could contain propagules[5] of invasive species, particularly plants and/or screening such materials to ensure they are propagule free
  - Post-construction and during rehabilitation and operation ensure that appropriate follow-up operations are continued until the invading species are effectively under control
  - During the operational phase carry out regular surveys to identify invading species; where they are found, carry out the necessary control operations
  - If and when the pipeline is replaced then follow the same procedures as for the construction.
  - When the gas pipeline is closed ensure that any invasions are controlled as part of the closure processes. As part of the hand-over process, ensure that the land-owner's responsibility to maintain the cleared areas is acknowledged in writing.

Box 1: Special considerations for threatened vegetation types (Pool-Stanvliet et al., 2017).

- No linear surface impacts such as those caused by pipelines or permanent installations (i.e. buildings) are allowed in areas assessed as CBA 1 because they will compromise the biodiversity objectives.
- For CBA 2 or ESAs such impacts are only permissible under restricted conditions.
- Each portion that is traversed will have to be justified and the cumulative impacts will be considered important in proposing possible alternative routes.
- Mitigation:
  - Firstly, ensure that such crossings are avoided and minimised as far as possible.
  - Locate all such structures on transformed, disturbed or low-value agricultural land, wherever possible.
  - Avoid special habitats or populations of endemic or threatened species.

Box 2: Special considerations for Protected Areas (Pool-Stanvliet et al., 2017).

- These include national and provincial parks as well as private conservancies and stewardship sites which should be avoided if at all possible.
- A proclaimed national or provincial park should be regarded as a potential no-go area.
- Crossings may be acceptable provided the pipeline is aligned with other features (e.g. servitudes, roads).
  - Mitigation:
    - All such crossings however should be subject to environmental management best practice and stringent standards to minimise the impacts.
    - They also should be subject any measures prescribed by the management plan for that protected area.
    - Consideration should be given to burying the pipeline much deeper to minimise the need for ongoing vegetation management.

[5] Any parts or life stages of organisms which could enable them to establish new populations

5.3 Post-construction rehabilitation stage

This will be critical to the overall environmental performance of the project (Sahley et al., 2017). However, as pointed out in the text there is a high to very high risk that rehabilitation will fail in the arid parts of the biome due to the low and unreliable rainfall. Provision must be made to re-do the rehabilitation should it fail until at least an acceptable degree of success is achieved and a high degree of success in highly and very highly sensitive areas. Rehabilitation to the full diversity of the original communities is not possible so there will always be some loss of ecosystem function and interactions and alteration of the habitat. The primary reason for this is the factors that determine success rates of re-establishment of most of the very diverse Fynbos plant species and specialised faunal groups (e.g. many of the invertebrates) are poorly known, in other words rehabilitation success is highly unpredictable. Given these limitations, the primary aim should be to restore ecosystem function so that the ecosystem is self-maintaining with as high a diversity of species as possible. Where there were endemic and threatened species, every effort should be made to reintroduce them. The exclusion of deep-rooted plant species from the vicinity of the pipeline may result in some loss of endemic, rare or threatened species within this area but such impacts should be minimised.

- **Impact 8: Introduction of non-local genetic stock**
  - Mitigation
    - All plant stock and seed must be from local populations wherever possible to avoid introduction of non-local genetic material
    - Use material from that section of the route in its rehabilitation or, where this is not feasible, from a source community matched as closely as possible, excluding Very High sensitivity areas
    - Wherever there is an evident change in the vegetation or community, keep the rehabilitation material for each community's section separate to minimise introduction of non-local genetic stock

- **Impact 9: Partial or complete failure to achieve effective rehabilitation affecting species diversity, resulting in changes in habitat suitability, reduction in endemic species populations or local or global extinction; changes in species movements, abundance and distribution, ecosystem functions and interactions; exposure of adjacent communities to unfavourable edge effects such as susceptibility to invasions by alien species**
  - Mitigation
    - Obtain expert inputs on appropriate rehabilitation techniques and species choices to ensure that ecosystem structure and function recover
    - Rapidly rehabilitate the area to pre-construction conditions where possible
    - Replacement of the top soil (seed bearing soil) should take place as soon as possible
    - Control dust to minimise impacts by regulating vehicle speeds and using geotextiles, particularly on soil dumps
    - Planting of plant stock and reseeding should be timed to maximise the likelihood of successful recruitment (e.g. do not revegetate after the end of spring)
    - Vehicle speeds must kept slow to minimise potential collisions with animals

5.4 Operations and Closure Stage

All the impacts and mitigation measures specified for construction (in Section 5.2 above), can also occur during operation and maintenance activities, during potential replacement of the pipeline, or during the eventual closure, particularly if the pipeline is removed.

The following additional mitigation actions are recommended:

- The access routes for maintenance activities must be kept as limited as possible and access should be controlled by gating access routes
- Vehicle speeds must kept slow to minimise potential collisions with animals and dust creation

        - Time environmental inspections to avoid the breeding season of conservation important taxa

- **Impact 10: Exclusion of deeper-rooted vegetation from the pipeline route and the access routes**
    - Gas pipelines are generally buried to a depth of ±1m below the surface and should not come into contact with plant roots. There have been very few studies of root systems in Fynbos, Renosterveld and Strandveld plant species but the shrubs, especially the tall shrubs, can have root systems that reach depths of 2-3 m or more (Cramer et al., 2014; Le Maitre et al., 1999; Smith and Higgins, 1992). Exclusion of the deeper-rooted species in the flora will alter the structure and habitat suitability of the pipeline strip, resulting in, for example, the loss of cover for small, slow moving species to shelter beneath. Although the strip that is kept under short vegetation may only be about 10 m in width (potentially wider in places), that, combined with its length, may still be enough to affect the movements of some fauna and dispersal of seeds.
        - Mitigation:
            - No direct measures. It is unlikely that the long-term disruption and fragmentation of the plant and animal communities will be a significant factor overall, provided the necessary processes (e.g. fires in the Fynbos and renosterveld) are maintained in the affected areas. However, there are likely to be ongoing and potentially significant impacts on ecosystem processes such as plant seed dispersal and movements of small, slow moving surface dwelling fauna.
            - Ongoing control of invading plant species (see above) as the alteration of the habitat structure and species composition may make the pipeline track more susceptible to invasion.

The generic impacts and degrees of mitigation that may be achieved have been summarised below (Table 6). There are no hard standards for defining the degree of mitigation but the following descriptions will give some background. Low mitigation implies that a basic community of plant and animal species would become established but species diversity, vegetation cover and ecosystem structure and function would be significantly altered compared to the original community. For example, only annual plant species may establish with no perennial species to provide habitat or act as foci for the recruitment of other species into the community; or the vegetation cover may be too sparse or ephemeral to prevent soil erosion. Given what is observed on old lands in these low rainfall environments, it is possible that the highly simplified vegetation community that will establish will remain little changed for decades. High mitigation implies that, over time, ecosystem structure and function will be reinstated, vegetation cover will reach levels comparable to the pre-development community, and that most species will re-establish themselves albeit with altered abundances. Some species may still not re-establish themselves, at least for some years. Moderate mitigation would result in a community somewhere between these two extremes on one or more measures.

The degree of confidence in the potential level of mitigation must be strongly tempered by the fact that this assessment deals with three broad types of ecosystems that occur over a very wide range of environmental conditions. This inherent variability will affect how these broad ecosystem types respond to the different kinds of impacts and mitigation. It is not possible to be specific about the effects on populations of every threatened species, especially animals, as one species may respond very differently from another. There are some generalisations such as the greatest impacts are likely to be on most ground dwelling and/or slow-moving, small bodied animals with narrow distributions and/or specific habitat requirements, and the lowest impacts will be on highly mobile, large species. Even for plants which, for example, can be divided into guilds based on their methods of persistence and reproduction, such as seed banks, will vary in other ways that could affect the impacts. For example, Fynbos includes species with canopy stored seeds which have no dormancy, seeds which require smoke chemicals to stimulate germination, some which require heat or more extreme soil temperatures to stimulate germination and many which have unknown cues. Each guild could respond differently to the removal and replacement of the top layer of the soil.

What can be said as a general rule is that where areas have been identified as conservation priorities based on the occurrence of threatened species, or the status of the vegetation type, they should be avoided completely (see also Boxes 1 and 2). If there is absolutely no alternative, then the routing should be such that: (a) in the case of threatened vegetation types, it should follow the edge rather than passing through the centre of a patch or cross it at a narrow point to minimise fragmentation of that remnant; and (b) in the case of threatened species, it avoids going through or near to such populations to prevent or minimise disturbance of themselves and their habitat. This level of route planning is best addressed when, and if, the actual pipeline routes are being selected and planned in detail.

Table 6: Summary of activities and impacts, including the timing (stage) and mitigation potential of impacts. These have been aligned with the stage in the development and grouped into categories. The number of the impact used above has been included as a guide but is not compete as some impacts are only described under one but are applicable to other stages as well as emphasised in the text.

Activity	Impact (number)	Timing	Mitigation potential
Impacts generic to all activities	**1, 2, 4, 5**: Human activities, movements and noise (including engine noise), creating disturbances for fauna and flora (including poaching and theft), and soil disturbance	Throughout	L
Pre-construction route surveys	**1**: Dust from vehicle movements affecting flora and fauna	Planning	M
Creation of access routes for machinery	**7**: Importation of alien species imported in road surfacing material	Construction	M-H
Movement of machinery onto site	**7**: Introduction of alien species via machinery and construction materials	Construction	M
	2: Dust from vehicle and machine movement and activities affecting flora and fauna	Construction	M
Machinery and vehicles working on site	**3**: Oil and fuel spills and their impacts on soils, fauna and flora	Construction	H
Removal of vegetation cover and top soil layer within pipeline footprint	**2**: Habitat loss and alteration, loss of shelter for fauna	Construction	M
	5: Endemic/rare species loss	Construction	M
	5: Endemic/rare species displacement	Construction	M
	2: Dust from removal and stockpiling of top soil layer affecting flora and fauna	Construction	M
Transport of pipes and other materials to site	**2**: Dust from vehicle and machine movement and activities on flora and fauna	Construction	M
	7: Impacts from introduction of alien species via vehicles and construction materials	Construction	H
Construction of pipe	**4**: Impacts of pipeline welding, assuming gas rather than arc welding	Construction	H
Excavation of pipe line trench	**2**: Dust from machine movements, excavation and stockpiling of material affecting flora and fauna	Construction	M
	6: Entrapment of fauna in the open trench	Construction	H
Refilling of trench	**2**: Dust from machine movements, replacement of material affecting flora and fauna	Construction	M
Levelling of site for top soil	**2**: Dust from machine movements, replacement of material affecting flora and fauna	Construction	M
Replacement of top soil layer	**2**: Dust from machine movements, replacement of material affecting flora and fauna	Construction	M
Introduction of plant material for active rehabilitation	**8**: Introduction of non-local genetic stock	Construction	H
	7: Introduction of alien species in plant material	Construction	H
	7: Establishment of alien invasive species	Construction	H
Recovery of rehabilitated	**9**: Recovery of only a few species (depends on	Rehabilitation and	L-M

Activity	Impact (number)	Timing	Mitigation potential
ecosystem (some impacts will persist e.g. when rehabilitation is not successful this could have medium to long-term effects and affect the operation phase as well)	many factors)	operation	
	9: Complete failure of recovery (depends largely on the amount and reliability of the rainfall)	Rehabilitation	L-M
	9: Changes in habitat suitability within the footprint	Rehabilitation and operation	M
	9: Endemic/rare species loss	Rehabilitation and operation	M
	9: Endemic/rare species population declines	Rehabilitation and operations	M
	9: Changes in species movements, abundance and distribution	Rehabilitation and operation	M
	9: Changes in ecosystem functions and interactions	Rehabilitation	M
	9: Exposure of adjacent vegetation to unfavourable edge effects such as susceptibility to invasions by alien species	Rehabilitation	M
Maintenance of access roads and infrastructure	**1**: Vegetation disturbance in pipeline route	Operation	L
	7: Introduction of alien species on vehicles	Operation	H
	7: Establishment of alien species	Operation	H
	5: Increased access to sensitive areas (poaching and collection of rare species)	Operation	H
Establishment of a linear feature (resulting in fragmentation of habitats and creation of edge effects and leading to impacts):	**10**: Changed in habitat suitability within the footprint	Operation	M
	10: Endemic/ rare species loss	Operation	M
	10: Endemic/rare species population declines	Operation	M
	10: Changed species movements, abundance and distribution	Operation	M
	10: Changed ecosystem functions and interactions	Operation	M
	10: Exposure of adjacent vegetation to unfavourable edge effects such as susceptibility to invasions by alien species	Operation	L-M

6 RISK ASSESSMENT

6.1 Consequence levels

Five consequence levels are proposed i.e. slight, moderate, substantive, severe, and extreme.

As a broad guideline, the following is proposed as definitions for the consequence categories:

- Extreme – Over 50% of a threatened habitat or Critically Endangered, Endangered or Vulnerable species populations are destroyed, severely disturbed or displaced even with mitigation.
- Severe – Any areas of a very highly sensitive environment or any individuals of Critically Endangered or Endangered species are destroyed, severely disturbed or displaced without appropriate mitigation.
- Substantial - Any areas of a highly sensitive environment are destroyed, and/or Vulnerable species are destroyed, severely disturbed or displaced without appropriate mitigation.
- Moderate - Any area of a moderately sensitive environment is destroyed or severely disturbed without appropriate mitigation.
- Slight - Areas of habitats or species not mentioned above are destroyed.

6.2 Risk assessment results

The risk assessment involves the consideration, at a high, strategic level, the three key impacts described in Section 5, with and without mitigation actions (i.e. actions to mitigate negative impacts or enhance benefits). The primary risk identified by this assessment is that of a failure to achieve an acceptable level of recovery of the disturbed ecosystems in terms of cover and function in the sense of being a self-sustaining ecosystem. As discussed elsewhere, because deep-rooted plants have to be excluded from the vicinity of the pipeline, most if not all of the shrub components of the ecosystems will have to be excluded from these areas. Therefore, it will be impossible to return these ecosystems to something closely resembling their original botanical and faunal composition and structure.

The growing body of research into Fynbos restoration and ongoing practical experience shows that ecosystem rehabilitation to an acceptable level of cover and composition can be achieved in the higher and more reliable rainfall areas of the Fynbos Biome (although the restoration of ecosystem function is less certain) (Esler et al., 2014; Fill et al., 2017; Gaertner et al., 2012b; Holmes, 2005; Holmes and Foden, 2001; Holmes and Richardson, 1999; Pretorius et al., 2008; Ruwanza, 2017). The affected areas include the Grassy Fynbos of the eastern parts of the biome (e.g. Phase 7), which should be easier to rehabilitate, at least to a reasonable grass cover. There are a number of examples of successful rehabilitation in the higher rainfall areas where roads have been upgraded during the past 10-15 years, although there are also examples of failures. Many climatic characteristics can play a role in determining the likelihood of successful rehabilitation of a given ecosystem but rainfall is a relatively easy example to use because rainfall amounts and temporal distribution are critical for soil moisture regimes and those regimes, in turn play a significant role in the likelihood of successful seed germination and plant establishment. This argument has focused on plants because they create the habitat and provide the food and shelter for the fauna but, obviously, species composition and structure (both vertical and horizontal) are key determinants of habitat suitability for fauna.

A feature of the rainfall in South Africa is the increasing variability in the rainfall as the amount of the rainfall decreases (Schulze et al., 2008; Zucchini et al., 1992). Although the winter rainfall experienced in the Fynbos Biome is particularly reliable (Cowling et al., 2005), the reliability of that rainfall decreases as the amount decreases. There is no clear threshold, but the risk of rehabilitation failure becomes high once the annual rainfall is less than 400 mm and very high when it is less than 200 mm (Figure 29). Areas with less than 400 mm per year occupy extensive areas in all the corridors, especially on the West Coast and in the interior and the Inland corridor. The Strandveld and Sand Plain Fynbos (e.g. the Sandveld) are expected to be particularly vulnerable to low and variable rainfall because of their generally well-drained soils. Alien species introductions are more likely to lead to their establishment and invasion in higher rainfall environments so alien species control measures will have to be more intensive and effective in these environments.

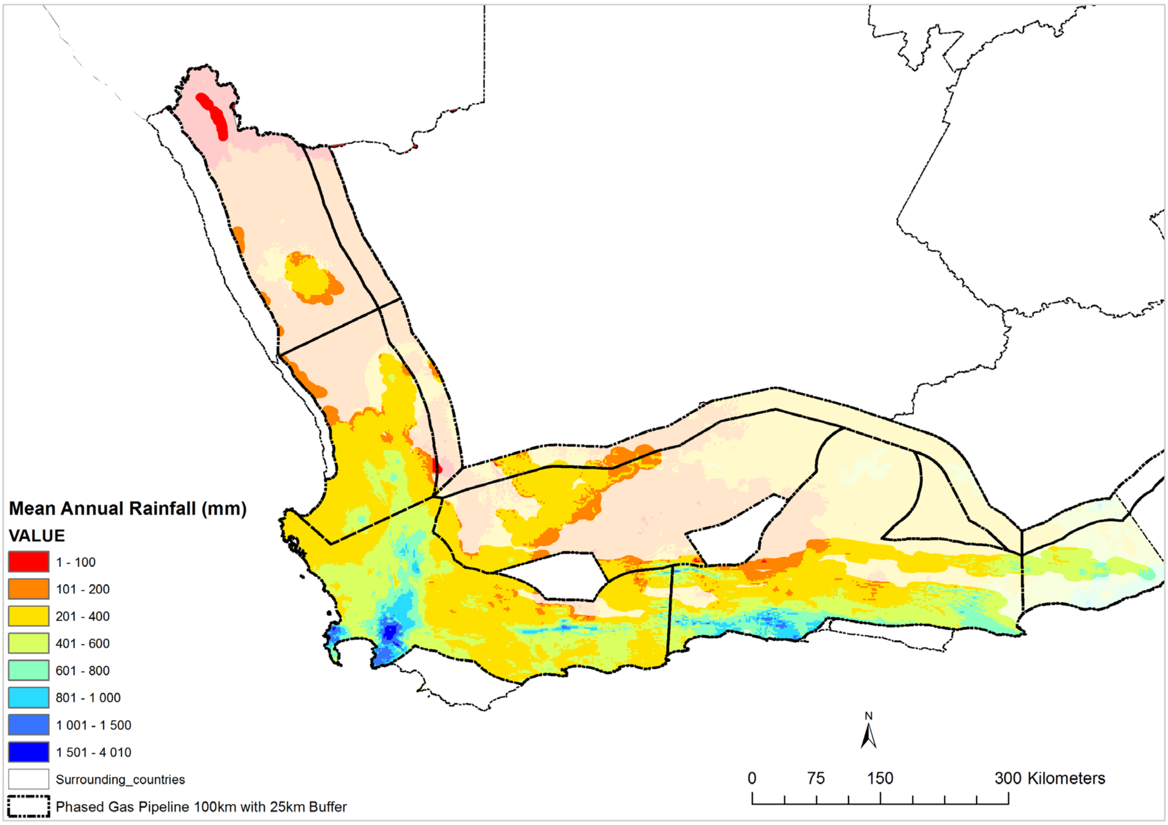

Figure 29: Mean annual rainfall in the Fynbos Biome (Schulze et al., 2008) with the biome boundary buffered by 5 km.

Experience at the Namakwa Sands mine (Pauw, 2011) and the findings of research on Karoo shrublands (Wiegand et al., 1995) emphasise the risks posed by low and variable rainfall. The research, thus far, has found that the herbaceous annual species could be restored fairly effectively but re-establishing the perennial components that are important for cover (which reduces the risk of wind erosion) community function and ecosystem services (e.g. grazing (Richardson et al., 2005)) were difficult to restore and success rates were low. The evidence suggests that successful recruitment of these perennial species may only occur in high rainfall years which are very difficult to predict. The findings at the Namakwa Sands mine were in Strandveld vegetation, but at low rainfall the rehabilitation of Renosterveld and Fynbos communities may be similarly problematic.

The three key impacts assessed for the corridors have been grouped and summarised in the Risk Assessment Table below (Table 7). More intensive and thorough mitigation efforts must be applied in the higher sensitivity areas. More arid environments are conducive to more dust generation and, therefore, greater dust impacts, but this can be controlled by more intensive dust management (e.g. limiting vehicles speed, using geotextiles). For some impacts the corridors have been grouped according to the likelihood that rehabilitation could fail based on the extent of arid Fynbos and Renosterveld vegetation types. The impacts of habitat loss and alteration through disturbance and changes in habitat suitability, species movements, abundance and distribution are also likely to be more severe and more persistent. The same rationale would apply to adverse changes in ecosystem functions and interactions and endemic, threatened or rare species population declines, displacement or loss. Ground dwelling and/or slow-moving, small bodied animals with narrow distributions and/or specific habitat requirements are also more likely to be severely affected.

Table 7: Assessment of the potential risks that the key impacts from constructing and maintaining gas pipeline infrastructure pose to the Fynbos biome, before- and after mitigation.

Impact	Study area	Location	Without mitigation			With mitigation		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Increased human activity (e.g. poaching, noise, movements) trampling and destroying vegetation, exposing and loosening soils, resulting in the generation of dust and leading to erosion, damaging and destroying flora and displacing or harming fauna	All Phases	Very high sensitivity area	Extreme	Very likely	Very high negative	Severe	Very likely	High negative
		High sensitivity area	Severe	Very likely	High negative	Severe	Very likely	High negative
		Moderate sensitivity	Substantial	Very likely	Moderate negative	Substantial	Very likely	Moderate negative
		Low sensitivity area	Moderate	Very likely	Low negative	Slight	Not likely	Very low negative
Introduction and establishment of alien invasive species and non-local genetic stock	All Phases	Very high sensitivity area	Extreme	Very likely	Very high negative	Severe	Not likely	Moderate negative
		High sensitivity area	Severe	Very likely	High negative	Substantial	Not likely	Moderate negative
		Moderate sensitivity	Substantial	Very likely	Moderate negative	Moderate	Not likely	Low negative
		Low sensitivity area	Moderate	Very likely	Low negative	Slight	Not likely	Very low negative
Habitat loss and alteration (incl. changes in ecosystem function, and local extinction or decline in the populations of endemic and rare species).	Phases 1,2,7	Very high sensitivity area	Extreme	Very likely	Very high negative	Severe	Very likely	High negative
		High sensitivity area	Extreme	Very likely	Very high negative	Severe	Very likely	High negative
		Moderate sensitivity	Severe	Very likely	High negative	Substantial	Likely	Moderate negative
		Low sensitivity area	Substantial	Likely	Moderate negative	Moderate	Likely	Low negative
Habitat loss and alteration (incl. changes in ecosystem function, and local extinction or decline in the populations of endemic and rare species).	Phases 5,6,Inland	Very high sensitivity area	Extreme	Very likely	Very high negative	Extreme	Very likely	Very high negative
		High sensitivity area	Extreme	Very likely	Very high negative	Extreme	Very likely	Very high negative
		Moderate sensitivity	Severe	Very likely	High negative	Severe	Very likely	High negative
		Low sensitivity area	Severe	Very likely	High negative	Severe	Very likely	High negative

6.3 Limits of Acceptable Change

The limits of acceptable change are highly subjective and driven as much by the values held by society as by ecological theory. But, for threatened species and ecosystems, it is clear from legislation and other measures that society has determined that adverse changes are not acceptable. There are specific policy and legal requirements for species nationally classified as Critically Endangered, Endangered, Vulnerable and Protected and some provinces have their own lists of protected species with a similar status. These require that the pipeline development should not lead to the destruction of individuals of any critically endangered species, and should set a goal of not destroying any individuals of any endangered or vulnerable species.

There are a number of national and provincial legislative requirements that relate to destruction of threatened ecosystems or habitats of threatened species. No further adverse changes should be allowed in threatened ecosystems assessed as Critically Endangered or Endangered, and should be avoided if at all possible in those assessed as Vulnerable or which occur in protected areas.

The individual provincial Critical Biodiversity Assessments are the key basis for defining acceptable change for conservation features. They require that CBA1 and CBA2 areas must be avoided if at all possible. If these cannot be avoided then full Biodiversity Impact Assessments should be undertaken and mitigation management guidelines followed. No destructive activities are allowed in CBA1 areas according to their guidelines. The Western Cape conservation planners have provided some specific constraints for certain activities or developments. For example, pipeline routes are not acceptable in CBA 1s in terms of the land-use guidelines in the WCBSP (Pool-Stanvliet et al., 2017). Similarly, crossing of formal protected areas will only be considered if the pipeline route is aligned with other linear features already in the protected area. These constraints are considered best practice and should be applied in the Northern and Eastern Cape provinces as well.

Whilst species destruction or loss is important, the protection of key ecological processes is fundamental to the long-term viability of ecosystems (Driver et al., 2003; Pressey et al., 2003). Changes in disturbance regimes (e.g. fires, extreme rainfall or drought), pollination and other gene flows, gene pools of populations hydrological flows, dispersal and migration, could have detrimental impacts that extend far beyond the actual footprint of the development. The impacts on these processes is also the main reason why the fragmentation of communities, especially dividing remnants by separating them into pieces, by the pipeline route needs to be minimised. As a general rule, the smaller the remnant the more the processes are altered, especially those that maintain species populations (Cowling and Bond, 1991; Heijnis et al., 1999; Sandberg et al., 2016). The result is that fragmentation results in the loss of species, and the smaller the fragment the greater the loss. These losses can trigger further losses, and example being the loss of a pollinator which then results in the loss of plant species it pollinated and so the cascade can continue.

7 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

This section puts forward best practice guidelines and management actions that cover the different stages or phases of the development: route selection, detailed planning, pre-construction alignment in the field, construction, post-construction, operations and closure. Many of the best practices have been included in the impact mitigation section of this assessment. Final- route-selection level assessments of the impacts will have to be based on detailed field surveys along the proposed gas pipeline and where any additional facilities need to be constructed. It is essential that these surveys are commissioned so that there is time to include surveys during the winter and spring when most species are active and plants are flowering, especially seasonal geophytes which are not visible in the summer. Otherwise the assessment will miss many of the threatened and rare species. This is particularly important in the arid Fynbos found in Phases 5 and 6 where good rains may not occur every year, and also in arid Renosterveld bordering on the Succulent Karoo. This recommendation applies to all the untransformed (i.e. not urban, mined or cultivated) communities along the entire route and not only to the sections identified as high or very high sensitivity. The reason for this is that species distribution records are invariably incomplete, so populations of threatened and other important species may well occur along the route and need to be avoided or the impacts mitigated.

7.1 Planning and pre-construction phase

Plan the route to minimise crossing of conservation features, especially CBA 1 and 2 and where these areas include threatened ecosystems or populations of threatened taxa. Wherever possible, align the pipeline along existing servitudes and linear disturbance such as a road and through degraded or transformed (e.g. cultivated) areas. Avoid, as far as possible and in ascending order of importance: (a) remnants of natural vegetation in good condition, (b) ESAs (especially ESA 1), (c) terrestrial CBA 2s, and (d) CBA 1s, especially those that are Irreplaceable, or have Endangered (EN) or Critically Endangered (CR) ecosystems and threatened species populations. Where such areas are unavoidable the pipeline should be routed to minimise fragmentation of the feature.

Where areas have been identified as conservation priorities based on the occurrence of threatened species, they should be avoided completely and not considered for the route. If there is absolutely no alternative, then the impact must be mitigated by routing the pipeline so that it avoids going near to or through such populations to avoid or minimise disturbance of them and their habitat and minimise fragmentation of that remnant. If there is still no other option, then offsets could be considered.

Wherever such features are encountered on the route, field surveys of those features must be undertaken at a suitable time of the year (e.g. when plants are active and flowering) to identify the location of populations of species, rare or threatened species that are to be avoided.

7.2 Construction phase

Tightly limit and enforce the restrictions on the construction footprint and follow sound best practice for site management.

The best way to facilitate successful rehabilitation of the vegetation is to ensure that the valuable top layer of the soil containing the seed banks is carefully removed and stored. The top layer of the soil (100 to 150 mm deep) should be stripped and replaced in a way that minimises disturbance (e.g. no tillage). The deeper layers of the soil can then be removed and stockpiled as well. Soils generally have a clearly defined layering with a topsoil that can be distinguished from the sub-soil and sometimes a third layer or horizon (Fey et al., 2010). It is best to keep these layers separate and the replace the layers in the same sequence in which they were removed.

The time that it is stored for should be kept to the absolute minimum. No indication was given of how long it will take from site clearing to final clean-up but it should be a matter of days to weeks. If that is the case the soil can be stored next to where it was stripped (as indicated in the diagram) and then replaced.

If more soil needs to be removed for any reason then that soil should be stored separately and replaced first. The initial top layer stripping and replacement is essentially a form of top-dressing which contains most if not all of the seedbank and is critical for successful rehabilitation.

Although the seeds of many Fynbos species require some form of stimulation to germinate (e.g. shifts in soil temperature regimes, heat from the fire, chemicals from smoke) (Esler et al., 2014; Hall et al., 2017; Holmes and Richardson, 1999; Ruwanza et al., 2013), the level of knowledge at present is not sufficient to determine whether or not specific treatments should be given as part of the rehabilitation process. Soil removal and replacement may provide some stimuli for germination but heat would not be practical to apply. The effectiveness of smoke treatment in the field, as opposed to the nursery, needs more research. A precautionary approach would be to conduct tests in different communities, especially in arid Fynbos and Renosterveld vegetation types, during the initial stages of the construction, to see whether the results justify its continued use.

Much of the area is subject to strong winds during the summer months, especially the West and Southern coastal lowlands. If the soils are prone to wind erosion then the option of erecting shade cloth fences or other wind-moderating barriers to minimise the risk of wind erosion. Brush packing using material removed during the site clearing is an option but could hinder follow-up work on alien plant species.

If alien plant species were present in the pipeline route prior to construction then they need to be treated appropriately during the site clearing and follow-up measures after rehabilitation of the disturbed areas. Fynbos is subject to invasions by a variety of plant species and it is not possible to list them all here. Information on the species that invade can be found in the following publications in the reference list (Bromilow, 2010; Esler et al., 2014; Esler and Milton, 2006; Henderson, 2001; Wilson et al., 2014) and on many websites including:

- Invasive species South Africa: http://www.invasives.org.za/
- Invasive Species Compendium: https://www.cabi.org/isc/

Experts should be consulted to advise on the treatments that are needed for the different species.

It is not clear whether the pipeline trench will be refilled and settled (not compacted) to the original level with material from the trench or if imported materials (e.g. sand) will be needed to bed the pipe in, at least in some locations. Assuming that no extra material is needed the soil from lower soil horizons should be used for the refilling first, then the next horizon, the replaced soil lightly compacted and the trench levelled area reshaped so that when the top layer is returned, the original surface level and slopes are restored.

7.3 Operations phase

Access roads and tracks to pigging stations and any other locations must be properly constructed and regularly maintained, especially their drainage, to ensure that ongoing disturbances of the ecosystems are minimised. This is particularly important in areas with deep, sandy soils where there is a natural tendency for them to widen, and the tracks to deepen over time. People then create new tracks which simply worsens the problem and this must be prevented.

There should be regular inspections by people trained to understand the local vegetation and to be able to monitor its recovery using recognised procedures (e.g. permanent survey and photo-plots). These surveys should be done once a year in the early stages (1-3 years) and bi-annually after that. The surveys should be in the same season so that trends can be assessed and any adverse trends in the species diversity, ecosystem structure or ecosystem function identified and addressed. Expert advice should be sought if deemed necessary. Methods for ecological surveys are too diverse to go into in detail here but should include at least the following: (a) vegetation canopy cover grouped by broad growth forms (e.g. annuals, succulent and non-succulent shrubs) to give a measure of structure; b) an estimate of soil stability or loss; and (c) record the occurrence and extent of fires in the corridor so that the fire recurrence intervals and season can be assessed against suitable standards (Kraaij and Wilgen, 2014; Richardson et al., 1994; Van Wilgen et al., 2011). The specialists involved in the route planning stage should be asked to recommend methods as part of their specialist study. Alien species invasions should be managed as part of ongoing pipeline corridor management.

7.4 Final rehabilitation and post closure

According to iGas, the current plan is that the pipeline will be formally decommissioned and hydrocarbons removed and replaced with air once the gas supply has been exhausted. The pipeline may be left *in situ* and only major valve installations and pigging stations will be removed (i.e., all above ground installations and installations that can be accessed from above ground e.g. valve pits etc.). Where the land owners require iGas to pay for the servitude, a business decision will be made at the time as to the future of the pipeline. If the pipeline becomes unsafe to operate then it could be replaced by a new pipeline, either alongside the planned pipeline or by replacing the planned pipeline with a new one in the same track. If the gas supply cannot be interrupted, then it is likely that the new pipeline will be constructed alongside the existing one and that the old one will be decommissioned as soon as the new is commissioned. Removing the old pipeline or construction of a second pipeline in sensitive areas is likely to entail even more disturbance than the construction and should be avoided if possible.

Vegetation rehabilitation to pre-construction state: This should be undertaken, whenever possible, before the onset of the winter rains to take maximum advantage of the growing season. Irrigation is not generally used in Fynbos restoration and is unlikely to be a viable option, except in special cases involving areas of a limited spatial extent.

Invasive alien plant control: management actions should not only focus on the woody shrub/tree invaders since Sand Plain Fynbos, Limestone Fynbos and Renosterveld are also very prone to invasion by introduced grasses which have a significant impact on herbaceous species and especially geophytes. Consequently management of such invasive grass species need needs special consideration. There are no set guidelines for management of herbaceous species; therefore expert input will be required when drawing up recommendations for the EMPs.

7.5 Monitoring requirements

There are far too many taxonomic groups, and species within those groups, to develop a detailed monitoring protocol here. Nevertheless there are some basic principles and basic community measures which are essential and can give important insights:

- Design the monitoring properly with appropriate sampling designs and frequencies to produce reliable data which can detect, for example, trends and undesirable outcomes in time for remedial action to be taken.
- The ideal is to sample both before and after construction with the baseline then being the pre-construction state. Given there will be changes in community structure and function, and that there is inherent variation, the best strategy is to combine before and after sampling with sampling of match sites that will not be affected by the construction.
- The sampling sites should be selected so that they include a representative sample of at least each of the different vegetation types which will be substantially affected by the pipeline development; even better would be to choose communities within those vegetation types.
- Monitoring of ecosystem function and processes is also important. This could be intensive and expensive but there are less intensive measures. A key process in all vegetation communities is regeneration or reproduction.
    - For Fynbos and Renosterveld the most basic monitoring would be to track fire incidence, i.e. how frequently a given area burns in a fire. Fire occurrence data are available from 2000 onwards and can be used to determine the historical fire frequency (and season). This information can be used to determine whether fire occurrences are changing as a result of the pipeline development. Monitoring protocols for Strandveld would need to be developed with input from specialists in these communities and could be based on existing approaches and experience (Carrick et al., 2015; Carrick and Krüger, 2007; Pauw, 2011).
    - More detailed assessments would record post-fire recruitment and determine whether selected species are regenerating as successfully within the pipeline route as they are outside it.
    - There is an important limitation which is, that although there are ways of determining, for example, whether the fire-regime is being maintained within acceptable limits for some Fynbos ecosystems and species groups (guilds) (Kraaij and Wilgen, 2014), such information is not available for most ecosystems, especially those on the margins of the Fynbos and in the ecotones with Succulent Karoo or Albany Thicket.
- Community level monitoring should focus on surveys at the growth, or life-form level with measures of the abundance of the different groups of species and community structure.
- Individual species-level monitoring can only be discussed here at a very general level as, for example, each of the taxonomic groups of threatened terrestrial species would need its own

monitoring protocol with, for example, plants, butterflies, frogs, tortoises, lizards all differing in the timing, frequency and the ways in which they are monitored. For plants the best time to monitor is in the spring as that is when most species are actively growing and flowering.

- Post-construction rehabilitation monitoring should be conducted twice yearly for the first 2 years and then annually thereafter. During the first two years, a second survey should be carried out in the autumn to assess the degree of summer-time mortality in the winter rainfall region. The timing of these surveys in the far eastern part of the biome (Phase 7) should be based on expert advice.
- If the rate of vegetation regeneration is sufficient to achieve levels of canopy cover and structure that are comparable to the un-altered communities adjacent to the pipeline with a couple of years, then there is unlikely to be significant wind or water erosion that needs to be monitored and corrected. If this is not the case, then assessments of erosion should be included and measures taken to control that erosion.
- Monitoring for alien species invasions is absolutely essential as has been noted as several points in this assessment. The process begins with ensuring that the term of reference for the surveys of the final route specify that invasive alien species occurrences and populations are mapped and the preparation of a plan for their control and management as part of the construction and operations EMPs. These plans should include monitoring of the effectiveness of the control treatments (initial control and follow-ups) as well as the recording of any new invasive species. If new species are observed, their control needs to be integrated into the control programme.

8 GAPS IN KNOWLEDGE

The gaps in current knowledge and practice have been repeatedly noted throughout this assessment, particularly in the section on assumptions and limitations (see Section 3.2), and will not be repeated here.

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APPENDIX A - PEER REVIEW AND SPECIALIST RESPONSE SHEET

Peer Reviewer: Professor Brian W. van Wilgen; Academic/Researcher (associated with the University of Stellenbosch)

EXPERT REVIEW AND SPECIALIST RESPONSES: Fynbos Biome – Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/Figure**	**Expert Reviewer Comments**	**Responses from Specialist**
Brian van Wilgen	2 and throughout		General comment	There are many acronyms used throughout the text without definition. I realise there is a list of acronyms on page 2 with definitions, but this document would be a whole lot more readable if the acronyms were to be defined at first use in each section of the report, as well as in the headings of tables and captions of figures where they are also used. The list on page 2 is also incomplete - missing acronyms include CBA1, CBA2, iGAS, SANBI, IDP, SDF, NEMA, NPAES	Acronyms have been added; All acronyms have been explained on first use in the text. iGas
Brian van Wilgen	5	4 to 5		A little more background at the start would be useful. The gas pipeline phases should be described, and the terms of reference of the report should be listed	Further background will be supplied by the integrative writer
Brian van Wilgen	5	13		Replace "fynbos can be divided" with "The vegetation in the fynbos biome can be divided"	Done
Brian van Wilgen	5	27		Replace "and do regenerate Renosterveld" with "and do stimulate regeneration in Renosterveld"	Done
Brian van Wilgen	6		Unnumbered table	The table heading could be more descriptive. The derivation of the corridor names in column 1 should be explained in the table heading. Overall suitability should also be explained. If something has moderate or low suitability for gas pipeline development, what does that mean? Does it mean that gas pipeline development would cause impacts of a moderate or low significance?	Will this heading be standardised across the assessments as a numbered table? The suitability refers to the potential for gap pipeline development based on the density, spatial distribution and nature of the sensitive conservation features within the biome in the corridor. Thus low suitability implies many features and this, in turn, means it will be difficult to minimise some impacts no matter what route is chosen so the impacts could be of a high significance. Response from CSIR Project Team: The headings will not be standardised across the assessments however additional detail will be provided in the Integrated Biodiversity Assessment chapter.
Brian van Wilgen	7	2 to 25		Sections 2 and 3 are too brief, especially if this report is read in isolation. A brief account of the	Further background will be supplied by the integrative writer; see pg. 7 lines 12-15 for the specific terms of reference; the

EXPERT REVIEW AND SPECIALIST RESPONSES: Fynbos Biome – Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
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				terms of reference, and the criteria that will apply to classifying impacts would be useful. If this is contained elsewhere in the SEA report, cross-references should be given.	criteria used in classifying impacts were drawn primarily from the WCBSP.
Brian van Wilgen	13		Table 2	Should include the Mountain Catchment Areas Act?	Added
Brian van Wilgen	17	28 - 31		Add Leptospermum?	Added
Brian van Wilgen	19	28		Reference (here and elsewhere) to faunal migration routes. I am not aware of any animals (other than birds, which are covered elsewhere) that rely on migration in the fynbos. The issue is rather disruption of movement?	There may be some local butterfly species migrations but I have removed the term migration or replaced it with movement where appropriate
Brian van Wilgen	28		Table 5	It would be useful if the terms "feature class sensitivity" and "buffer distance sensitivity" could be explained in the table heading. In the first row, 4th column, replace "High (10 km4)" with "High (10 km)4"	Will a standardised set of definitions be developed on these lines? (see Table 4): (a) Very high - the feature is a CBA 1 or a PA so the objective for the feature is to protect biodiversity so any loss will be very highly significant; Very high - the feature is a CBA 2 of threatened species occurrence so the objective for the feature is to protect biodiversity so losses will be highly significant; (c) etc.; error corrected. Response from CSIR Project Team: Additional detail will be provided in the Integrated Biodiversity Assessment chapter.
Brian van Wilgen	56	26		What is a side slope? Do you mean steep slope?	A side slope refers to the slope at right angles to the orientation of the road i.e. where cut and fill could be needed; text reworded
Brian van Wilgen	57	17		"loss or decline" Do you mean "decline in numbers, or local or even global extinction"? Good to be clear about this.	Changed to "local extinction or decline in the populations"
Brian van Wilgen	57	35		See earlier comment on migration.	See above i.e. There may be some local butterfly species migrations but I have removed the term migration or replaced it with movement where appropriate
Brian van Wilgen	58	4		It may be helpful to indicate what kinds of burrows should be avoided. For example, larger mammals like aardvark and aardwolf burrows may be easier to detect and avoid. Mole borrows will be almost impossible to avoid?	Added "of porcupines, aardvarks and carnivores"

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Brian van Wilgen	58	53		Putting in fences may be a double-edged sword. They could trap animals and increase the risk of falling into the trenches. In these areas, rather increase the number of ramps or ladders. Also, be clear what you mean by ladders - few animals can climb ladders, but may benefit from steps rather than ramps.	Agree that fences could be problematic which is why they were listed last and they need to be put right round the open section of trench and secured to prevent entry; wording amended; ladders changed to steps
Brian van Wilgen	58	16		How is it proposed to control dust? Will it be possible to use water in such a water-stressed region? If not, what other methods are feasible?	Dust from vehicles can be reduce by making them travel slowly as recommended. Dust can be controlled by covering dumps with geotextiles; text amended
Brian van Wilgen	59	Whole page		It would be useful to differentiate between sites that are invaded prior to the start of construction, and sites that are free of invasive species. For already-invaded sites, the aim would be to reduce invasions to manageable levels, and how sustainable that will be will depend on the degree to which surrounding areas are invaded, and will provide an ongoing source of propagules for re-invasion. More importantly, sites that are not yet invaded should be managed to prevent any invasion. Furthermore, if potentially invasive species are introduced to these areas, management should be designed to (1) detect such species as early as possible, and (2) to eradicate them locally before they become established.	Identification of alien species **prior** to construction was listed as a step under mitigation; this would take care of species already present; regular surveys are specified with the objective of achieving control of any new occurrences. The following text was added to the opening paragraph: "Studies of invasive species control measures have shown that eradication of a species cannot be achieved except in the initial stage of establishment. Therefore, effective control in this context should be that alien plant species cover within the pipeline servitude is reduced to, and maintained at, less than 5% canopy cover."
Brian van Wilgen	59	38		"Ensure that any invasions are controlled". Please define what is meant by "controlled". Reduced to a level where they can be maintained at that level with available resources in perpetuity?	See responses above and: "As part of the hand-over process, ensure that the land-owner's responsibility to maintain the cleared areas is acknowledged in writing."
Brian van Wilgen	60	10 to 14		Limited knowledge of re-establishment requirements is not a reason for failing to achieve full rehabilitation. It is a factor that restricts our ability to predict whether or not rehab attempts will be successful.	Text reworded: "The primary reason for this is the factors that determine success rates of re-establishment of most of the very diverse Fynbos plant species and specialised faunal groups (e.g. many of the invertebrates) are poorly known, in other words rehabilitation success is highly unpredictable."
Brian van Wilgen	60	29		Genetic stock for rehabilitation will have to be collected off-site. That will be an additional impact	The reviewer is not necessarily correct, there may not be any need to collect material off-site. Mitigation measure changed to

EXPERT REVIEW AND SPECIALIST RESPONSES: Fynbos Biome – Gas Pipeline Development					Change has been effected in the report / No change has been effected in the report (i.e. not required and supported by response by Specialist)
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				at the collection site; in critically rare vegetation types, it will be an important impact.	read: "Use material from that section of the route in its rehabilitation or from a source community matched as closely as possible, excluding Very High sensitivity features"
Brian van Wilgen	60	32		Replace "complete loss" with "local or global extinction"	Done
Brian van Wilgen	62		Table 6	Please explain the mitigation potential categories (L, M, H) in the table heading.	Rather than expand the table heading the following section has been added to the text: "There are no hard standards for defining the degree of mitigation but the following descriptions will give some background. Low mitigation implies that a basic community of plant and animal species would become established but species diversity, vegetation cover and ecosystem structure and function would be significantly altered compared to the original community. For example, only annual plant species may establish with no perennial species to provide habitat or at as foci for the recruitment of other species into the community; or the vegetation cover may be too sparse or ephemeral to prevent soil erosion. Given what is observed on old lands in these low rainfall environments, it is possible that the highly simplified vegetation community that will establish will remain little changed for decades. High mitigation implies that, over time, ecosystem structure and function will be reinstated, vegetation cover will reach levels comparable to the pre-development community, and that most species will re-establish themselves albeit with altered abundances. Some species may still not re-establish themselves, at least for some years. Moderate mitigation would result in a community somewhere between these two extremes on one or more measures."
Brian van Wilgen	64	29		The concept of a self-sustaining ecosystem. You can remove a few species (especially rare species) from an ecosystem and it will still be self-sustaining. If that is the case, there is no loss of ecosystem function, or no loss of critical functionality - the only loss is of the rare (or other) species that have been eliminated. So the risk is loss of species, not of loss of ecosystem sustainability, unless it can be shown what that	I agree that you can remove a few or even several species and still have a functioning ecosystem. The studies to date have found that while annual species can be re-established relatively easily, perennial species have not become established. This is important because the perennial species form nuclei for the establishment of other species. They are probably key habitat providers for the fauna. The ability of the annual plant dominated systems to maintain, for example, sufficient cover to control wind erosion is probably poor. This is why there is

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				loss of sustainability will mean in the longer term?	concern about the ability to even recreate a self-sustaining system and, thus, the medium to long-term sustainability.
Brian van Wilgen	67		Table 7	First impact in column 1. The disturbance is not an impact; it is something that will lead to an impact. The impact brought about by disturbance is that animals are either killed, forced to move to new areas, or fail to reproduce. Oil spills and other pollution will also kill or injure plants.	Text reworded
Brian van Wilgen	68	6 and 21		In line 6, it says that adverse effects are not acceptable. On line 26, it says that adverse effects must be avoided if at all possible, indicating that there may be circumstances where they are in fact acceptable. It would be useful to explore what circumstances would lead to an acceptable action.	The first instance is dealing with the prescriptions threatened species or ecosystems; the second is dealing with areas classified as CBAs and the specific prescriptions for them in terms of acceptable activities. If these areas has threatened features then the former rules would apply. No changes made to the text.
Brian van Wilgen	68	27		The statement is made that "crossing of formal protected areas will only be considered if the pipeline route is aligned with other linear features already in the protected area". On page 13 it says that "no development" is permissible in protected areas. Again, this seems contradictory. What development, exactly, is permissible in protected areas, and under what circumstances?	I was not able to find the reference on page 13 that is referred to, only this: "No development, construction or farming may be permitted in a nature reserve without the prior written approval of the management authority" which does not totally prohibit development. The WCBSP which is being summarised in this section is attempting to set criteria for what is acceptable and unacceptable which is simply placing some bounds on what can be permitted. No changes made to the text
Brian van Wilgen	68	47		"different stages of phases of the development" - what are stages of phases? Delete "of phases"?	of should be or
Brian van Wilgen	70	9		replace "conducts" with "conduct"	Completed
Brian van Wilgen	70	28		Full stop needed.	Completed
Brian van Wilgen	70	46 to 53		"There should be regular inspections by people trained to understand the local vegetation .... These surveys should be done at least once a year". The practicality of this recommendation has to be questioned. First, is it really necessary to send people out to cover hundreds of kilometres of pipeline, every year or even more often? Would the cost be justified? And if adverse trends are detected, what could be done?	My opinion is that it is essential that the rehabilitation is monitored intensively **in the early stages** to ensure that it is effective and, if it isn't, to take measures to correct any adverse outcomes at an early stage. The words "at least" have been removed, the following change has been made: "These surveys should be done once a year in the early stages (1-3 years) and bi-annually after that. The surveys should be in the same season.." and the words: "Expert advice should be sought if deemed necessary."
Brian van Wilgen	71	32 to 54		There is a proposal to develop appropriate	Thanks for the input. My opinion is that it is necessary to

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				sampling designs and frequencies. Again, the practicality of this proposed monitoring system should be considered. I would recommend the following manageable set of indicators: (1) the selection of a set of representative indicator species to monitor; (2) the inclusion of an indicator on vegetation cover as monitoring sites; (3) the inclusion of an indicator of erosion (e.g. permanent pegs); and (4) the implementation of a set of "thresholds of potential concern" around the fire regime, in fire-prone ecosystems only (see van Wilgen, B.W., Govender, N, Forsyth, G.G. and Kraaij, T. (2011). Towards adaptive fire management for biodiversity conservation: Experience in South African national parks. Koedoe: 53, 102 – 110).	customise the measurements. For example: A 20% canopy cover of annual species and 20% cover of a mixture and annual and perennial species represent different states of community structure and function. Fire regimes are an important indicator of ecosystem function and dynamics in the moister fynbos but are not necessarily useful in arid fynbos where fires are rare as noted in the text. However, the corridor represents only a small portion of the landscape so it may not be practical to monitor its fire regime independent of the landscape it is embedded in. Nevertheless, monitoring of fire occurrence and extent has been recommended.
Brian van Wilgen	72	7 to 11		Many of the ecosystems in the area are either not fire-prone, or not fire-dependent. Maybe list the vegetation types that need to be monitored in this regard, and those that do not.	Essentially all the systems in the Fynbos Biome are fire prone although fires may be rare in some such as the arid fynbos and some dune thicket and strandveld types. There are small forest patches that do not burn but these are very unlikely to be encountered in the corridor and so were not included. No changes made to the text

Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa

Appendix C.1.2

Biodiversity and Ecological Impacts

(Terrestrial Ecosystems and Species) - Savanna and Grassland Biomes

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

SAVANNA AND GRASSLAND BIOMES

Contributing Authors	Graham von Maltitz[1] with GIS assistance from Bonolo Mokoatsi[1]

[1] CSIR – Natural Resources and Environment (NRE) – Global Change and Ecosystems Dynamics Group (now operating within Smart Places)

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TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

CBA	Critical Biodiversity Area
CR	Critically Endangered
EN	Endangered
EIA	Environmental Impact Assessment
GIS	Geographic Information System
IAP	Invasive Alien Plants
NEMBA	National Environmental Management: Biodiversity Act, 2004
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
TOPS	Threatened or Protected Species Regulations
VU	Vulnerable

SUMMARY

South African grasslands have a large number of species which occur nowhere else in the world (high endemism) and are threatened due to the high degree of transformation. Grasslands are one of the most threatened biomes in the country as they are the biome in which most crop agriculture and forestry takes place, as well as being the region with a high proportion of South Africa's human settlement and mining (Mucina and Rutherford 2006). The Grasslands have a high diversity of dichotomous plant species as well as a number of threatened animal species, especially reptiles. Past activities have already transformed large areas of some grassland types and therefore the remaining pockets of these grasslands are critical from a conservation perspective (Neke and Du Plessis 2004, Reyers et al. 2001). As a consequence, many of the remaining natural Grasslands are classified as Critical Biodiversity Areas and, if possible, should be avoided by pipeline development. Phase 7 has a disproportionately high level of threatened plant and animal species.

Savannas, though having a high biodiversity, are relatively homogenous over large areas. Compared to Grasslands, Savannas have far lower levels of threatened plant species. Despite this there are some very unique and threatened Savanna habitats requiring special conservation. Many of South Africa's key National and Provincial Parks are found within the Savannas, and the Savannas contain many of South Africa's iconic large mammals, some of which are Endangered or Vulnerable. Re-establishment of large trees will be prevented in a 10 m wide strip above the pipeline (i.e. within the registered servitude). With the exception of areas identified as Critical Biodiversity Areas, routing through the Savannas should have relatively low significance impacts provided suggested mitigation measures are adhered to.

Both Savanna and Grassland are fire dependent ecosystems. It is important that fire regimes are maintained in both these biomes to maintain natural biodiversity.

Summary of key issues by phase

Corridor	Overall Suitability	Comment
Phase 3	Moderate suitability for gas pipeline infrastructure development.	This corridor has a number of pinch points. The Zululand area has a number of large and important conservation areas as well as important biodiversity. The second main pinch point is crossing the Drakensberg, where the high altitude Grasslands contain important biodiversity. Finally, the Gauteng region is extremely complex due to the large urban and agricultural expansion, with remaining natural areas being important conservation refugia.
Phase 4	Moderate suitability	This corridor passes through areas of high biodiversity importance linked to the Maputaland centre of plant endemism, with a large number of Critical and Vulnerable Ecosystems which, combined with important conservation areas such as the iSimangaliso Wetland Park, Umfolozi Hluhluwe complex, Ndumo and Mkhuze reserves, create pinch points for development.
Phase 7	Low suitability for gas line infrastructure development.	This corridor crosses the Maputuland-Pondoland and Albany centre of endemism and large area of endangered or critically endangered habitat. Many of the Grassland and Savanna types are poorly conserved and especially the Grasslands have been extensively transformed or degraded. The area has a disproportionally high degree of plant endemism, as well as threatened species.
Phase 8	Low suitability for gas line infrastructure development	This corridor passes through a number of pinch point areas created by conservation areas, threatened ecosystems and the complexities of crossing the Drakensberg.
Inland corridor and phase 2	Not suitable from a grass perspective	Only tiny patches of grassland are found in this corridor, but where they are found they should be avoided as they are all classed as critical biodiversity areas, with some in conservation areas.

1 INTRODUCTION

Pipeline developments are linear in nature and require total destruction of the aboveground vegetation during the underground installation of pipes. Although this is in a relatively narrow strip of 50 m in width (for the construction right-of-way), summed over the pipeline length this can become thousands of hectares of destroyed biodiversity, if not restored appropriately. The trench represents a substantial disruption of soil and drainage to a depth of approximately 2 m and width of about 1.5 m, some effects of which, despite restoration, persist for centuries. Further, during the construction phase the trench is a temporary barrier to animal movement. Post-installation, and assuming full revegetation with indigenous fauna, the impacts are substantially less, although the vegetation in a narrow corridor (i.e. a 10 m wide operational servitude) may exclude deep-roots and large trees. Because the habitat along the pipeline may differ in species and structure from the original habitat it can conceivably result in a barrier to the movement of insects, small animals, birds, and plant propagules, especially if not fully restored to its initial biodiversity and vegetation structure. Pipeline routing that takes the pipeline parallel to environmental gradients is likely to have greater potential impacts on migration, and also may well cut through a large proportion of any one vegetation type as the vegetation also tends to follow gradients. The soil disturbance during pipeline installation will make the area highly susceptible to invasion by invasive alien plant (IAP) species, and these will need active and long term control to prevent a number of secondary environmental impacts.

Without sound management it is likely that the pipeline corridor can be a source of soil erosion. The pipeline will often, out of necessity, route directly up or down slopes. The unvegetated and loose soil just post construction can easily become trigger points for erosion.

When considering infrastructure projects of this nature it is important to consider the functional attributes of the biomes that may be impacted and how the development may impact on these functional attributes.

The unique feature of Savanna (see Figure 1) that separates them from Grassland is the occurrence of a tree layer in addition to an herbaceous layer. Savanna, although having a high *alpha* diversity (i.e. species diversity at the plot level), the species turnover, *beta* diversity, and landscape (*gamma*) diversity is relatively low (Scholes, 1997). This attribute of Savanna makes them relatively resistant to small-scale disturbances as a small disturbance is unlikely to have catastrophic loss to any particular species. However; there are specific locations with threatened and endangered species where these species would need protection. In addition, a number of the individual tree species within Savannas are protected and require a permit to be cut (see Appendix A).

Grasslands (see Figure 1), as the name implies, are dominated by a grass layer. However, from a biodiversity perspective it is the huge diversity of non-grass species, often referred to as forbs, that give the Grasslands biome their high diversity (O'Connor and Bredenkamp 1997, Mucina and Rutherford 2006). It is also these forbs that are typically the rare and endangered species within the Grassland biome (Appendix C). Identifying and conserving these non-grass species will be of particular importance during the construction phase. In many cases these plants can be dug up and replanted once construction is completed.

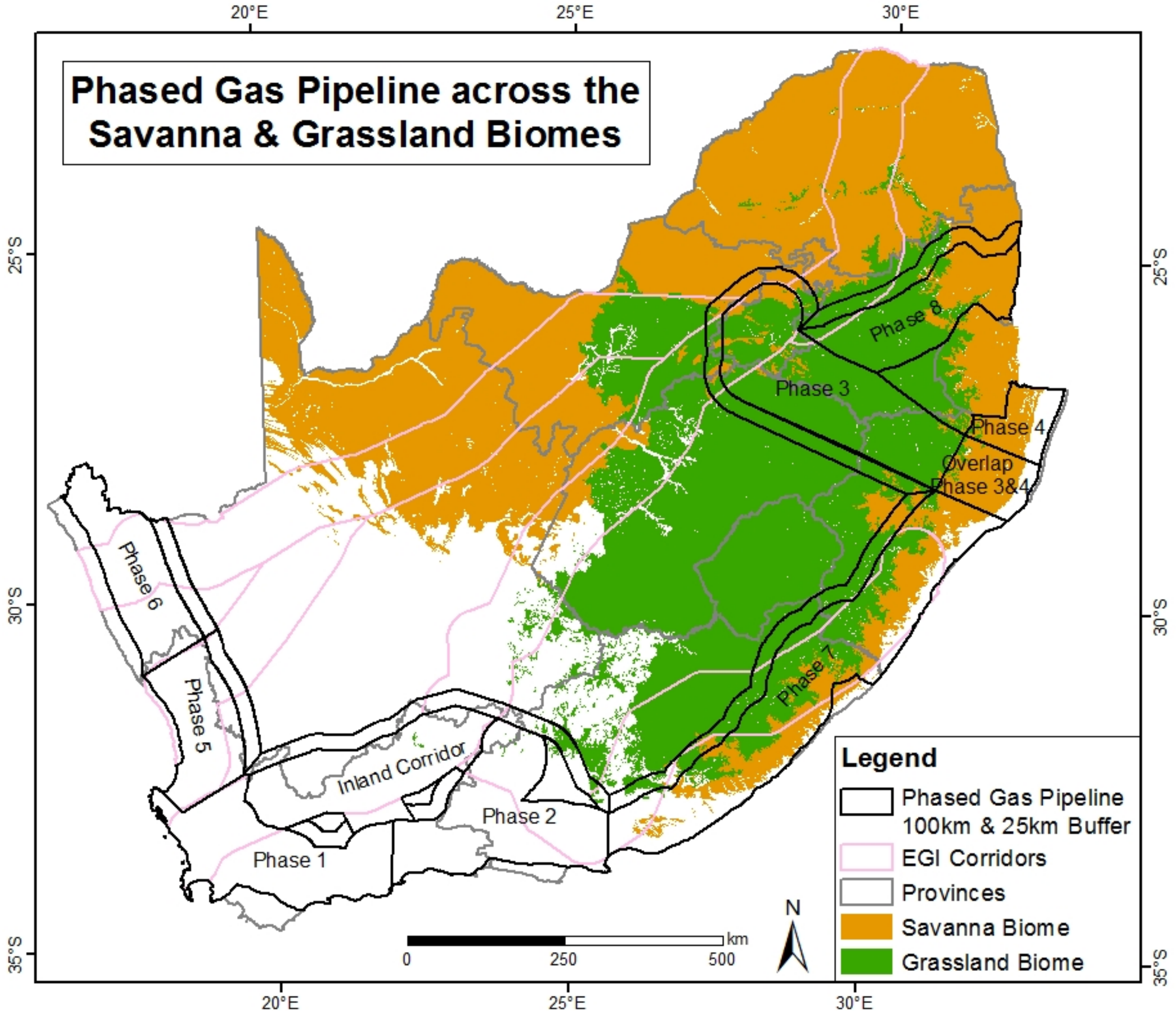

Figure 1: The location of the proposed Gas Pipeline Phases in relation to the national extent of Savanna and Grassland vegetation. Electricity Grid Infrastructure (EGI) corridors Gazetted in early 2018 (https://egis.environment.gov.za/egi) are also presented to indicate the broader energy planning context in South Africa.

Savanna as a biome, is well conserved; however, many of the specific Savanna vegetation types found within the corridors, are very poorly conserved (see Figure 2) (Mucina and Rutherford, 2006). Grasslands are arguably one of the most threatened biomes in the country, with many Grassland types very poorly conserved (Figure 3) (SANBI no date; Mucina and Rutherford, 2006). In addition, Grasslands have some of the most transformed vegetation types, with a large proportion of the national cereal crop agriculture taking place in the Grasslands (Reyers et al 2001, Fairbanks et al 2000). Most of the plantation forestry, a large proportion of mining as well as some of the biggest metropolitan areas are also located within the Grasslands. In Gauteng, there is exceptionally limited natural or even semi-natural Grassland remaining. Similarly, large amounts of the Grassland in the Eastern Cape corridor have also been transformed. This places a high conservation importance on all remaining Grassland.

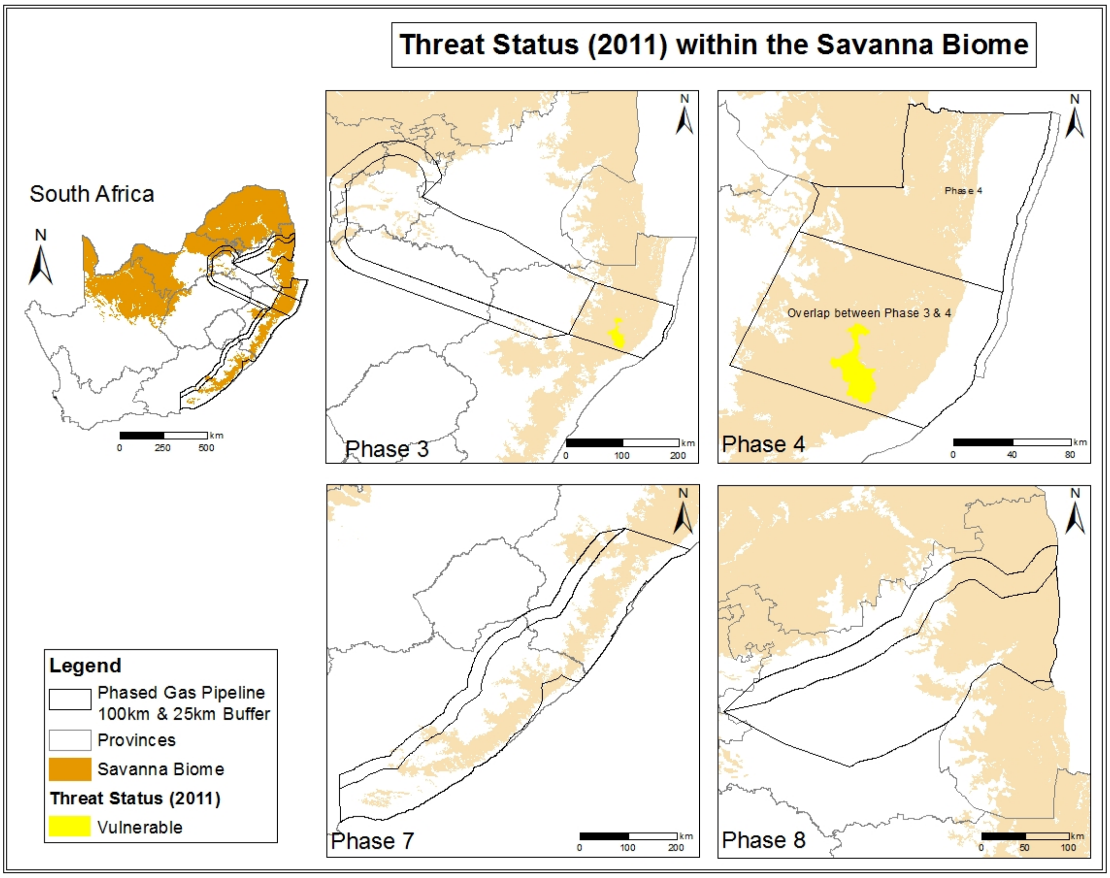

Figure 2: Conservation status of individual Savanna ecosystems (functionally vegetation types from Mucina and Rutherford (2006)) as gazetted (Gazette No 34809 of 2011).

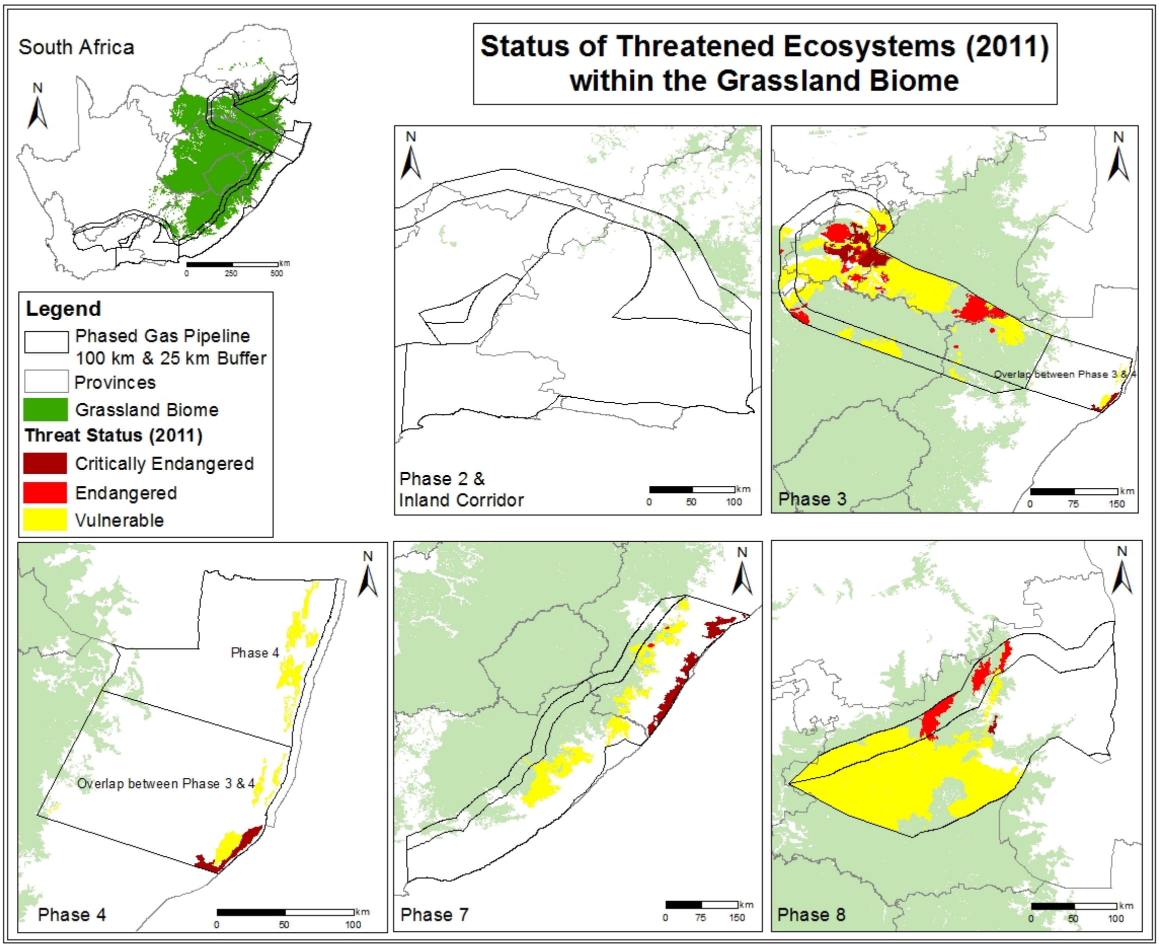

Figure 3: Conservation status of individual Grassland ecoregions (functionally vegetation types from Mucina and Rutherford (2006)) as gazetted (Gazette No 34809 of 2011). Note, some coastal grasslands depicted here fall outside of the grassland biome and are covered in the Indian Ocean Coastal Belt Biome Specialist Assessment.

Savanna and Grassland are the home to a large number of mammals, and these animals move over considerable distances to locate grazing. During the pipeline construction phase it is feasible that the movement of animals might be hindered if not managed appropriately, but this is not likely to be a factor in the post-construction phase assuming adequate rehabilitation is conducted. Small mammals, rodents, reptiles, invertebrates and ground birds may also be hindered during construction. If the post-construction habitat does not have the same functional attributes (e.g. vegetation type and density) as the original habitat, then some of these species may have difficulty crossing or utilizing the new habitat. Many of the large and charismatic threatened mammal species such as both black and white rhinoceroses (*Diceros bicornis & Ceratotherium simum)*, cheetah (*Acinonyx jubatus)* and cape hunting dogs (*Lycaon pictus)* are found in the Savanna and Grassland corridors (see Appendix B). These species are almost exclusively limited to protected areas and private reserves and as such their distribution is easily identified. Despite preventative measures being in place, during construction there is a potential threat of these species falling into the construction trench, although post construction impacts will be minimal. A few large endangered mammals such as leopard (*Panthera pardus)*, mountain reedbuck (*Redunca fulvorufula)* and Oribi (*Ourebia ourebi)* may occur in suitable habitats outside of conservation areas and will need specialists to identify potential locations where these species may be encountered (Child et al. 2016).

The distribution of small mammals, reptiles and insects are far harder to ascertain, although a large number of Critically Endangered, Endangered and Vulnerable species occur within the pipeline corridors (see Appendix B - E and Figure 5). In many cases these species have small ranges and often use burrows for shelter and breeding. As such the construction phase could potentially have high significance impacts. For instance, some of the golden moles e.g. the critically endangered rough-haired golden mole

(*Chrysosphalax villosus*) or the endangered– Juliana's golden mole (*Eamblysomus julianae)* are limited to a few sites. A pipeline trench could conceivably cut through a population and create a habitat that cannot be crossed by this burrowing species. A number of golden moles are found within the potential corridors. The sungazer lizard (*Smaug giganteus)* is an example of an endemic and Vulnerable reptile from the arid Grasslands. Understanding likely occurrences of threatened species will need a qualified specialist with a keen knowledge of the specific habitat requirements of the species. Attempting to map habitat requirements for all endangered species goes beyond the scope of this study, although locations of known occurrences are included and buffered.

Bats and birds, although a critical component of Savanna and Grassland habitats, are not considered in this report as they are fully covered in dedicated specialist reports (Appendices C.1.8 and C.1.9 of the Gas Pipeline SEA Report, respectively). Similarly, river and wetland systems and species are also dealt with in their own specialist report (Appendix C.1.7 of the Gas Pipeline SEA Report), however, although they form an integral part of savanna and grassland ecosystems and this connectivity means that the independent studies must be considered together, not in isolation. Forest patches, including the Critically Endangered Sand Forest, are embedded in the grasslands. All forest patches are assumed excluded from potential routings and as such are given a Very High Sensitivity rating. It is also important to point out that the Indian Ocean Coastal Belt biome is considered in a separate assessment (Appendix C.1.3 of the Gas Pipeline SEA Report), this despite it having both large areas of open grassland as well as areas that have previously been defined as savanna.

The social importance of natural areas, including 'sense-of-place' is not covered in this report. However, it is important to emphasise that in addition to cropping and forestry, biodiversity-based tourism is an economically important and growing land use activity within the Savanna and Grassland Biomes along the East Coast of KwaZulu-Natal. Biodiversity-based tourism is particularly sensitive to visual and sense-of-place impacts, regardless of whether they endanger the biodiversity populations directly or not.

Both Savanna and Grassland are fire dependent environments. Fire frequency is dependent on mean annual precipitation, with fire return intervals being once every two to three years in moist area, but reducing in dry areas. Maintaining a fire frequency on the restored land is important for maintaining biological integrity of the vegetation type (Mucina and Rutherford 2006, O'Connor and Bredenkamp 1997, Scholes, 1997).

Although both Grassland and Savanna habitats are relatively well adapted to disturbances, a complete clearing of the vegetation during the construction phase will need direct intervention to ensure rapid rehabilitation. Experience has shown that abandoned old fields in Savannas can take 20 or more years before trees re-establish, and even then it is often by early succession tree species. Active intervention will be needed if the habitats are to revert to near-natural vegetation within reasonable timeframes.

Construction phase disturbance is also likely to result in alien invasive plant species colonising the post-installation ground. Active alien plant removal interventions will be required until a natural vegetation cover is fully established. Although this concern is for both Grasslands and Savannas, it is the Grasslands which are most sensitive to this impact, with species such as *Acacia mearnsii* (black wattle) having seeds that can remain in the soil for decades, but which germinate in response to disturbances. Triffid weed, *Chromolaena odorata* is one of multiple common weeds in Savanna and is very common in the Zululand area where it can form impenetrable thickets. Given the vast range of habitats that will be covered by the pipelines, there are a large number for potential invasive species that can be involved. However, inspecting vehicles and clothing to ensure they do not accidently spread alien seeds into the area as well as ensuring identified alien plants are removed before they reach reproductive age can help mitigate impacts.

2 SCOPE OF THE BIODIVERSITY ASSESSMENT FOR THE SAVANNA AND GRASSLAND BIOMES

This study focuses only of areas of Savanna and Grassland biomes, and considers these only from a biodiversity perspective. As noted above, embedded wetlands and river systems form a critical and integral component of Savannas and Grasslands, and in many cases are areas of greatest biodiversity concern. These areas are, however, excluded from this assessment as they are covered within a wetland specific assessment (Appendix C.1.7 of the Gas Pipeline SEA Report). The same is true for birds (Appendix C.1.8 of the Gas Pipeline SEA Report) and bats (Appendix C.1.9 of the Gas Pipeline SEA Report). The study considers both the construction phase of the pipeline (i.e. the trenching, laying of the pipeline, closing of the trench and rehabilitation) as well as the operational phase. It is assumed that the pipeline will remain in the ground once the project ceases so there is no true decommissioning phase. It is further assumed that there are no specific decommissioning impacts. If the pipeline is either removed, or replaced by a new pipeline, then the impacts are assumed to be equivalent to the impacts during the construction phase.

The biomes as defined by Mucina and Rutherford (2006) are used as the basis for defining areas of Savanna and Grassland. It is, however, recognised that vegetation types within the Indian Ocean Coastal Belt have many commonalities with both Savanna and Grassland biomes and has been considered as part of these biomes in the past. The embedded sand forest has also been seen as a Savanna type in the past.

This study is a high-level overview based on available secondary data sources. Fortunately, provincial assessments of Critical Biodiversity Areas (CBAs) are available for all the provinces and these provincial assessments of biodiversity importance form the backbone of this assessment. The Geographic Information System (GIS) data used, based on these provincial assessments and other data sources was compiled and provided by the South African National Biodiversity Institute (SANBI).

In addition, existing conservation areas are regarded as very high sensitivity or high sensitivity for conservation. There are a large number of national parks and provincial nature reserves within the corridors including the southern section of Kruger National Park (Phase 8) and the Hluhluwe–Imfolozi Reserve (Phase 3, 4, and 7 intersection).

All forest patches, although not Grassland or Savanna, have been rated as very high sensitivity and included in the Grassland and Savanna assessment where they are imbedded in these biomes.

Note that this Specialist Assessment Report was peer reviewed prior to release to stakeholders for review. The report was updated, as required, following the peer review findings. A copy of the peer review report and responses from the Specialist Team is included in Appendix F of this report.

2.1 Assumptions and Limitations

This assessment provides a strategic overview or important conservation concerns. It is not a detailed impact assessment for a specific location, and such assessments would be required once a proposed routing for a pipeline project is decided. Given the scale of this assessment it cannot identify all specific issues and location specific concerns.

Only biodiversity related constraints are included, and constraints from agriculture, settlement, mining, defence and other land uses are not included. Aesthetic impacts, although often linked to biodiversity, are also not considered.

This assessment only considers terrestrial biodiversity. It is important to emphasise that, within particularly the Grasslands, there are numerous imbedded wetlands that form an integral component of the Grassland ecosystems. The importance of these wetland features is emphasised, although they have been excluded from this section as they are fully covered in a section of their own (Appendix C.1.7 of the Gas Pipeline SEA Report). The same is true for bird and bat populations (Appendices C.1.8 and C.1.9 of the Gas Pipeline SEA

Report, respectively). Again they are an important component of the Savanna and Grassland biodiversity, but have been excluded based on the fact that they are being fully covered in their own section.

It was decided that buffering was not appropriate for most features and from a strictly biodiversity perspective. However, buffering for bird and bat impacts would be appropriate, (but is covered in a separate study (i.e. Appendix C.1.8 and Appendix C.1.9 of the Gas Pipeline SEA Report). Given that exact locations of rare and endangered species is not known, and due to the fact that these species may be mobile (animals) or more examples are likely to occur within the identified habitat (animals and plants), this data has been buffered.

Each province used a separate approach to determine areas of high biodiversity importance. Sensitivity levels between provinces differ, with some provinces potentially using higher sensitivities than others. Provincial biodiversity conservation plans are used subject to all the assumptions that underpin the creation of the plans. Differences in approach between provinces are not assessed, but rather each province's plan is accepted independently. Further, since each province's assessment of core biodiversity areas is determined independently, there may be poor edge matching between provinces.

2.2 Relevant legislation and regulations

National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004)

The National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) (NEMBA) provides regulations on the management of biodiversity in South Africa, including regulations relating to threatened or protected species. It provides for listing threatened or protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Protected. Activity 12 in Listing Notice 3 (Government Notice R324 of April 2017 as per the 2014 Environmental Impact Assessment (EIA) Regulations, as amended) relates to the clearance of 300 m^2 or more of vegetation, within Critical Biodiversity Areas.

Threatened or Protected Species Regulations of 2013 (ToPS)

The TOPs relates to Section 56 of NEMBA. Species categorised as CR, EN, VU or Protected require permits for activities relating to:

i. Hunt / catch / capture / kill
ii. Gather / collect / pluck
iii. Pick parts of / cut / chop off / uproot / damage / destroy
iv. Import into South Africa / introduce from the sea
v. Export (re-export) from South Africa
vi. Possess / exercise physical control
vii. Grow / breed / propagate
viii. Convey / move/ translocate
ix. Sell / trade in / buy / receive / give / donate/ accept as a gift / acquire /dispose of
x. Any other prescribed activity

(See Appendix A to E for species that might be encountered).

National Environmental Management Act (Act 107 of 1998), as amended

The National Environmental Management Act 107 of 1998 (NEMA), outlines measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

NEMA EIA 2014 Regulations, as amended (Government Gazette 40772) (April 2017)

These regulations provide listed activities that require environmental authorisation prior to development because they are identified as having a potentially detrimental effect on natural ecosystems. Different sorts of activities are listed as environmental triggers that determine different levels of impact assessment and planning required. The regulations detail the procedures and timeframes to be followed for a basic or full scoping and EIA.

The National Forests Act (Act 84 of 1998)

The objective of this Act is to monitor and manage the sustainable use of forests. In terms of Section 12 (1) (d) of this Act and GN No. 1012 (promulgated under the National Forests Act), no person may, except under licence:

- Cut, disturb, damage or destroy a protected tree; or
- Possess, collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree or any forest product derived from a protected tree.

The Gazette 37941 of 2014. This gazette relates to the National Forest Act of 1998 and lists the tree species that receive protected status under the act. List of protected trees species, many of which are relevant to the corridors in which Savanna and Grassland are present (Appendix A).

KwaZulu-Natal Nature Conservation Management Act (Act 9 of 1997)

This act specifies the institutional structure for nature conservation in KwaZulu-Natal, the establishment of control and monitoring bodies and mechanisms as well as other matters relating to this, including the gazetting of regulation.

The KwaZulu-Natal Environmental, Biodiversity and Protected Areas Management Bill, 2014 (25 February 2015)

The Management Bill, 2014 was passed to provide for the establishment, functions and powers of Ezemvelo KZN Wildlife; the protection and management of the environment and biodiversity; the protection and conservation of indigenous species, ecological communities, habitats and ecosystems; the management of the impact of certain activities on the environment; the sustainable use of indigenous biological resources; the declaration and management of protected areas; and to provide for matters connected therewith.

The Bill includes lists of provincial protected animal and plant species, and it sets rules for activities in protected areas, as well as for the protection of biodiversity.

Mpumalanga Nature Conservation Act, No. 10 of 1998

This Act relates to the establishment and management of conservation areas, and provides legislation relating to protected animals and plants.

Schedules to the Mpumalanga Nature Conservation Act 1998

This Act provides a list of protected species, and rules for conservation areas.

Gauteng Nature Conservation Bill 2014

This bill provides rules for conservation areas; and enables the protection of wild animals and plants including lists of protected species.

Eastern Cape Nature and Environmental Conservation Ordinance (19/1974)

This Ordinance includes rules for conservation areas, and enables the protection of wild animals and plants including lists of protected species.

Note: Much of the Eastern Cape legislation relies on the pre-1994 legislation of the Eastern Cape, Transkei and Ciskei.

3 KEY ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREAS

3.1 Corridors Description

A brief overview of the characteristics and likely impacts per proposed Gas Pipeline Phase, relevant to biodiversity of Savanna and Grasslands is given in Table 1

Table 1: Summary description the likely impacts to Savanna and Grasslands in the proposed Gas Pipeline Phases.

Site	Brief description
Phase 3	This corridor effectively links the Richards Bay area with Gauteng. This corridor cuts from the coast to the centre of the country. With the exception of the coastal strip this corridor falls almost exclusively within Savanna and Grassland regions, with a few embedded forest patches. There are two key pinch points, the one relates to Savanna biodiversity and a string of game reserves centred on the Hluhluwe–Imfolozi Reserve and Nduna reserve in Zululand and the related Maputaland centre of plant endemism. The second is Grassland areas as the corridor cuts through the Drakensberg mountains. In addition the northern half of Gauteng is a complex area due to parallel mountain ranges, and the area being an ecotone between the Highveld Grasslands and Savanna bushland regions.
Phase 4	This corridor is in the Zululand area running from Richards Bay up to the Mozambique border. About half of this corridor is common to Phase 3. The second half being in the Zululand area and running parallel to the sea. With the exception of the coastal strip, most of this corridor is Savanna vegetation, and most is in the Maputaland centre of plant endemism. This region has a number of important private and provincial nature reserves that create pinch points. These include Ndumu, Tembe, Mkuzi and the Isimangaliso wetland park (though this is mostly not Savanna or Grassland).
Phase 7	This is a long corridor running parallel to the sea and stretching from Richards Bay to Port Elizabeth. This corridor runs through and important Pondoland centre of plant endemism. It has a large number of unique and poorly conserved Grassland and Savanna vegetation types with a large number of endemic species, rare and vulnerable species. Pinch points are not created by conservation areas, but rather by un-conserved or poorly conserved areas of high value and irreplaceable biodiversity. The nature of the linear structure of the pipeline combined with the altitudinal alignment of vegetation types mean that it may well cut across almost all areas of a specific vegetation type. This corridor cuts right across three centres of plant endemism.
Phase 8	This phase is a corridor from the Mozambique border to Gauteng (linking to Phase 3). This route is almost exclusively through Savanna and Grassland, with a few embedded forest patches. There are a number of critical squeeze points, the first being through the narrow gap below Kruger National Park and associated conservation areas, and the bulge of Swaziland with the Songimvelo and Barberton Nature reserves. There are also a large number of private reserves in this area. The second pinch point is when crossing the Drakensberg escarpment. Forestry patches as well as important Grasslands are encountered in this area.
Inland corridor and phase 2	The inland corridor and Phase 2 have small patches of grassland (Karoo Escarpment Grassland) within the corridors and the buffer zones. Although small, these patches are identified as having critical biodiversity importance and should be avoided in routing through this corridor. The small, most westerly block is almost entirely within the Karoo National Park. They form solid barriers to using the buffer zone as an alternative routing.

3.2 Feature Sensitivity Mapping

3.2.1 Identification of feature sensitivity criteria

Feature sensitivity mapping is based on available national and provincial data (Table 2). The sensitivity of classes is based largely on sensitivities as used in Provincial biodiversity plans. All National and Provincial conservation areas are considered of national biodiversity importance. For provinces, each province's critical biodiversity plan was seen as the baseline for biodiversity conservation with CBA1 areas given very high status.

Occurrence of CR, EN or VU species within the pipeline corridors is an issue of concern. Unfortunately, by the very nature of these species, for many of them exact locations of all individuals in the population are not known. Therefore, buffers around recorded locations are used as a caution that these species may be found in the area and that precautions should be taken. It is recommended that if the pipeline is likely to cross an area with recorded CR, EN or VU species, that specialist advice is sought from experts in the specific taxa to better understand if the pipeline route is likely to encounter any of the listed species.

Table 2: Data sources and descriptions of sensitivity features.

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors
Protected Areas	National Department of Environmental Affairs South African Protected Areas Database, 2017.	DEA Protected Areas database was compared against the SANBI protected areas database and discrepancies were resolved. Protected areas were added to the DEA data layer based on the SANBI layer in the Western Corridor, otherwise both layers were consistent. ***Note: The Corridor area of the Hluhluwe–Imfolozi complex has a missing section on the National Protected Area Database. This has been corrected in this report, but not in the base GIS maps.***	All corridors assessed in this assessment of Savanna and Grassland Biomes
Critical Biodiversity Areas	Provincial datasets (GP - 2011, EC - 2007, FS - 2016, KZN - 2016, Limpopo - 2013, MP - 2013, NW - 2014, WC - 2017, NC - 2016)	As prepared by SANBI. Eastern Cape was updated with draft 2017 data (ECBCP, 2017).	All corridors assessed in this assessment of Savanna and Grassland Biomes
Threatened ecosystems	DEA and the SANBI 2011, Western Cape threatened Ecosystems, Eastern Cape updated threatened ecosystems	Data as downloaded from the SANBI website	All corridors assessed in this assessment of Savanna and Grassland Biomes
Natural Forest Areas	National Forest Inventory (NFI), sourced 2016, Department of Agriculture, Forestry and Fisheries (DAFF) EC CBA Plan	As prepared by SANBI	All corridors assessed in this assessment of Savanna and Grassland Biomes
Critically Endangered, Endangered and Vulnerable species	Mammals – Child et al. 2016 Reptiles – Bates et al. 2014 Frogs – Minter et al. 2004 Plants - Raimondo et al 2009 as updated 2018	As prepared by SANBI. Buffers of 2.5km around the Rodentia, Soricomorpha and Afrosoricida. 5km around everything else. For reptiles, amphibians and butterflies, a 2.5 km buffer, with the exception of *Crocodylus niloticus*, who should get a 25 km buffer. Mammal species have not been shown as they are predominantly linked to conservation areas (E.g. rhinoceros, wild dog) or are close to ubiquitous (leopard).	All corridors assessed in this assessment of Savanna and Grassland Biomes
Protected Area Expansion Areas	Eastern Cape Protected Areas Expansion	DEA. 2016. National Protected Areas Expansion Strategy for South Africa.	All corridors assessed in this

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors
	Strategy, Eastern Cape Parks and Tourism Area		assessment of Savanna and Grassland Biomes
	Western Cape Protected Areas Expansion Strategy, Cape Nature.	DEA. 2016. National Protected Areas Expansion Strategy for South Africa.	All corridors assessed in this assessment of Savanna and Grassland Biomes

The ranking of sensitivity classes per feature is given in Table 3.

Table 3: Ratings and buffer areas allocated to feature types.

Corridor	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
All Phases	Protected Areas – national and provincial parks, forest wilderness, special nature reserves and forest nature reserves	Very High	None
	Coastlines	Very High	None
	All indigenous forests	Very High	None
	CBA (CBA1 for EC)	Very High	None
	CBA 2 EC	High	None
	Threatened ecosystems CR	Very High	None
	EN	High	None
	VU	Medium	None
	Land Cover: Natural Area Land Cover: Modified areas	Low	None
	Game Farms	Medium	None
	SANParks Buffer	High	
	Protected Environments	High	None
	National Protected Area Expansion	Medium	None
	Mountain Catchment Areas	High	None
	Biospheres	Medium	None
	Botanical Gardens	Medium	None
	Individual threatened taxa	High	As per the data in the table above
	ESA	Medium	None

3.2.2 Feature maps

This section highlights the different features that have been combined to develop the overall sensitivity map. These maps are of a descriptive nature with the order of the drawing of features being the reverse order of the legend i.e. the first feature in the ledged is drawn on top of lower features if they overlap. The feature maps are to aid in understanding of the sensitivity maps (section 3.3), but in no way attempt to designate sensitivity either in the order of features or the colours used. Although a single map (Figure 10) attempts to consolidate all features, it is easier to understand the issues by considering specific features in isolation, such as results from the provincial biodiversity assessments (Figure 4), and individual plant and animal species (Figure 5 – Figure 9). From the individual species data, it is clear that the phase 7 corridor, in particular, is a hotspot for endangered species, and especially plant species. It is also clear that from a species perspective the Grasslands are more vulnerable than the Savanna areas.

The feature maps only include the Savanna and Grassland biomes. If parts of some features are of a different biome, then in most cases they have been clipped out. It also means that important features such as conservation areas within the phase, but outside of the Grassland and Savanna may not be displayed.

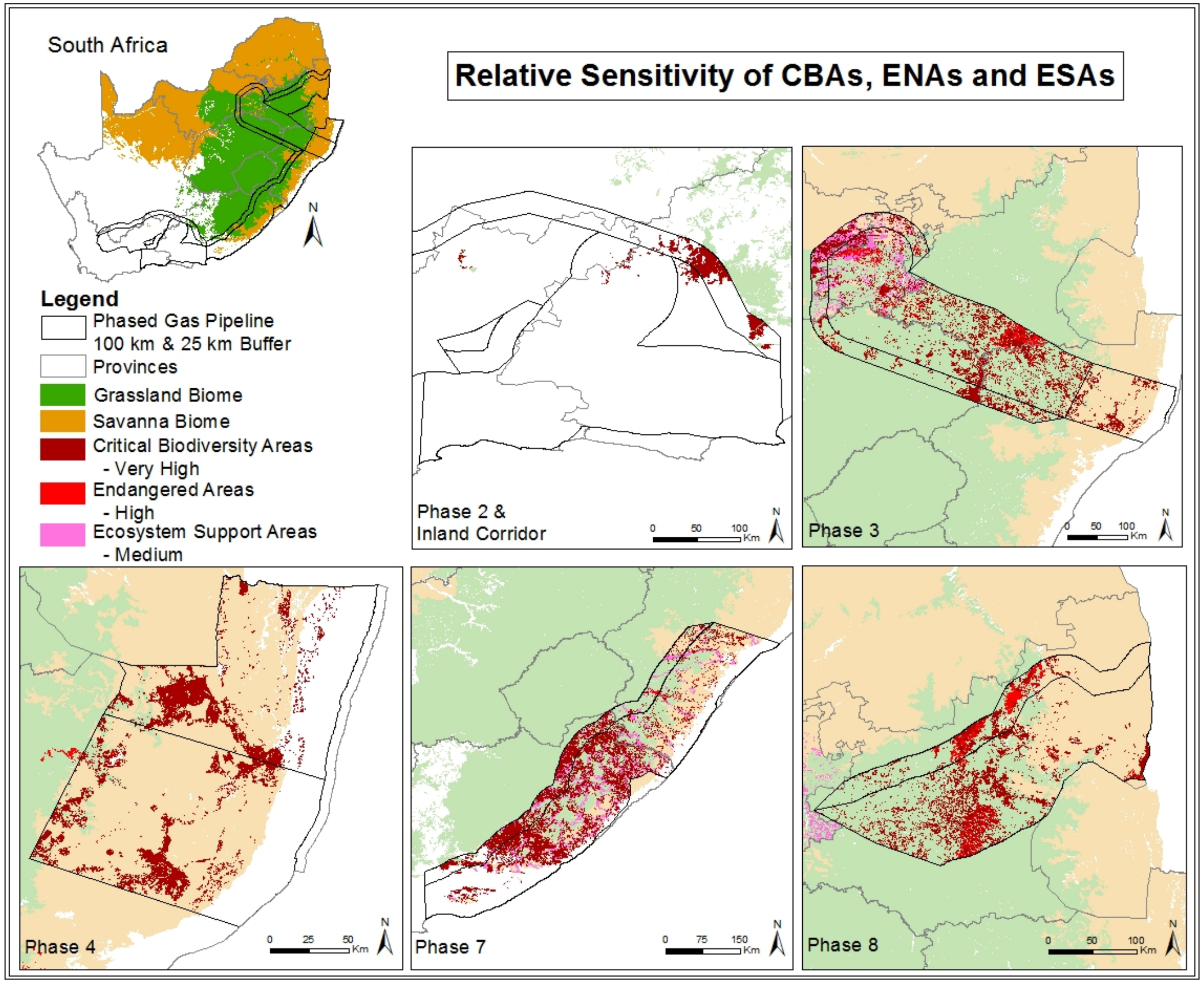

Figure 4: The provincial biodiversity plans were used to identify Critical Biodiversity Areas, Endangered Areas (ENA's) (CBA2 for Eastern Cape) and Ecological Support Areas (ESAs). Note: individual provinces assessments used different criteria for defining their CBAs. National and Provincial parks are excluded from the map, but part of most provinces CBAs.

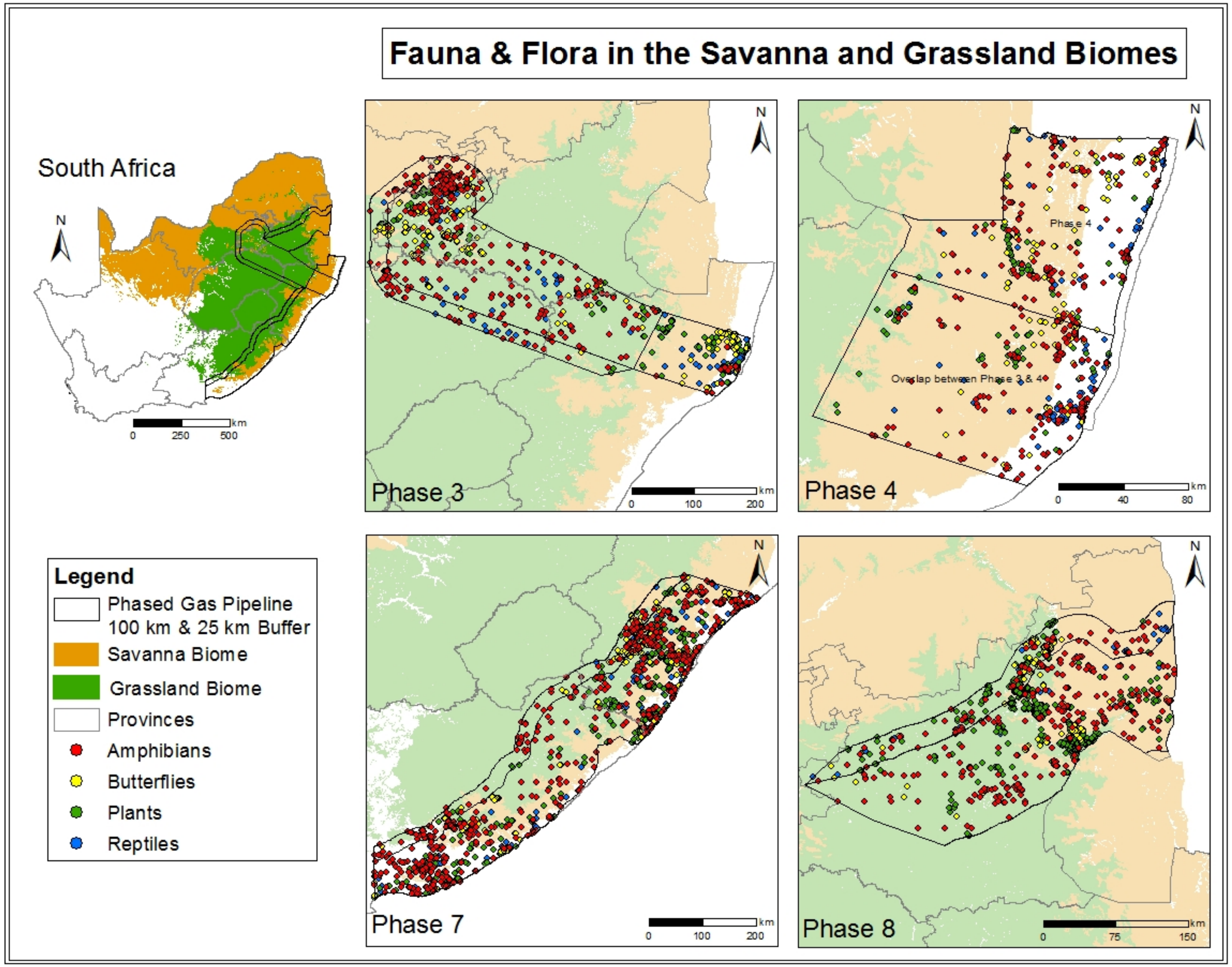

Figure 5: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened fauna and Critically Endangered, Endangered, Vulnerable flora likely to be encountered in the different phases. Large mammals are also excluded. For the inland corridor and Phase 2 see Figure 14.

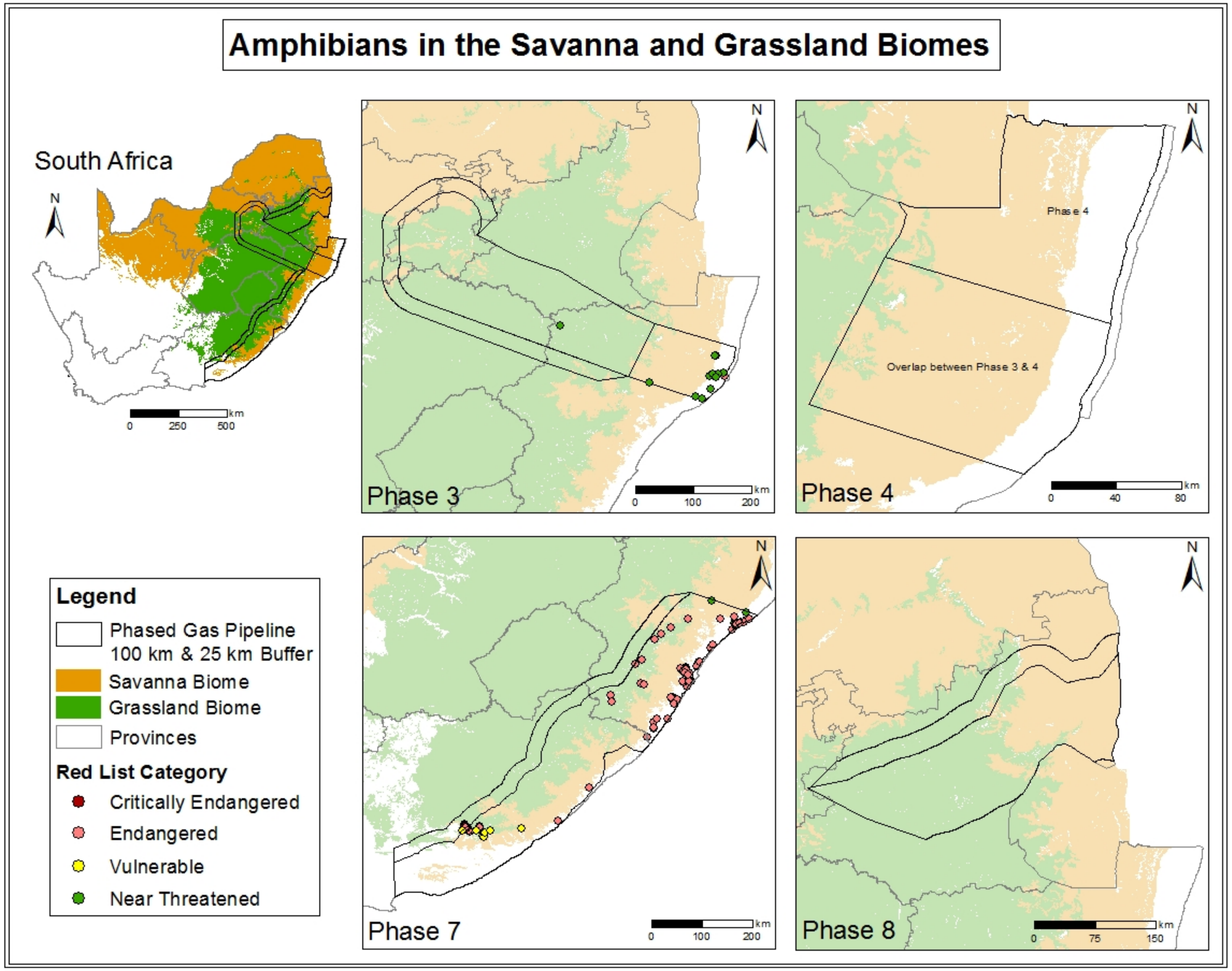

Figure 6: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened Amphibia likely to be encountered in the different phases. For the inland corridor and Phase 2 see Figure 14.

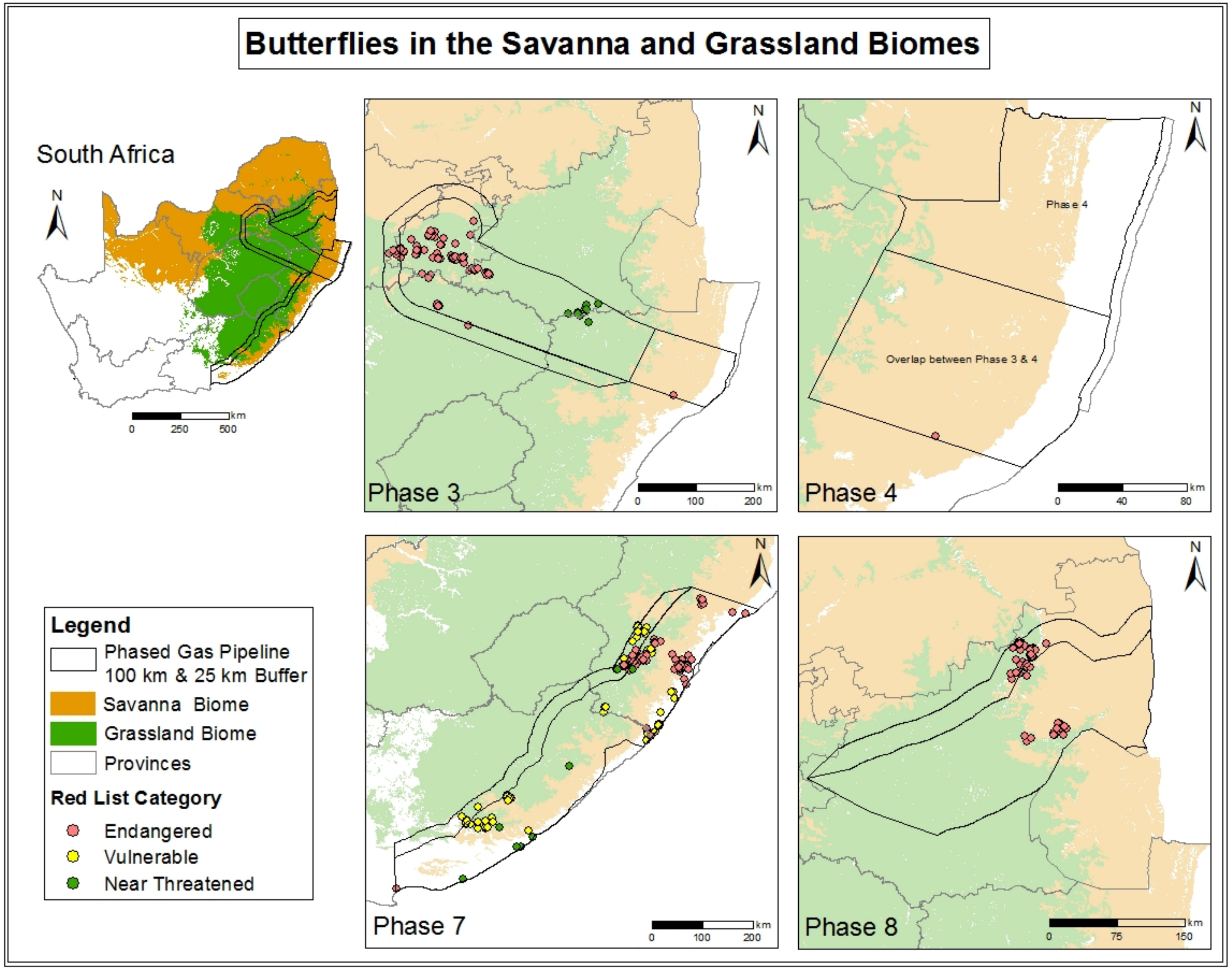

Figure 7: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened butterflies likely to be encountered in the different phases. No butterflies were identified for the inland corridor and Phase 2.

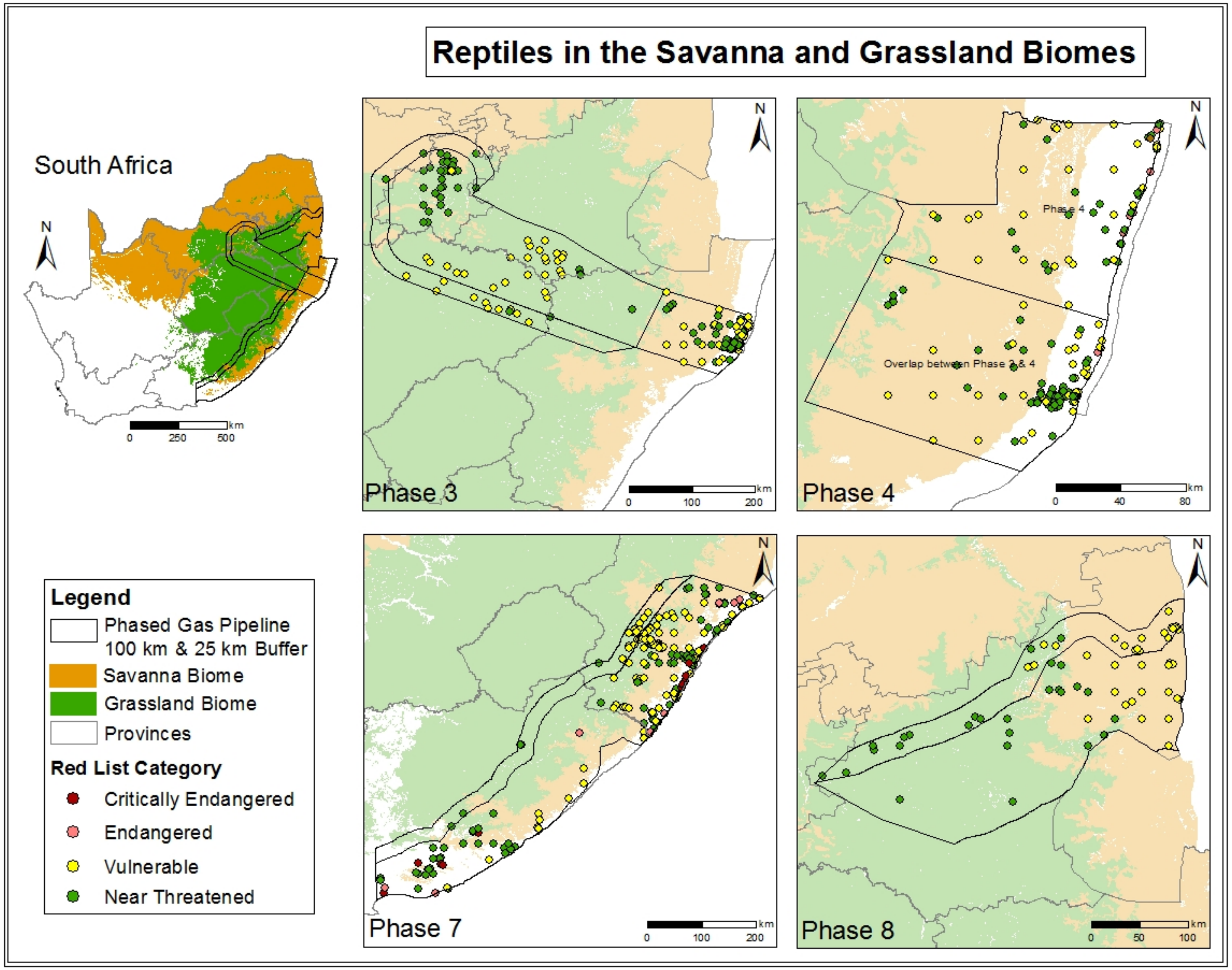

Figure 8: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened reptiles likely to be encountered in the different phases. For the inland corridor and Phase 2 see Figure 14.

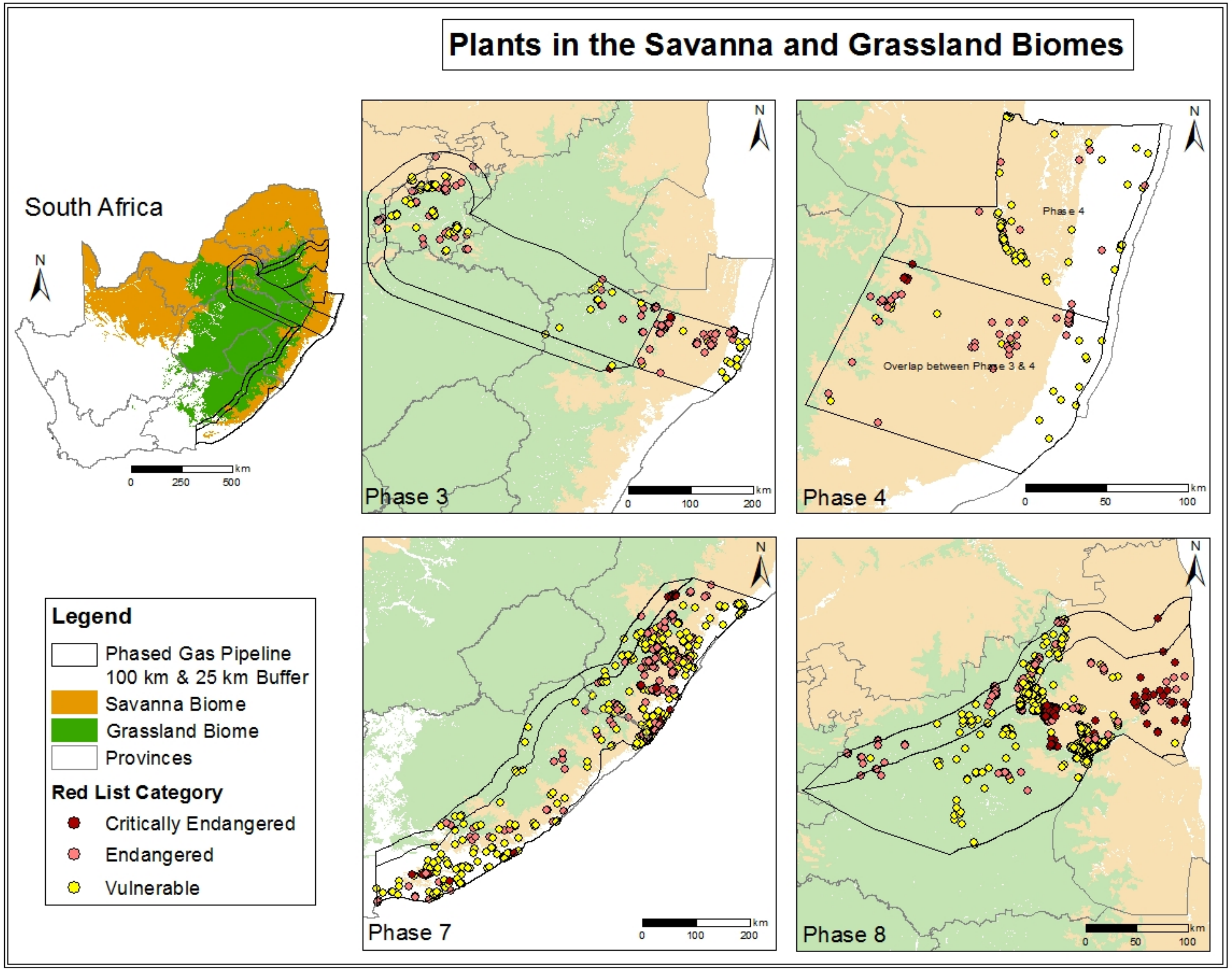

Figure 9: Summary map of all Critically Endangered, Endangered, Vulnerable plants likely to be encountered in the different phases – no plant species mapped onto the inland corridor and Phase 2.

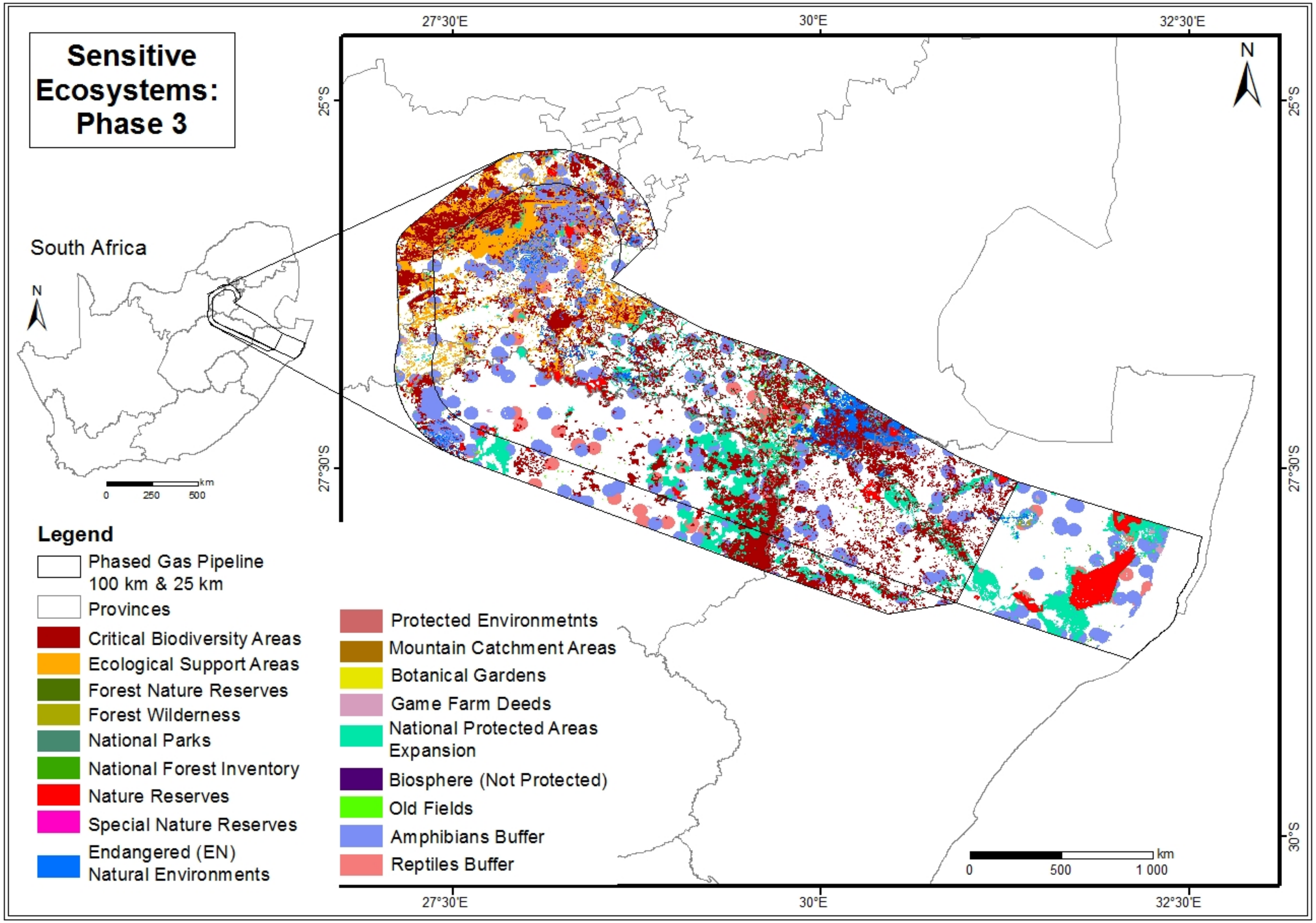

Figure 10: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 3.

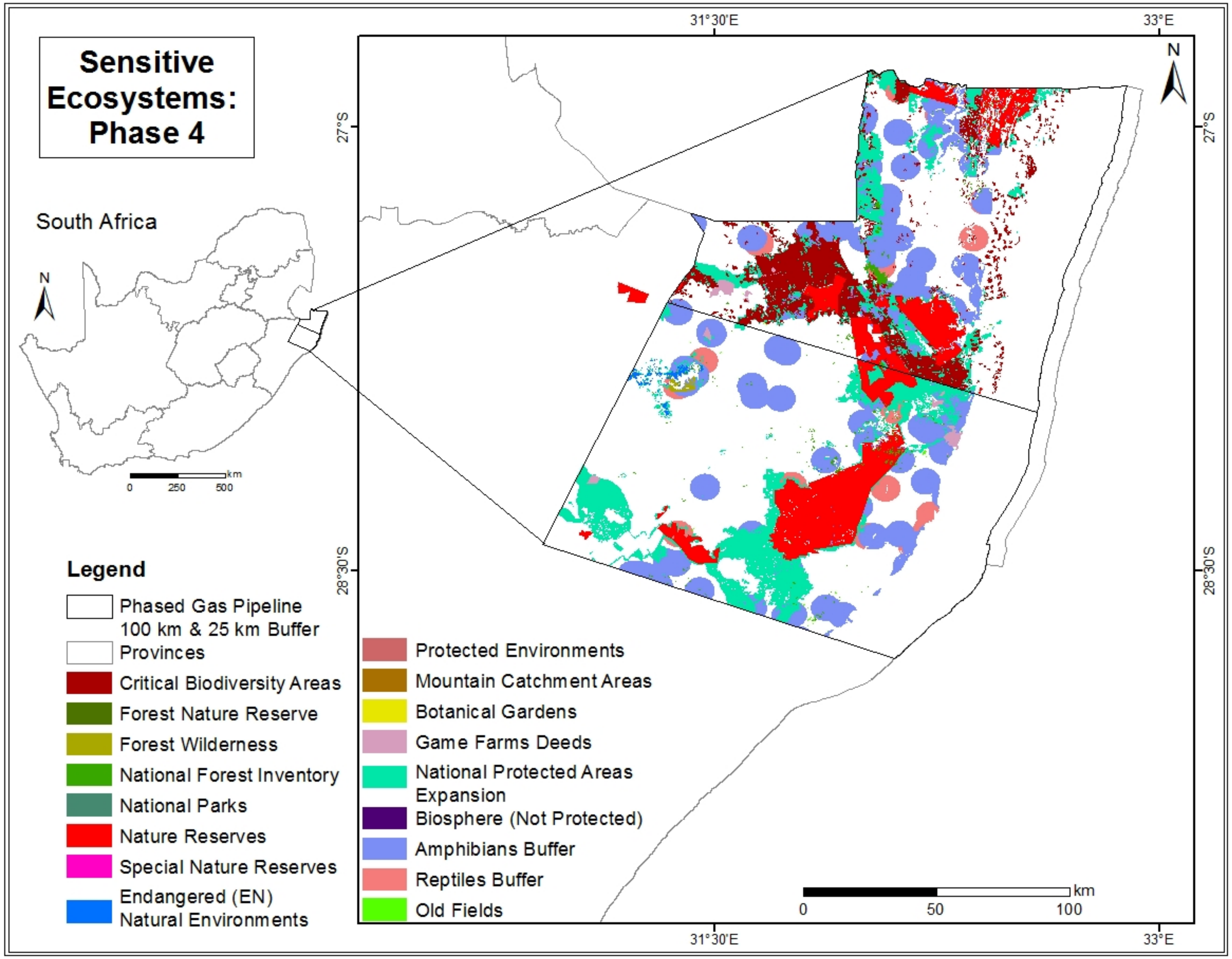

Figure 11: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 4.

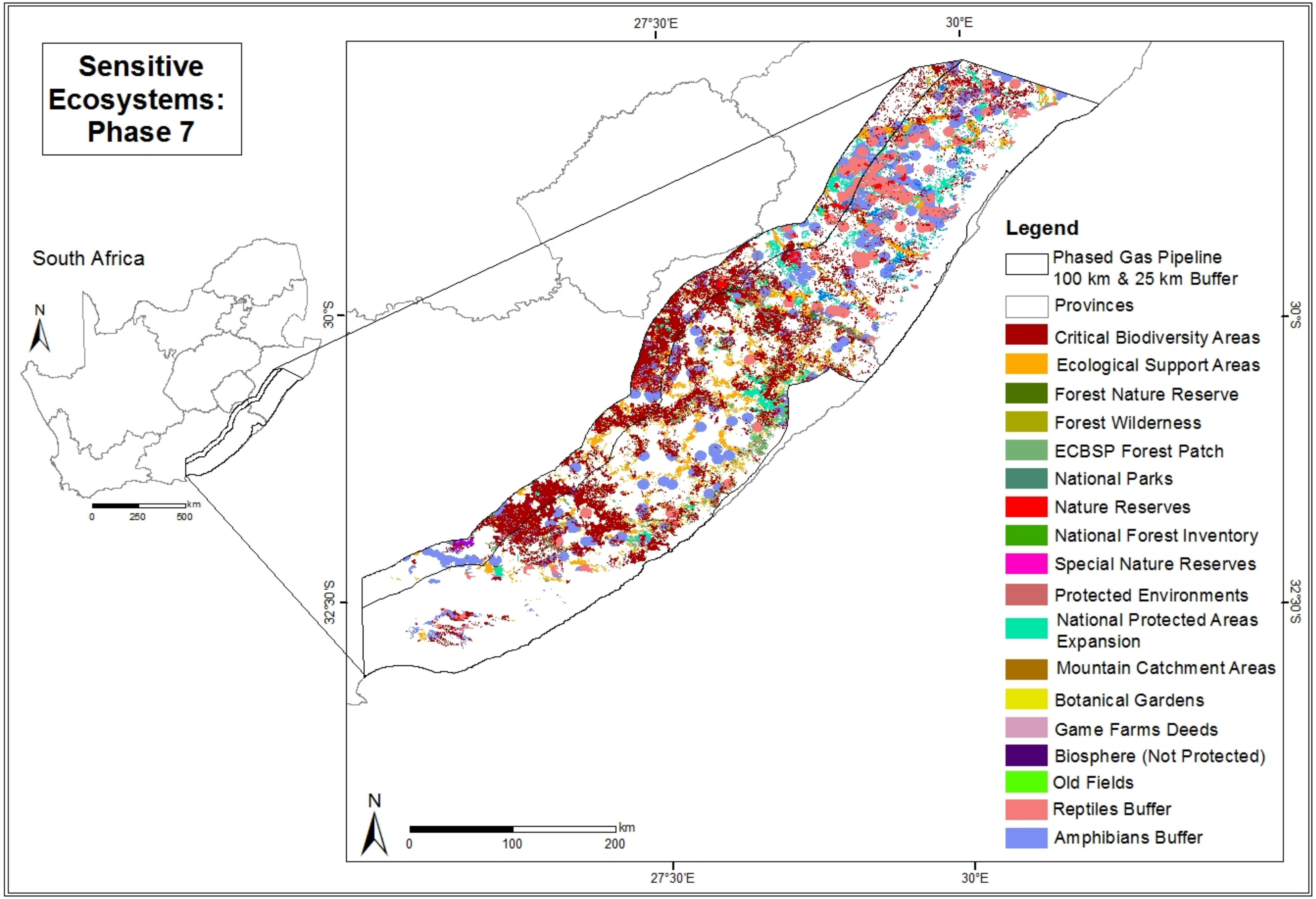

Figure 12: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 7.

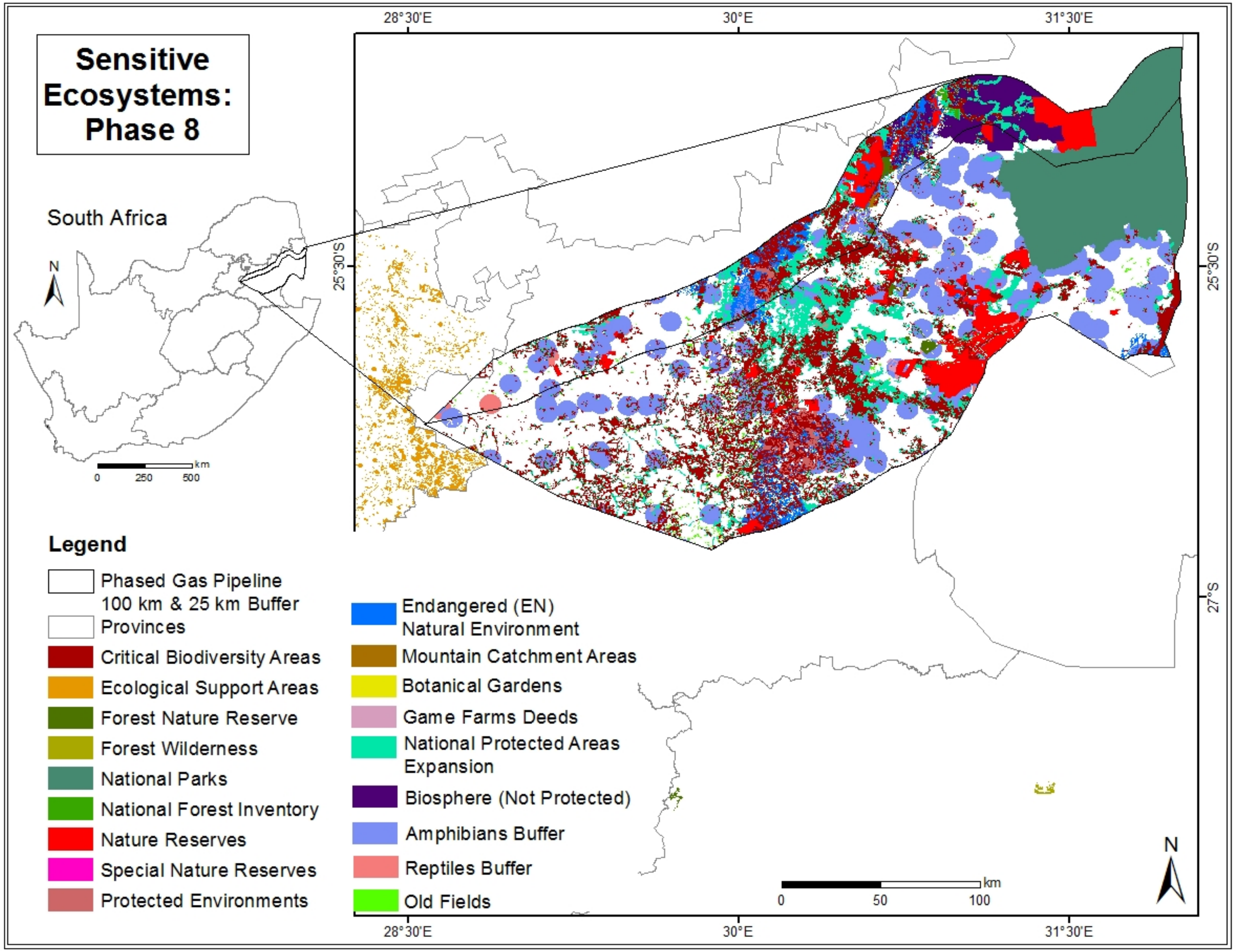

Figure 13: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 8.

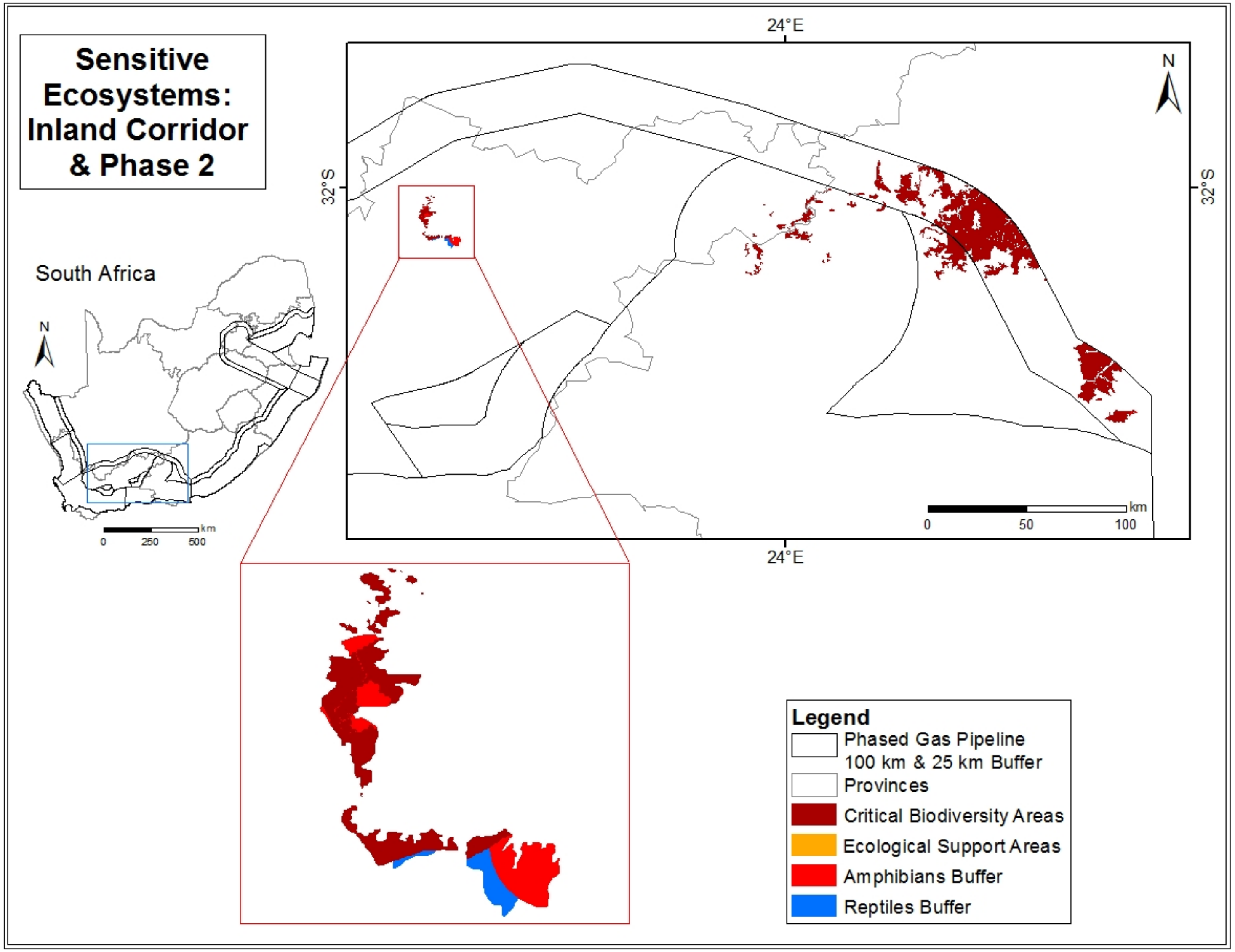

Figure 14: Summary map of features used in the sensitivity assessment for Gas Pipeline inland corridor and Phase 2

3.3 Four-Tier Sensitivity Mapping

The relative sensitivity mapping follows a four tier sensitivity classes approach with:

- Dark Red: Very High Sensitivity
- Red: High Sensitivity,
- Orange: Medium Sensitivity
- Green: Low Sensitivity

Sensitivity maps use a simple approach based on colourations with all criteria of the same sensitivity getting the same colours. The sensitivities are built up from lowest to highest, so on the map the colour seen is the highest sensitivity for a specific area.

3.3.1 Gas Pipeline Phase 3

A sensitivity map for Gas Pipeline Phase 3 is given in Figure 15. Apparent pinch points from a biodiversity perspective relate to the areas around the provincial parks in Zululand, crossing of the Drakensburg and the Gauteng region.

3.3.2 Gas Pipeline Phase 4

A sensitivity map for Gas Pipeline Phase 4 is given in Figure 16, obvious pinch points from a biodiversity perspective relate to the areas around the provincial parks in Zululand as well as areas of high CBA values linked to these parks.

3.3.3 Gas Pipeline Phase 7

A sensitivity map for Gas Pipeline Phase 7 is given in Figure 17. Apparent pinch points relate to the high biodiversity of the Pondoland region, especially within the Eastern Cape. This area has an exceptionally high occurrence of endangered and endemic species.

3.3.4 Gas Pipeline Phase 8

A sensitivity map for Gas Pipeline Phase 8 is given in Figure 18. Apparent pinch points relate to the narrow gap between Kruger National Park and Swaziland, as well as crossing of the Drakensberg Mountains.

3.3.5 Gas Pipeline inland corridor and Phase 2

A sensitivity map for Gas Pipeline inland corridor and phase 2 is given in Figure 19. This area has no savanna and very limited grassland so overall pinch points cannot be identified, however, all grassland areas are considered sensitive and should be avoided. These are, however, a very small and restricted area within the phase 2 corridor.

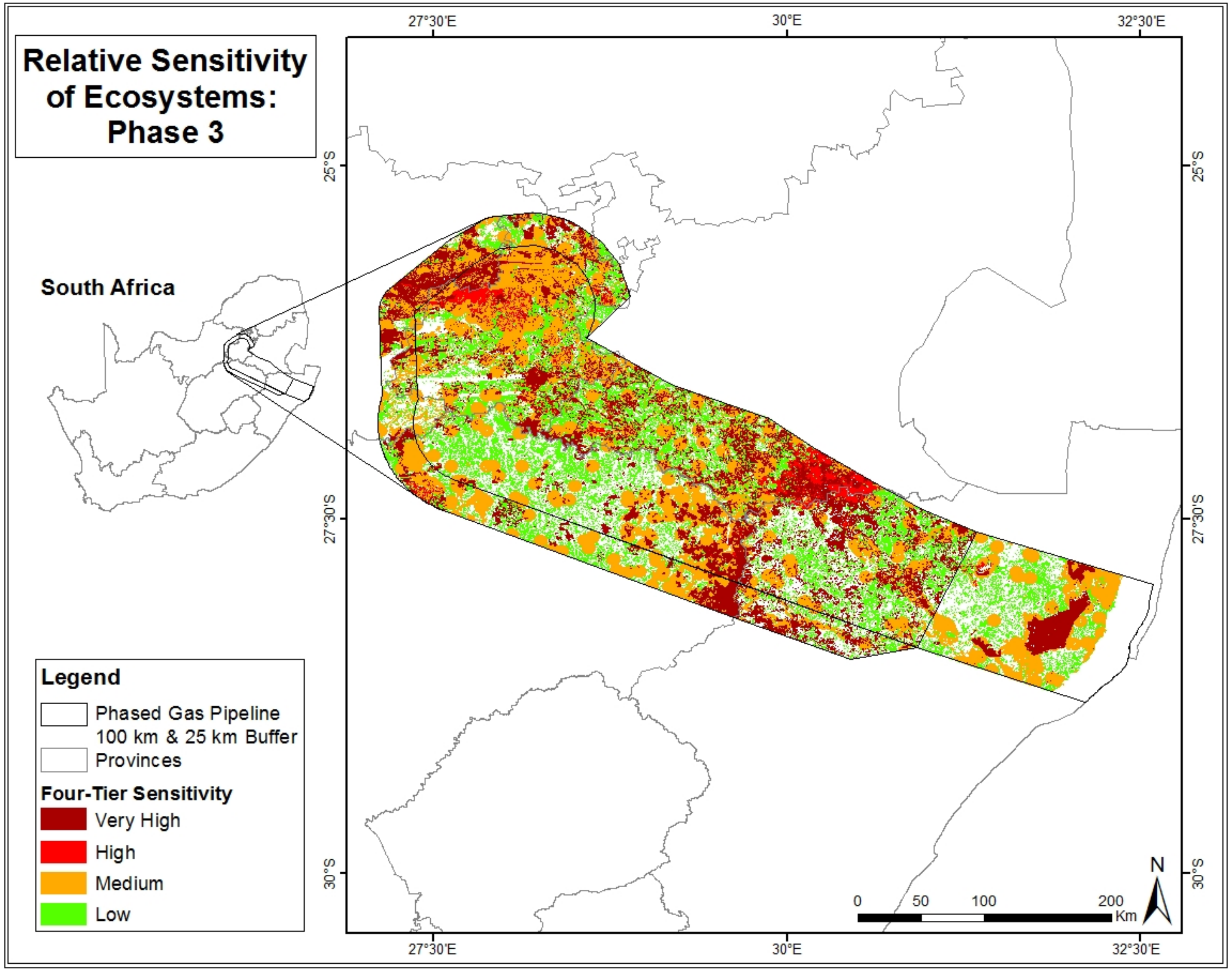

Figure 15: Sensitivity map for Gas Pipeline Phase 3.

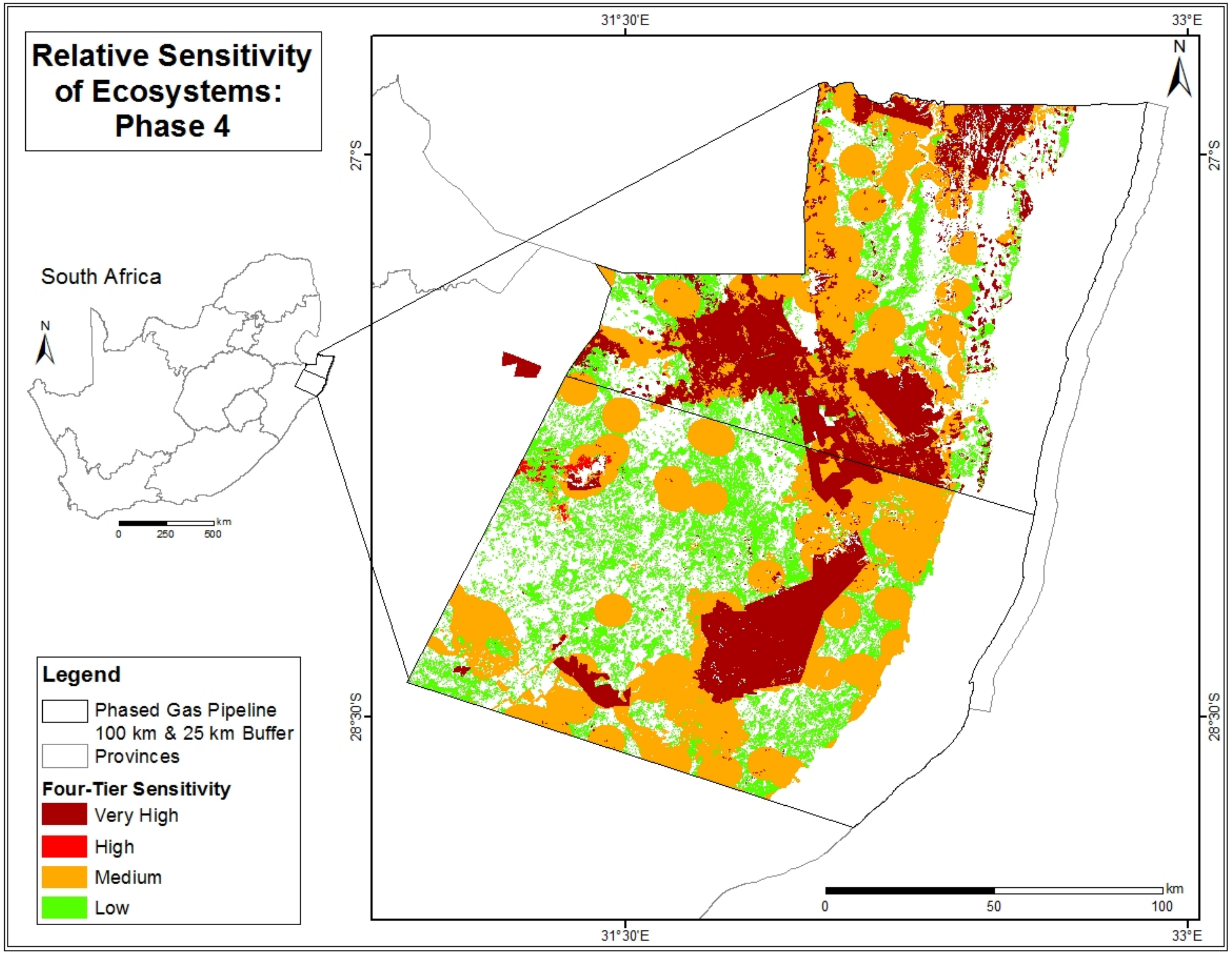

Figure 16: Sensitivity map for Gas Pipeline Phase 4.

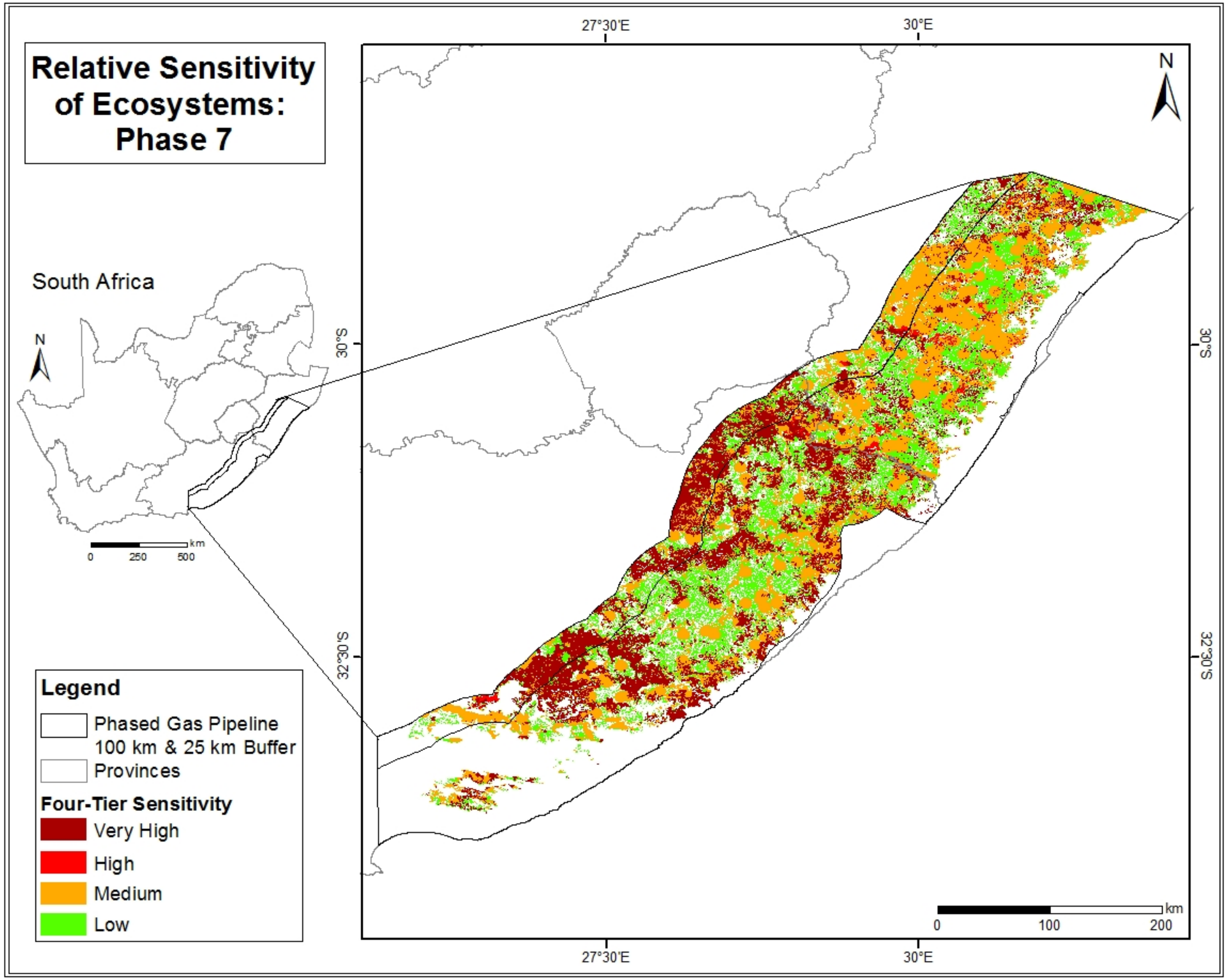

Figure 17: Sensitivity map for Gas Pipeline Phase 7.

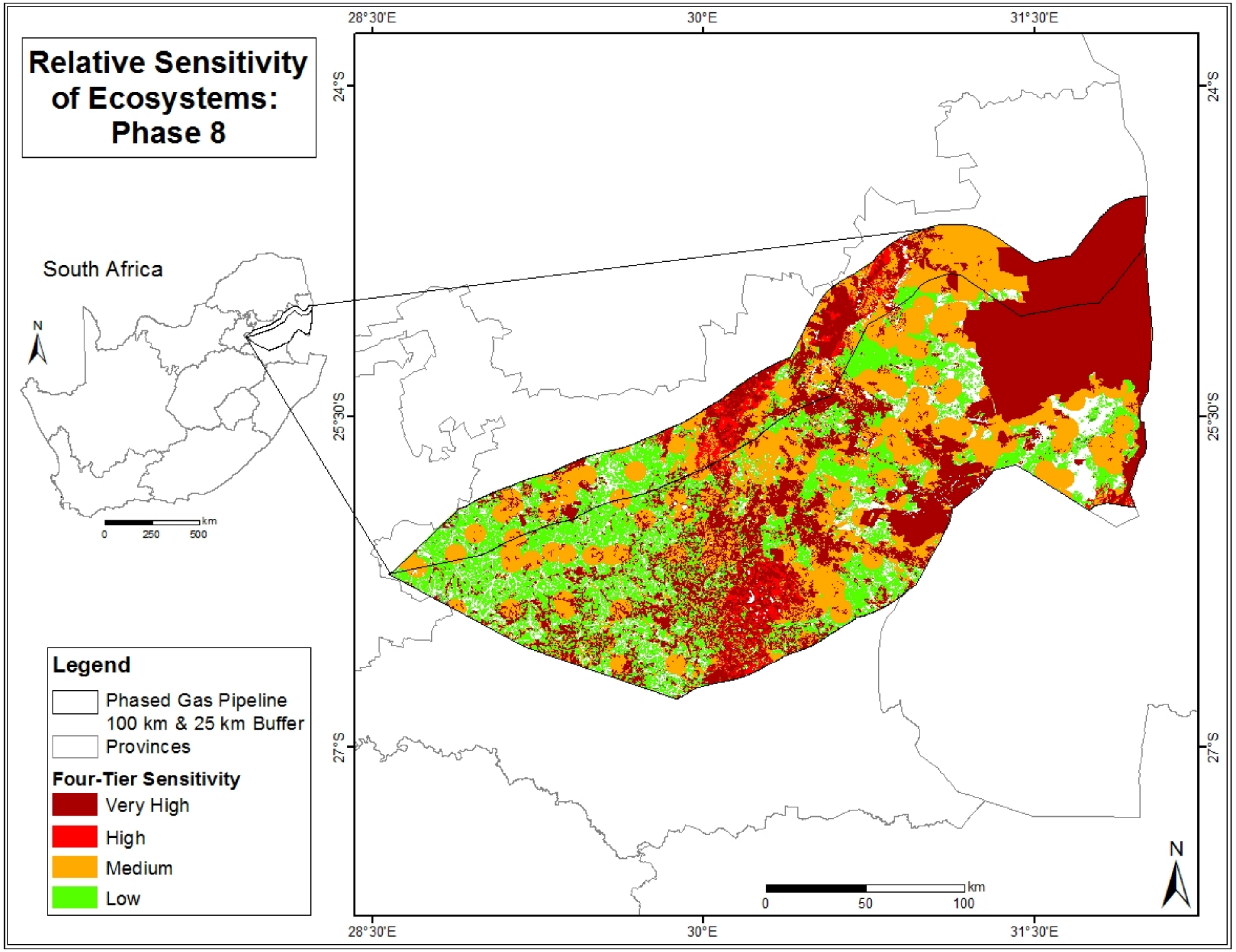

Figure 18: Sensitivity map for Gas Pipeline Phase 8.

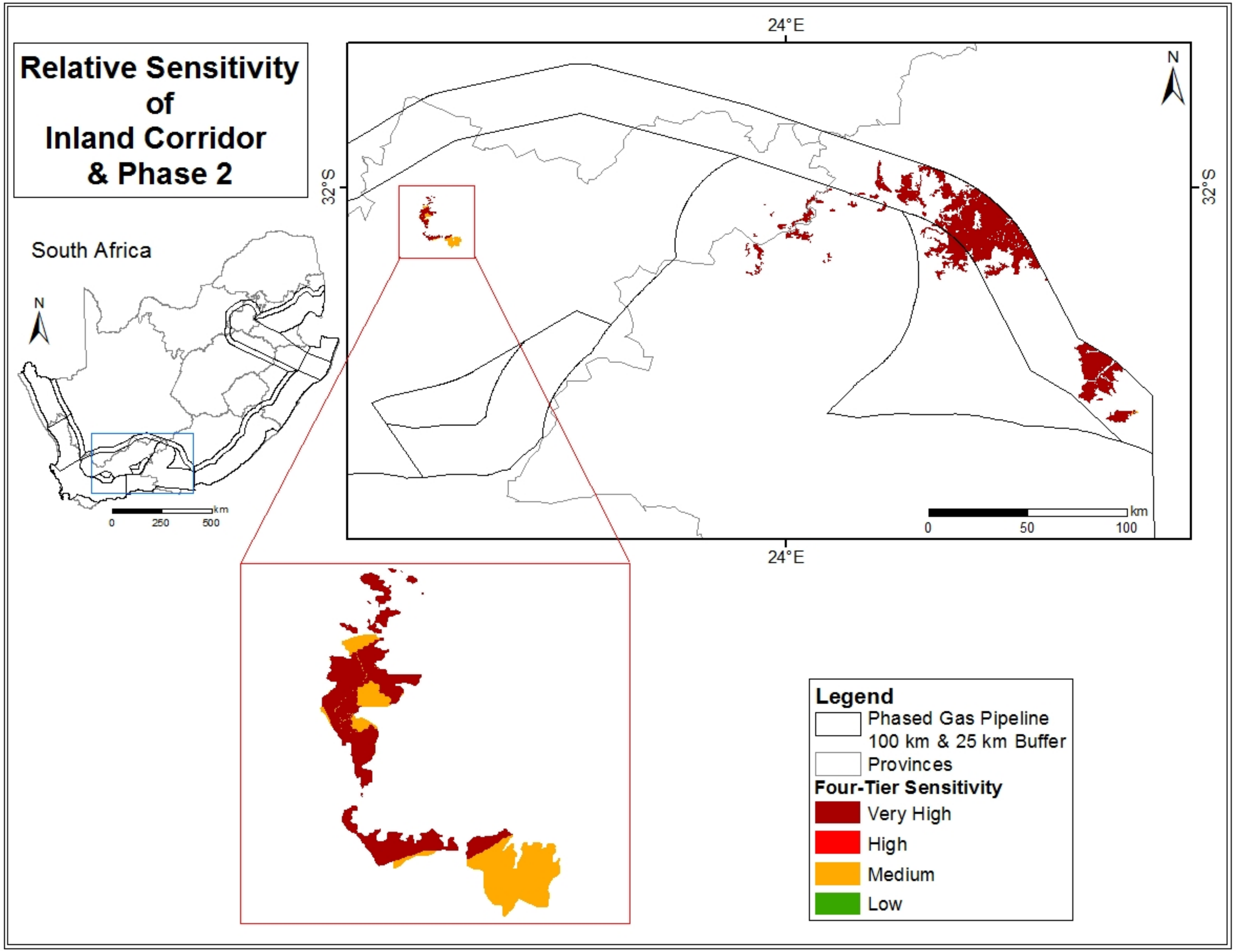

Figure 19: Sensitivity Map of grasslands in the inland corridor and Phase 2

4 KEY POTENTIAL IMPACTS AND THEIR MITIGATION

4.1 Impact 1. Physical disruption of the land surface as a result of vegetation clearance and development infrastructure

An area of 50 m in width suffers almost total degradation of vegetation during the construction phase for the right-of-way (see Figure 20). The most severe degradation is the actual trench line which is a few meters across and may vary in depth, but is typically about 2 m to the top of the pipeline. The remaining area suffers varying degrees of degradation dependent on the use, but includes surface soil storage, subsoil storage and transportation. The transportation zones may suffer high levels of compaction. These activities will destroy all or most of the biodiversity in the pathway. Although the construction line is relatively narrow (30-50 m), it can occur over hundreds of kilometres, potentially having high impacts on narrow vegetation types that follow the same path (Figure 21 - Figure 22). During construction there will be noise and vibrations from the trenching, drilling and blasting. These will all impact on faunal species, driving the more mobile species from the area, but potentially having devastating impacts on less mobile species, or those species that seek refuge underground. Both during and after construction the trench-line as well as the temporary soil storage can alter hydrological patterns, drainage and runoff movements, leading to short term or long term erosion and altered hydrological patterns. For instance, disruption to impermeable rock layers in the trench-line may create new subsurface drainage patterns, or the newly filled trench-line may easily erode and channel water in new ways. This could potentially lead to drying of wetlands or creating new wetland areas. This may be particularly relevant where trenches cut across unstable sodic soils. Where trenches cut across vertic soils, consideration will need to be made for the inherent movement of these soils as they swell and contract with soil moisture levels.

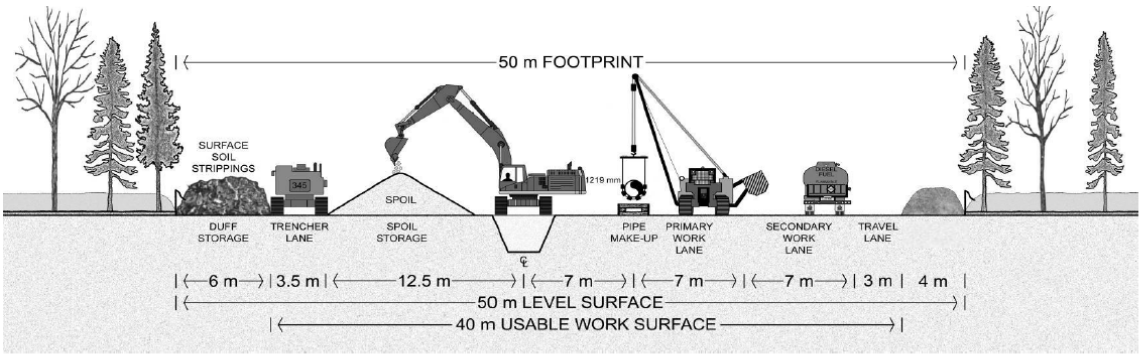

Figure 20: Illustration of a typical construction path as provided by Ephraim (2017) as background to the project.

This Figure 21 illustrates how many of the Grassland vegetation types follow environmental gradients running parallel to the coast for Gas Pipeline Phase 7 (the same is true for the Savanna types (Figure 22)). A pipeline running parallel to the coast could, by chance, follow the same vegetation type (e.g. the Vulnerable Ngonguni) for most of its route, effectively cutting through every large patch and having a disproportionately high impact on that vegetation type. Although less threatened, the same impact is likely for the Bisho Thornveld.

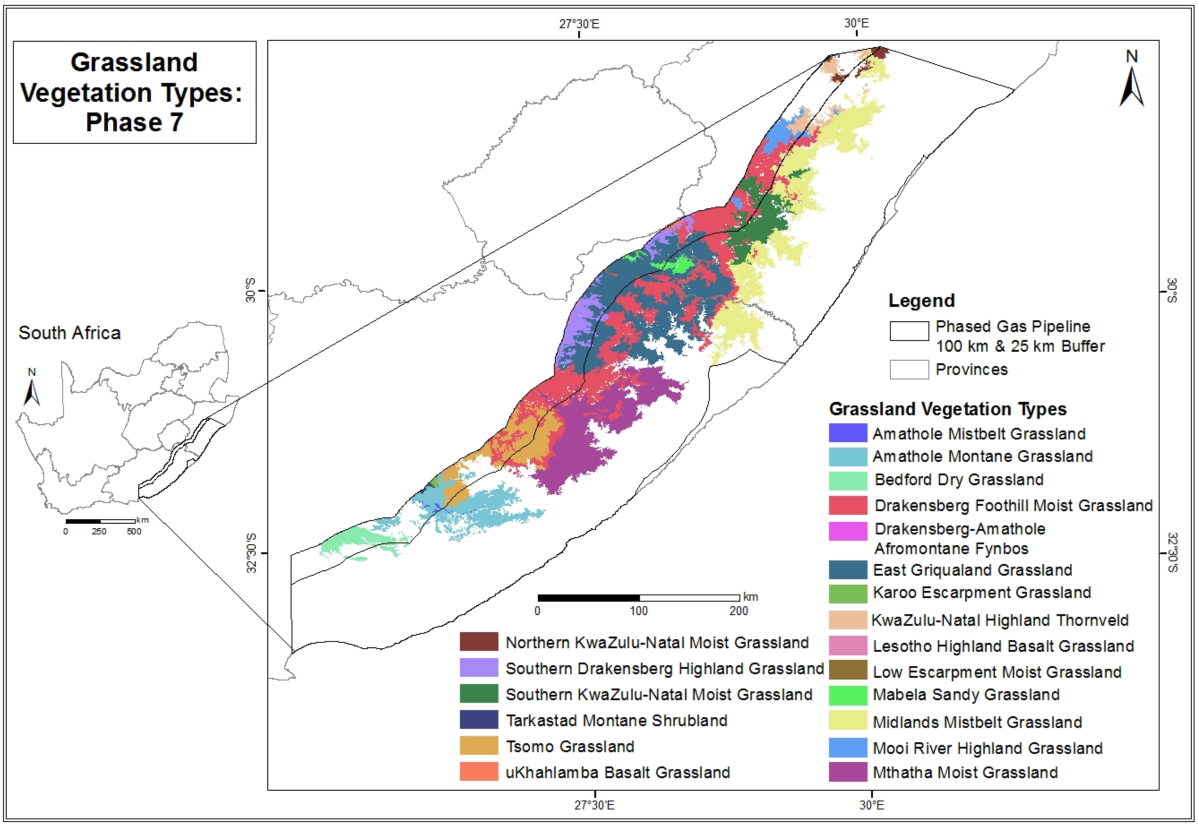

Figure 21: Narrow grassland vegetation types present in Gas Pipeline Phase 7.

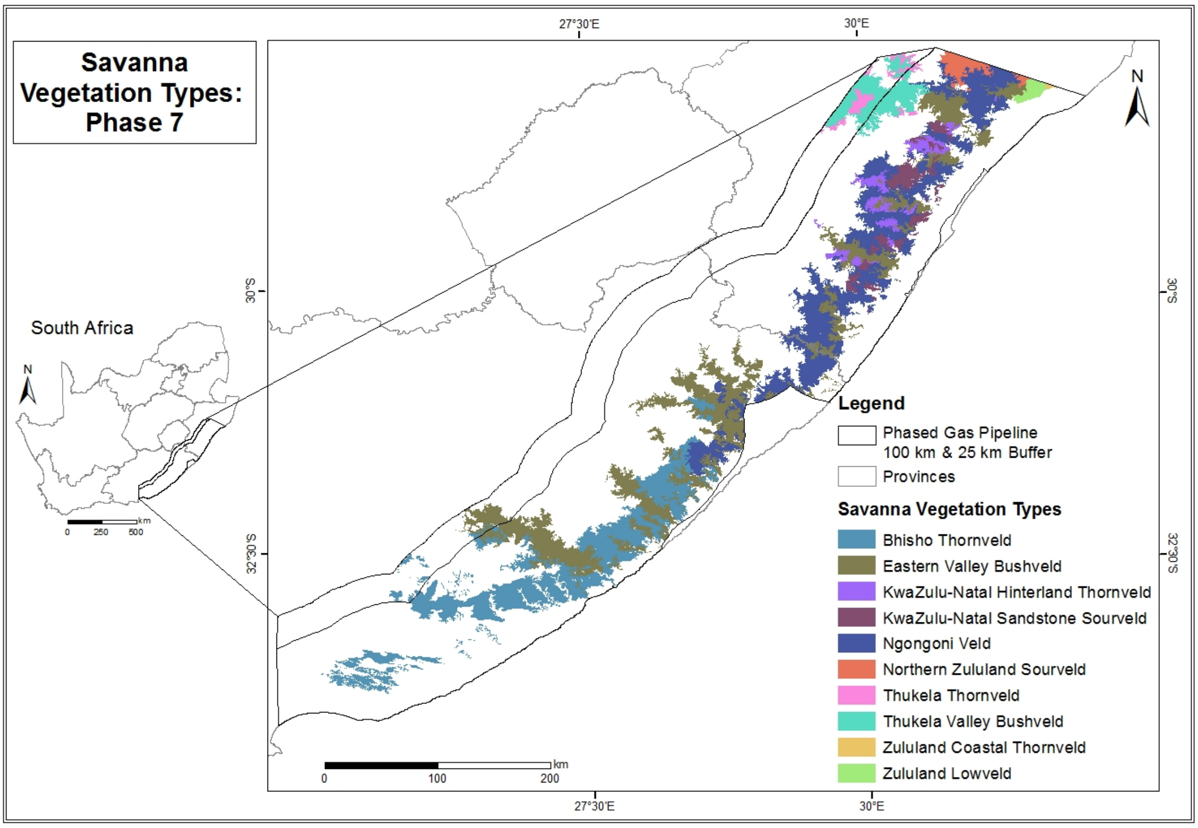

Figure 22: Narrow savanna vegetation types present in Gas Pipeline Phase 7.

4.1.1 Mitigation

- As far as possible avoid High and Very High Sensitivity areas, and where avoidance is impossible work with fauna and flora specialists to mitigate impacts. This may include relocations, additional controls during construction, selecting best seasonal timings, and shortening the duration of the impact.
- Specialist faunal and floral assessments in areas of Medium to Very High sensitivity to finalise micro-siting of route.
- Avoidance of roosts, nests and burrows of sensitive species where possible. If not possible then conduct the trenching operations outside of the breading season and/or have specialists relocate the individuals that are being threatened.
- Avoid crossing of key migration or movement corridors, or limiting construction in these areas to less sensitive seasons (e.g. winter for many species). Reduce the construction phase to the shortest possible time.
- If possible, avoid construction activities in the breeding season of conservation important taxa.
- Minimising the width of the construction zone, and minimising the duration of construction.
- Ensure that rare and endangered species are not buried under the temporary soil dumps.
- Replacing soil in the sequence it was extracted, and replacing the topsoil on the top, avoiding rare and endangered species where possible. This should be done, within a month of excavation. This not only limits changes in the soil, but ensures that the exposed area of the trench, a potential trap for animals, is minimised.
- Transplanting / replanting rare and endangered species, and re-establishing natural vegetation on the zone after completion, except deep rooted trees.
- Allowing the revegetated areas to advance to as near natural a state as possible, this includes allowing tall trees to re-establish (possibly with a limited buffer around the pipeline), managing invasive alien vegetation, and maintaining natural fire regimes.
- If at all possible rootstock of existing vegetation should be retained in all but the trench area. Most Savanna trees have an incredible ability to sprout from felled trees and hence can re-colonise the area far faster than new seedlings.
- Include drainage structures to prevent erosion, and where required (especially on slopes) ensure suitable engineering structures are in place to direct or redirect surface runoff and sub-surface flows.
- Ensure that were the pipeline cuts through sodic soils that adequate interventions are taken to prevent erosion and piping.
- Care must be taken on vertic soils to ensure that soil movement does not cause damage to the pipeline with resultant secondary environmental damage.

4.2 Impact 2. Prevention of animal movement during the construction phase and loss of forage habitat

During construction, both the trench and the pipeline (before going into the trench) effectively create an impenetrable barrier to animal movement. Depending on the construction, this could conceivably be over distances of many kilometres at any point in time. There are two consequences, animals cannot migrate over their normal areas and secondly small animals (e.g. mammals, reptiles) might fall into the trench and be trapped. In addition, animals lose access to the habitat for forage or other purposes, either directly or through the trench preventing access.

4.2.1 Mitigation

- Where possible avoid High and Very High Sensitive areas. Where avoidance is impossible work with fauna specialists to mitigate impacts. This may include relocations, additional controls during construction, selecting best seasonal timings, shortening the duration of the impact, and working on short sections at a time to limit the spatial extent of the impact.
- Specialist faunal assessments to finalise micro-siting of route.

- Keep the development footprint to a minimum.
- Control dust settlement on the surrounding vegetation.
- Control sedimentation runoff into rivers and water bodies.
- Reducing the time of construction at any one point to a minimum.
- Doing daily patrols for trapped animals.
- If there is a risk of preventing seasonal migrations, then time the construction to a season where this is less critical.

4.3 Impact 3. Death or harm to animals or loss of breeding habitat

During construction, both the trench and the pipeline (before going into the trench) effectively create potential harm to animals. This could be either through direct contact, or through the animal falling into the trench and being either trapped or harmed. In addition, the large workforce during construction creates a very real possibility of illicit poaching, setting of snares, killing of perceived harmful animals (snakes, chameleons etc.), providing poaching intelligence, collecting plants for traditional medicine, and accidently creating fires.

4.3.1 Mitigation

- Construction activities to either avoid the breeding or migration periods of conservation important taxa that may be encountered along the route, or take measures to minimise impacts where this avoidance is not possible.
- Construction activities to happen in short phased stretches and continuous rehabilitation to occur as sections are complete.
- In addition to areas with open trenches being demarcated and fenced, all open trenches are to be equipped with ladders or ramps every 50m to enable trapped animals to escape.
- Fencing to be placed in higher animal activity areas to prevent animals falling into trenches.
- A walk through of the route to be conducted prior to clearing of vegetation and breaking of ground to ensure no animals or nests/ burrows/ roosts are harmed, or to minimise the risk to these or relocate them when this is possible.
- Rescue and release of less mobile species such as snakes, frogs, reptiles, invertebrates and certain burrowing mammals to occur prior to construction.
- Undertaking daily patrols for trapped animals.
- If there is a risk of preventing seasonal migrations, then timing the construction to a season where this is less critical.
- Ensure that rare and endangered species are not buried under the temporary soil dumps.
- Vehicles to move slowly along access roads to prevent collision with animals.
- Training of staff regarding biodiversity responsibilities, monitoring staff behaviour and sanctioning of transgressions should be undertaken.

4.4 Impact 4. Limiting animal (and plant) movement in the post-construction phase

The pipeline creates a long cleared strip within the natural vegetation. This may remain an altered habitat or revert to a near natural habitat over time depending on management. While revegetation is taking place this altered habitat can be a barrier to many, especially small, animal species. For instance, a structure change of the habitat from woody plants to a low Grassland might inhibit movement of animals dependent on moving from tree to tree. In extreme situations this could also inhibit plants adaptation responses to climate change. Plants and their associated pollinators need to migrate with a changing climate. For plants this is done mostly through seed/propagule dispersal, which for some species is over very limited distances. Although unlikely, it is feasible that altered vegetation could create a barrier that prevents this migration.

4.4.1 Mitigation

- Return the area to as near natural a state as possible, with natural processes such as fire being retained.

4.5 Impact 5. Soil disturbance leading to Invasive alien plants

Disturbed ground is often re-colonised by invasive species rather than the natural vegetation. This then changes the composition of the vegetation as well as acting as a conduit for alien species to invade into the surrounding habitat. Bush encroachment of indigenous species may also be enhanced by disturbance. For instance, many abandoned old fields become thickets of *Dichrostachys cinerea* (sekelbos), a species uncommon in good quality mature vegetation.

4.5.1 Mitigation

- Clear alien invasion over the lifespan of the project or until they show no signs of invading the area.
- Actively re-vegetate to the natural vegetation cover.
- Keep future disturbances to a minimum.

4.6 Impact 6. Soil erosion

Accelerated soil erosion is possible on the post construction, re-vegetated land. This is especially likely where the pipeline runs perpendicular to the contour lines, i.e. straight up or down a hill slope. A combination of slope, rainfall intensity and soil type leads to enhanced erosion, so it is difficult to specify at what gradient this will start to occur. Any gradient of more than 10 degrees should be treated with caution.

4.6.1 Mitigation

- Where possible avoid running the pipeline or access and maintenance roads up or down steep slopes. Where avoidance is not possible then ensure that water management and erosion control structures are in place.
- Establish dense cover vegetation as soon as possible after completion of the construction phase.
- Install appropriate soil conservation measures.
- Ensure appropriate water drainage.

4.7 Impact 7. Rupture of pipe

Rupture, puncturing of the pipe or other causes of gas leakage could result in gas pollution in the atmosphere, and in a worst case scenario, explosion. Gas leakage, especially if of short duration is unlikely to have major effects on flora, but could potentially be devastating for immobile fauna. An explosion (most likely linked to an existing fire event) could result in vegetation fire or the total destroying of vegetation and animals in the proximity of the explosion. Such events are, however, considered as extremely unlikely. Further, any repairs to the pipeline are likely to have a similar scale of impact to pipeline installation and should be treated in a similar manner from a mitigation perspective.

4.7.1 Mitigation

- Sensors for loss of pressure as well as automatic cut off valves are located at regular intervals. This greatly reduces the risks associated with leakage, and limits the extent of the leakage.
- If repair is required on the pipeline, the same environmental considerations as used in the construction apply.
- Prevention of potential causes of problems such as preventing deep-rooted plant species directly above the pipeline.

- Due consideration of possible impacts to the pipe infrastructure when routing the pipeline through vertisols (clays that extract and expand) or through peat (which can carry deep underground and very hot fire).

5 RISK ASSESSMENT

5.1 Consequence levels

Five consequence levels are proposed i.e. slight, moderate, substantive, severe, and extreme.

As a broad guideline, the following is proposed as definitions for the consequence categories:

- Extreme – Over 10% of a threatened habitat or Critically Endangered, Endangered or Vulnerable species are destroyed.
- Severe – Any area of a very highly sensitive environment or any individuals of Critically Endangered or Endangered species are destroyed without appropriate mitigation.
- Substantive - Any area of a highly sensitive environment is destroyed, or and Vulnerable species are destroyed without appropriate mitigation.
- Moderate - Any area of a moderate sensitive environment is destroyed without appropriate mitigation.
- Slight - Areas of habitats or species not mentioned above are destroyed.

5.2 Risk assessment results

The risk assessment considers impacts with and without mitigation actions (i.e. actions to mitigate negative impacts or enhance benefits) (Table 4). The management actions are described in Section 6.

5.3 Limits of Acceptable Change

What constitutes limits to acceptable change is highly subjective and as much driven by societal values as by ecological theory. Legislative requirements relate to species classified as Critically Endangered, Endangered, Vulnerable and Protected. Note that some provinces have their own lists of protected species, as does the Department of Agriculture, Forestry and Fisheries (as noted above). The individual provincial Critical Biodiversity Assessments should form the key basis for acceptable change. In this regard CBA1 and CBA2 areas should be avoided if at all possible. If these cannot be avoided, then full Biodiversity Impact Assessments should be undertaken and mitigation management guidelines followed.

Clearly there are a number of legislative requirements that relate to destruction of habitats and individual species (see legislative section).

Clearly the development should not lead to the destruction of individuals of any critically endangered species, and should have as its goal not to destroy any individuals of any endangered or vulnerable species.

Provincial CBA plans set out guidelines on what activities should be allowed/disallowed from CBAs. CBA1 areas according to their guidelines should not have any destructive activities.

Although destruction of individual plant and animal species is of concern, a far higher concern is that the development effects important ecological processes. Changes in hydrological flows, fire regime etc. could have wide and long term detrimental impacts that extend far beyond the actual footprint of the development.

Table 4: Risk assessment for the impacts of gas pipeline development (all Phases) to the biodiversity and ecology of the Grassland and Savanna biomes.

Impact	Location	Without mitigation			With mitigation		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Physical disruption of the land surface as a result of vegetation clearance and development infrastructure	Very high sensitivity area	Severe	Very likely	High negative	Substantial	Very likely	Moderate negative
	High sensitivity area	Substantial	Very likely	Moderate negative	Moderate	Very likely	Low negative
	Medium sensitivity area	Moderate	Very likely	Low negative	Slight	Very likely	Very low negative
	Low sensitivity area	Slight	Very likely	Very low negative	Slight	Very likely	Very low negative
Prevention of animal movement during the construction phase and loss of foraging habitat	Very high sensitivity area	Severe	Likely	High negative	Substantial	Likely	Moderate negative
	High sensitivity area	Substantial	Likely	Moderate negative	Substantial	Likely	Moderate negative
	Medium sensitivity area	Moderate	Likely	Low negative	Moderate	Likely	Low negative
	Low sensitivity area	Slight	Likely	Very low negative	Slight	Likely	Very low negative
Death or harm to animals or loss of breeding habitat	Very high sensitivity area	Severe	Likely	High negative	Substantial	Not likely	Moderate negative
	High sensitivity area	Substantial	Likely	Moderate negative	Substantial	Non likely	Moderate negative
	Medium sensitivity area	Moderate	Likely	Low negative	Moderate	Not likely	Low negative
	Low sensitivity area	Slight	Likely	Very low negative	Slight	Not likely	Very low negative
Limiting animal (and plant) movement in the post construction phase.	Very high sensitivity area	Severe	Very unlikely	Low negative	Substantial	Extremely unlikely	Very low negative
	High sensitivity area	Substantial	Very unlikely	Low negative	Substantial	Extremely unlikely	Very low negative
	Medium sensitivity area	Moderate	Very unlikely	Low negative	Moderate	Extremely unlikely	Very low negative
	Low sensitivity area	Slight	Very unlikely	Very low negative	Slight	Extremely unlikely	Very low negative
Soil disturbance leading to Invasive alien plants	Very high sensitivity area	Severe	Very likely	High negative	Moderate	Likely	Low negative
	High sensitivity area	Substantial	Very likely	Moderate negative	Moderate	Likely	Low negative
	Medium sensitivity area	Moderate	Very likely	Low negative	Slight	Likely	Very low negative
	Low sensitivity area	Moderate	Very likely	Low negative	Slight	Likely	Very low negative
Soil erosion	Very high sensitivity area	Substantial	Very likely	Moderate negative	Substantial	Not likely	Moderate negative
	High sensitivity area	Moderate	Very likely	Low negative	Moderate	Not likely	Low negative
	Medium sensitivity area	Moderate	Very likely	Low negative	Moderate	Not likely	Low negative
	Low sensitivity area	Slight	Very likely	Very low negative	Slight	Not likely	Very low negative

Impact	Location	Without mitigation			With mitigation		
Leakage, rupture and explosion	Very high sensitivity area	Severe	Very unlikely	Low negative	Severe	Very unlikely	Low negative
	High sensitivity area	Severe	Very unlikely	Low negative	Severe	Very unlikely	Low negative
	Medium sensitivity area	Slight	Very unlikely	Very low negative	Slight	Very unlikely	Very low negative
	Low sensitivity area	Slight	Very unlikely	Very low negative	Slight	Very unlikely	Very low negative

6 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

This section provides "best practice" (or "good practice") guidelines and management actions (including relevant standards) that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: During planning, construction, operations, rehabilitation.

Recommendations are based on Richardson et al. (2017).

6.1 Planning phase

- Consider where high biodiversity areas can be avoided
- Consider where threatened species can be avoided
- Consider seasonal timing
- Consider the workflow so that any area is only disrupted for a short period of time
- Align and design the route such that hillslope hydrology and soil erosion impacts are minimised

6.2 Construction phase

- Scan the proposed corridor for rare and threatened species. Obtain the appropriate permits. If they cannot be avoided, then either re-locate them or remove them for replanting (where possible)
- Carefully retain topsoil
- If possible, cut trees in the construction zone in a way that will allow them to re-sprout, provided that they do not impact on the pipeline during the operational phase in relation to deep roots within the pipeline servitude. Minimise the construction period at any site
- Conduct daily patrols to rescue any animals trapped in the trench
- Replace soils in the reverse order
- Replace topsoil
- Undertake rehabilitation activities.
- Train the construction workers and inspectors with regards to their responsibilities regarding biodiversity and ecological impacts, and monitor, reward or penalise their actions.

6.3 Operations phase

- Ensure revegetation is occurring to plan
- Control alien invasive plants (this will be a yearly or more frequent activity that needs to be maintained until there is no further infestation)
- Ensure sound soil and water management to prevent erosion
- Repair erosion when identified
- If unintended subsurface drainage (e.g. desiccation of wetlands or creation of new wetlands), piping or erosion around the former trench is identified, take remedial action such as excavation drains or installing plugs

6.4 Rehabilitation and post closure

- It is assumed that closure leaves the pipeline in the ground and as such few or any impacts are anticipated. If the pipeline were to be removed, then the impacts would be equivalent to the initial installation phase.

6.5 Monitoring requirements

- Monitoring should be conducted twice yearly in late spring and autumn for the first 2 years, then yearly in summer until natural vegetation cover is fully re-established, no erosion is being observed and there has been a 2 year period of no new alien invasion
- Monitor vegetation re-establishment to ensure that there is a succession to the natural vegetation cover.
- Monitor the structure of the rehabilitated vegetation.
- Monitor for erosion and changes in wetland areas.
- Monitor the species composition.
- Monitor for alien infestation
- Monitoring of poaching/livestock theft/illegal plant collection along the line of the pipeline, especially where it passes through private or public protected areas, especially during construction, but also during operation.

7 GAPS IN KNOWLEDGE

Location of specific sites with rare and threatened species is based on relatively crude assessments that are not of sufficient detail for detailed route planning and would require onsite inspections. In many cases the location of rare and threatened species is recorded at the level of a ¼ degree square (1:50 000 map sheet). In many cases the species is likely to occur only within specific habitat types within this broad location and specialist input will be required. Development of habitat specific location maps could increase the usability of this data in the future.

Core to this assessment is the use of the provincial biodiversity plans. This assessment is therefore subject to all the gaps in knowledge that underpinned the provincial plans.

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APPENDIX A: Trees protected through the National Forestry Act (Act 84 of 1998) and the phases in which they are likely to be encountered. Some of the species are limited to riverine or forest habitats and not strictly Savanna or Grassland species (Government Gazette 37941, 29 August 2014). Species marked n/a are unlikely to be found growing naturally in the grassland or savanna pipeline areas. No protected trees are anticipated in the small patches of grassland in the inland corridor and Phase 2.

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	GAS PIPELINE PHASES WHERE SPECIES MAY OCCUR
Acacia erioloba	Camel thorn	Kameeldoring	168	n/a
Acacia haematoxylon	Grey camel thorn	Vaalkameeldoring, Mokholo	169	n/a
Adansonia digitata	Baobab	Kremetart, Seboi, Mowana	467	n/a
Afzelia quanzensis	Pod mahogany	Peulmahonie, Inkehli	207	3, 4, 7, 8
Balanites subsp. maughamii	Torchwood	Groendoring, Ugobandlovu	251	3, 4, 8
Barringtonia racemosa	Powder-puff tree	Poeierkwasboom, Iboqo	524	3, 4
Boscia albitrunca	Shepherd's tree	Witgat, Umvithi	122	3, 4, 7, 8
Brachystegia spiciformis	Msasa	Msasa	198.1	n/a
Breonadia salicina	Matumi	Mingerhout, Umfomfo	684	3, 4, 8
Bruguiera gymnorrhize	Black mangrove	Swartwortelboom, IsiHlobane	527	n/a
Cassipourea swaziensis	Swazi onionwood	Swazi uiehout	531.1	3, 4
Catha edulis	Bushman's tea	Boesmanstee, Umhlwazi	404	3, 4, 7 ,8
Ceriops tagal	Indian mangrove	Indiese wortelboom, Isinkahe	525	n/a
Cleistanthus schlechteri	False tamboti	Bastertamboti, Umzithi	320	3, 4, 8
Colubrine nicholsonii	Pondo weeping thorn	Pondo-treurdoring	453.8	7
Combretum imberbe	Leadwood	Hardekiil, Impondondlovu	539	8
Curtisia dentata	Assegai	Assegaai, Umagunda	570	3, 7, 8
Elaeodendron transvaalensis	Bushveld saffron	Bosveld-saffraan, Ingwavuma	416	3, 4, 8

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	GAS PIPELINE PHASES WHERE SPECIES MAY OCCUR
Erythrophysa transvaalensis	Bushveld red balloon	Bosveld-rooiklapperbos	436.2	8
Euclea pseudebenus	Ebony guarri	Ebbeboom-ghwarrie	598	n/a
Ficus trichopoda	Swamp fig	Moerasvy, Umvubu	54	4
Leucadendron argenteum	Silver tree,	Silwerboom	77	n/a
Lumnitzera racemosa	Tonga mangrove	Tonga-wortelboom, isiKhahaesibomvu	552	n/a
Lydenburgia abbottii	Pondo bushman's tea	Pondo-boesmanstee	407	7
Lydenburgia cassinoides	Sekhukhuni bushman's tea	Sekhukhuni-boesmanstee	406	n/a
Mimusops caffra	Coastal red milkwood	Kusrooimelkhout, Umkhakhayi	583	3, 4, 7
Newtonia hildebrandtii	Lebombo wattle	Lebombo-wattel, Umfomothi	191	3, 4, 7, 8
Ocotea bullata	Stinkwood	Stinkhout, Umnukane	118	3, 4, 7, 8
Ozoroa namaquensis	Gariep resin tree	Gariep-harpuisboom	373.2	n/a
Philenoptera violacea	Apple-leaf	Appelblaar, isiHomohomo	238	3, 4, 8
Pittosporum viridiflorum	Cheesewood	Kasuur, Umfusamvu	139	3, 4, 7, 8
Podocarpus elongatus	Breede river yellowwood	Breeriviergeelhout	15	n/a
Podocarpus falcatus (Afrocarpus falcatus)	Outeniqua yellowwood	Outeniquageelhout, Umsonti	16	3, 4, 7, 8
Podocarpus henkelii	Henkel's yellowwood	Henkel se geelhout, Umsonti	17	3, 7
Podocarpus latifolius	Real yellowwood	Regte-geelhout, Umkhoba	18	3., 4, 7, 8
Prota comptonii	Saddleback sugarbush	Barberton-suikerbos	88	8
Protea curvata	Serpentine sugarbush	Serpentynsuikerbos	88.1	n/a
Prunus africana	Red stinkwood	Rooistinkhout, Umdumezuz	147	3, 4, 7, 8
Pterocarpus	Wild teak	Kiaat, Umvangazi	236	8

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	GAS PIPELINE PHASES WHERE SPECIES MAY OCCUR
angolensis				
Rhizophora mucronata	Red mangrove	Rooiwortelboom	526	n/a
Sclerocarya birrea subsp. caffra	Marula	Maroela, Umganu	360	3, 4, 8
Securidaca longepedunculata	Violet tree	Krinkhout, Mmaba	303	8
Sideroxylon inerme subsp. inerme	White milkwood	Witmelkhout, Umakhwelafingqane	579	3, 4, 7, 8
Tephrosia pondoensis	Pondo poison pea	Pondo-gifertjie	226.1	n/a
Warburgia salutaris	Pepper-bark tree	Peperbasboom, isiBaha	488	3, 4, 8
Widdringtonia cedarbergensis	Clanwilliam cedar	Clanwilliamseder	19	n/a
Widdringtonia schwarzii	Willowmore cedar	Baviaanskloofseder	21	n/a

APPENDIX B: Savanna and Grassland Endangered and Vulnerable mammals that are likely to be encountered in the different phases (species that may occur in the tiny patch of grassland in the inland corridor and Phase 2 were not included).

ORDER	FAMILY	BOTANICAL NAME	ENGLISH COMMON NAMES	GAS PIPELINE PHASES WHERE THE SPECIES IS LIKELY TO OCCUR
Endangered				
Afrosoricida	Chrysochloridae	*Amblysomus marleyi*	Marley's Golden Mole	Grassland Phase 4
Afrosoricida	Chrysochloridae	*Chrysospalax trevelyani*	Giant Golden Mole	Forest Patches Phase 7
Afrosoricida	Chrysochloridae	*Neamblysomus julianae*	Juliana's Golden Mole	Phase 8 Savanna/Grassland
Artiodactyla	Bovidae	*Hippotragus equinus*	Roan Antelope	Grassland / Savanna Phase 3
Artiodactyla	Bovidae	*Nesotragus moschatus zuluensis*	Suni	Savanna Phase 4
Artiodactyla	Bovidae	*Ourebia ourebi ourebi*	Oribi	Grassland Phase 3, 7, 8
Artiodactyla	Bovidae	*Redunca fulvorufula fulvorufula*	Mountain Reedbuck	Grassland Phase 3, 4, 7, 8
Carnivora	Canidae	*Lycaon pictus*	African Wild Dog	Savanna Phase 3, 4, 8
Hyracoidea	Procaviidae	*Dendrohyrax arboreus*	Tree Hyrax	Savanna Phase 7
Perissodactyla	Rhinocerotidae	*Diceros bicornis minor*	Southern-central Black Rhinoceros	Savanna Phase 3, 4, 7, 8
Vulnerable				
Afrosoricida	Chrysochloridae	*Chrysospalax villosus*	Rough-haired Golden Mole	Grassland Phase 3, 7, 8
Artiodactyla	Bovidae	*Damaliscus lunatus lunatus*	Tsessebe	Savanna Phase 4, 7, 8
Artiodactyla	Bovidae	*Hippotragus niger niger*	Sable Antelope	Savanna Phase 8
Artiodactyla	Bovidae	*Philantomba monticola*	Blue Duiker	Savanna Phase 3, 4, 7
Carnivora	Felidae	*Acinonyx jubatus*	Cheetah	Savanna 3, 7, 8
Carnivora	Felidae	*Felis nigripes*	Black-footed Cat	Grassland Savanna Phase 3, 8
Carnivora	Felidae	*Panthera pardus*	Leopard	Grassland Savanna 3, 4, 7, 8
Perissodactyla	Equidae	*Equus zebra hartmannae*	Hartmann's Mountain Zebra	Grassland Phase 7
Pholidota	Manidae	*Smutsia temminckii*	Temminck's Ground Pangolin	Savanna 3, 4, 8
Primates	Cercopithecidae	*Cercopithecus albogularis labiatus*	Samango Monkey	Savanna 3, 4, 7, 8
Rodentia	Nesomyidae	*Mystromys albicaudatus*	White-tailed Rat	Grassland Phase 3, 7

APPENDIX C: Grassland Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) plant species likely to be found in the Grassland and forest habitats in each phase. The hot links link to the SANBI red list of South African plants where details including likely location of each species are likely to be found. (Species that may occur in the tiny patch of grassland in the inland corridor and Phase 2 were not included).

GRASSLAND SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE THE SPECIES IS LIKELY TO BE FOUND
Acalypha entumenica Prain EN	3, 4
Alepidea cordifolia B.-E.van Wyk EN	3, 4, 8
Aloe chortolirioides A.Berger var. chortolirioides VU	8
Aloe condyae Van Jaarsv. & P.Nel VU	8
Aloe craibii Gideon F.Sm. CR	8
Aloe integra Reynolds VU	8
Aloe kniphofioides Baker VU	8
Aloe neilcrouchii R.R.Klopper & Gideon F.Sm. EN	7, 3
Aloe saundersiae (Reynolds) Reynolds CR	4, 3, 7
Argyrolobium longifolium (Meisn.) Walp. VU	3, 4, 7
Asclepias bicuspis N.E.Br. CR	7
Asclepias bicuspis N.E.Br. CR	7
Asclepias disparilis N.E.Br. EN	7
Asclepias dissona N.E.Br. CR PE	8
Asclepias gordon-grayae Nicholas EN	3, 4
Asclepias schlechteri (K.Schum.) N.E.Br. EN	7
Asclepias schlechteri (K.Schum.) N.E.Br. EN	7
Aspalathus abbottii C.H.Stirt. & Muasya VU	7
Aspalathus gerrardii Bolus VU	3, 4, 7
Aspidoglossum demissum Kupicha VU	3
Aspidoglossum demissum Kupicha VU	3
Brachystelma gerrardii Harv. EN	3, 4, 7
Brachystelma ngomense R.A.Dyer EN	3, 4
Brachystelma sandersonii (Oliv.) N.E.Br. VU	3, 4, 7
Brachystelma tenellum R.A.Dyer VU	7
Brachystelma vahrmeijeri R.A.Dyer EN	4
Brunia trigyna (Schltr.) Class.-Bockh. & E.G.H.Oliv. CR	7
Cephalaria foliosa Compton VU	3
Cineraria dryogeton Cron VU	7
Cyathocoma bachmannii (Kük.) C.Archer VU	4, 7
Dierama ambiguum Hilliard EN	7
Dierama dubium N.E.Br. VU	3, 4
Dierama luteoalbidum I.Verd. VU	7
Dierama pallidum Hilliard VU	7
Dierama pumilum N.E.Br. VU	7, 3
Dioscorea brownii Schinz EN	7
Disa amoena H.P.Linder VU	8
Disa clavicornis H.P.Linder EN	8
Disa clavicornis H.P.Linder EN	8
Disa vigilans McMurtry, T.J.Edwards & Bytebier EN	8
Encephalartos ghellinckii Lem. VU	7
Encephalartos heenanii R.A.Dyer CR	8
Encephalartos middelburgensis Vorster, Robbertse & S.van der Westh. CR	8

GRASSLAND SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE THE SPECIES IS LIKELY TO BE FOUND
Encephalartos msinganus Vorster CR	3
Eriosema latifolium (Benth. ex Harv.) C.H.Stirt. VU	7
Eriosema populifolium Benth. ex Harv. subsp. populifolium EN	7
Eriosema umtamvunense C.H.Stirt. EN	7
Eriosema umtamvunense C.H.Stirt. EN	7
Eriosemopsis subanisophylla Robyns VU	7
Euphorbia flanaganii N.E.Br. VU	7
Geranium natalense Hilliard & B.L.Burtt VU	7
Geranium sparsiflorum R.Knuth VU	7
Gerbera aurantiaca Sch.Bip. EN	3, 4, 7, 8
Gymnosporia woodii Szyszyl. EN	3, 4
Haworthiopsis limifolia (Marloth) G.D.Rowley VU	4, 8
Helichrysum citricephalum Hilliard & B.L.Burtt CR	7
Helichrysum ingomense Hilliard EN	4
Helichrysum montis-cati Hilliard VU	7
Helichrysum pannosum DC. EN	7
Helichrysum summo-montanum I.Verd. EN	8
Huttonaea woodii Schltr. VU	7
Kniphofia latifolia Codd EN	7
Kniphofia leucocephala Baijnath CR	3, 4
Ledebouria remifolia S.Venter VU	8
Macowania conferta (Benth.) E.Phillips VU	7
Macowania conferta (Benth.) E.Phillips VU	7
Moraea hiemalis Goldblatt VU	7
Nerine gibsonii Douglas VU	7
Nerine gracilis R.A.Dyer VU	8
Oxygonum dregeanum Meisn. subsp. *streyi* Germish. EN	3, 4, 7
Pachycarpus acidostelma M.Glen & Nicholas CR	7
Pachycarpus concolor E.Mey. subsp. *arenicola* Goyder VU	3, 4
Pachycarpus suaveolens (Schltr.) Nicholas & Goyder VU	8
Phylica simii Pillans VU	7
Plectranthus malvinus Van Jaarsv. & T.J.Edwards VU	7
Polygala praticola Chodat VU	3, 7
Psoralea abbottii C.H.Stirt. VU	7
Restio zuluensis H.P.Linder VU	3, 4
Riocreuxia flanaganii Schltr. var. alexandrina H.E.Huber CR	7
Riocreuxia woodii N.E.Br. CR PE	7
Schizoglossum ingomense N.E.Br. EN	3, 4
Schizoglossum peglerae N.E.Br. EN	7
Schizoglossum rubiginosum Hilliard VU	7
Searsia rudatisii (Engl.) Moffett EN	7
Selago zuluensis Hilliard EN	3, 4
Senecio dregeanus DC. VU	3, 4, 7
Senecio exuberans R.A.Dyer EN	7
Senecio ngoyanus Hilliard VU	3, 4
Senecio triodontiphyllus C.Jeffrey VU	8
Senecio villifructus Hilliard EN	4
Sisyranthus fanniniae N.E.Br. VU	7
Struthiola anomala Hilliard VU	7
Syncolostemon incanus (Codd) D.F.Otieno EN	8
Syncolostemon latidens (N.E.Br.) Codd VU	3, 4

GRASSLAND SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE THE SPECIES IS LIKELY TO BE FOUND
Tephrosia bachmannii Harms VU	7
Tephrosia inandensis H.M.L.Forbes EN	3, 4, 7
Tephrosia pondoensis (Codd) Schrire EN	7
Thesium polygaloides A.W.Hill VU	3, 4, 7
Turraea pulchella (Harms) T.D.Penn. VU	7
Turraea streyi F.White & Styles CR PE	7
Watsonia bachmannii L.Bolus VU	7
Watsonia pondoensis Goldblatt EN	7

APPENDIX D: Savanna Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) plant species likely to be found in the Savanna and forest habitats in each phase. The hot links link to the SANBI red list of South African plants where details including likely location of each species are likely to be found. (There is no savanna in the inland corridor and Phase 2).

SAVANNA SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE SPECIES IS LIKELY TO BE FOUND
Ledebouria ovatifolia (Baker) Jessop subsp. *scabrida* N.R.Crouch & T.J.Edwards VU	3
Plectranthus porcatus Van Jaarsv. & P.J.D.Winter VU	3
Encephalartos lebomboensis I.Verd. EN	4
Raphionacme elsana Venter & R.L.Verh. EN	4
Warneckea parvifolia R.D.Stone & Ntetha CR	4
Aloe pruinosa Reynolds VU	7
Tephrosia pondoensis (Codd) Schrire EN	7
Euphorbia gerstneriana Bruyns VU	3, 4, 7
Dioscorea sylvatica Eckl. VU	3, 4, 7, 8
Ceropegia cimiciodora Oberm. VU	4, 3

APPENDIX E: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened reptiles likely to be found in each proposed Gas Pipeline Phase.

REPTILES SCIENTIFIC NAME	IUCN STATUS	GAS PIPELINE PHASE WHERE SPECIES IS LIKELY TO BE FOUND
Acontias poecilus	Endangered	7
Bitis albanica	Critically Endangered	7
Bitis gabonica	Near Threatened	4
Bradypodion caeruleogula	Endangered	7
Bradypodion dracomontanum	Near Threatened	3
Bradypodion kentanicum	Vulnerable	7
Bradypodion melanocephalum	Vulnerable	7
Bradypodion nemorale	Near Threatened	7
Bradypodion ngomeense	Near Threatened	4
Bradypodion pumilum	Vulnerable	8
Bradypodion taeniabronchum	Endangered	7
Bradypodion thamnobates	Vulnerable	7
Caretta caretta	Vulnerable	4, 7
Chamaesaura aenea	Near Threatened	3, 7, 8
Chamaesaura macrolepis	Near Threatened	3, 4, 7, 8
Chelonia mydas	Near Threatened	7
Cordylus niger	Near Threatened	8
Crocodylus niloticus	Vulnerable	3, 4, 7, 8
Cryptoblepharus boutonii	Endangered	4
Dendroaspis angusticeps	Vulnerable	4, 7, 8
Dermochelys coriacea	Endangered	4, 7
Eretmochelys imbricata	Near Threatened	4
Homoroselaps dorsalis	Near Threatened	3, 4, 7, 8
Leptotyphlops sylvicolus	Data Deficient	7, 4
Leptotyphlops telloi	Near Threatened	4
Lycophidion pygmaeum	Near Threatened	4, 7
Macrelaps microlepidotus	Near Threatened	4, 7, 8
Nucras taeniolata	Near Threatened	7
Pelusios rhodesianus	Vulnerable	4, 7
Pseudocordylus spinosus	Near Threatened	7
Scelotes bourquini	Vulnerable	7
Scelotes gronovii	Near Threatened	8
Scelotes inornatus	Critically Endangered	7
Smaug giganteus	Vulnerable	3
Tetradactylus breyeri	Vulnerable	3, 7, 8

APPENDIX F: Peer Review and Specialist Response Sheet

Peer Reviewer: Professor Bob Scholes; University of the Witwatersrand Johannesburg

EXPERT REVIEW AND SPECIALIST RESPONSES: Savanna and Grassland Biomes - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
RJ Scholes	4	3		See my comments on the electricity grid assessment report with respect to this rather bald statement. It needs a bit more explanation, detail and action to be useful. Comment on EGI Report: Endemism is a well-defined technical term, but in a summary statement it is better to spell it out 'South African grasslands have a large number of species which occur nowhere else in the world.	Modified as suggested
RJ Scholes	4	19		Not 'likely'. It is an inevitable consequence of the operating rules that no tree will be permitted within 10 m either side.	Reworded to make it explicit that tree establishment of large trees will not be allowed within the registered servitude.
RJ Scholes	4	27		Remaining', not 'Reaming'	An autocorrect error, now corrected
RJ Scholes	5	4		And substantial disruption of soil and drainage to a depth of approximately 2 m and width of 1.5 m, some effects of which, despite restoration, persist for centuries.	Added
RJ Scholes	6	6		You use preserved here, conserved a line later. They are not synonyms.	Changed
RJ Scholes	7	2		Mucina, not Musina	Changed
RJ Scholes	8	5		ISII? Do you mean small?	Thanks - a type error
RJ Scholes	9	52		See my comments or the Grid assessment. Which much less critical for a pipeline, you cannot simply dismiss the visual/sense of place issue so lightly here, by saying they are dealt with elsewhere. Their importance is precisely because of the biodiversity connection, so you need to flag that here quite explicitly.	Agreed and strengthened
RJ Scholes	10	5		Similar issue: You cannot meaningfully separate the wetlands from their landscape. Doing so plays directly into the problem of a reductionist, fragmented, discipline based assessment, instead of a systemic one. You need to point out the CONNECTIONS. These are much more important here even than in the electricity pylon case, because blasting a deep trench, even if later filled in, will alter the subsoil hydrology in a way which can affect the relationship of the wetland to the savanna or grassland which supplies it.	Agreed and strengthened. Note from CSIR Project Team Integrating Author: The integrated chapter highlights connections between the various terrestrial and aquatic ecosystems and features assessed, and the importance of these connections.

EXPERT REVIEW AND SPECIALIST RESPONSES: Savanna and Grassland Biomes - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
RJ Scholes	10	9		There is an implicit buffering in the operating rule that no 'deep-rooted' plant (i.e. tree, I think they mean, quite without evidence) is allowed within 10 m. Does this rule make any sense? If so, given what we know about savanna tree rooting, is 10 m enough? If there is no evidence supporting it, why have it at all - allowing trees to regrow would greatly reduce both the functional and visual impact. And you DO use a buffer in figure 10. On what basis did you decide it? Does it make sense, given what we know about the species distributions?	This was given to us under their specifications Note from CSIR Project Team: The pipeline will be about 1-2 m below ground. iGas has mentioned that deep rooted vegetation would impact the structure of the pipeline, hence they will be removed from the 10 m servitude as per the recommendations provided in the EMPr.
RJ Scholes	12		1	Phase 7. This corridor would be a barrier to any migration??? I don't think you meant that. It is actually quite hard to see how a buried pipeline constitutes a barrier at all	Removed
RJ Scholes	15	5		What a miss is a statement about how these sensitivity surfaces overlaid. Such a procedure needed to have a shared logic with other studies. Is it a summation rule, a multiplicative rule, or a max rule? In other words, if there are two or more constrains, do they simply accumulate, or do they interact, or does a given level of one (e.g. very high) set the overall score?	Added - these maps do not attempt to order sensitivity
RJ Scholes	33	3		This discussion misses the critical difference between a powerline and a pipeline, which is that the latter is buried. This means that there is disruption not only of the surface, but right through the soil profile. Since many of these soils are only 0.5 m thick, and the majority of cases, it will require blasting into the underlying rock. Even if you carefully repack the soil, the shattered channel will persist, essentially for ever. What impact will this have on hillside subsurface flow? How can this be mitigated?	This has been added
RJ Scholes	35	5		In practice this is not operational. Would you in fact change the alignment to avoid a burrow or roost? How far would you need to avoid it by? Really the only way to do this would be to realign at a much higher scale, to avoid whole colonies.	Modified to give additional mitigation options
RJ Scholes	35	11		...and within a month of excavation. This not only limits changes in the soil, but ensures that the exposed area of trench, a potential trap for animals, is minimised.	Added
RJ Scholes	35	12		...avoiding burying rare and endangered species under the temporary soil dumps	Added
RJ Scholes	35	22		Need to add a point relating to slope drainage: where there is a potential to create an erosion feature, or to channel subsurface water in an undesirable way drainage points need to be engineered into the	Added both descriptive text on the impact as well as mitigation measures.

EXPERT REVIEW AND SPECIALIST RESPONSES: Savanna and Grassland Biomes - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	Page Range	Line/s	Table/ Figure	Expert Reviewer Comments	Response from Specialist
				design (rather like mitre drains are engineered into roads) to harmlessly redirect flow. On this point, many of these routes (especially through KZN and the EC) cut across unstable, erosion prone sodic soils. A preferential channel will quickly lead to a deep donga, endangering the stability of the pipeline and causing sedimentation problems. This will need specialised engineering. Others will cut across vertic soils. What is needed there?	
RJ Scholes	35	32		The biggest impact will come from having up to 500 construction workers milling around, setting snares, providing poaching intelligence, collecting plants for traditional medicine, lighting fires…so training and key performance indicators are critical.	Strengthened to include more on this impact
RJ Scholes	36	31		There seems to be no evaluation of what would happen in the event of an unplanned disaster: a landslide/earthquake/flood; or a pipe rupture, or a deliberate act of sabotage. What would the biodiversity impacts be? How could they be mitigated, during the event and in the emergency clean-up?	Added
RJ Scholes	37	24		Is the same criterion used in other specialist studies? Why 50%? Surely any reduction which would result in less than viable population would meet the criterion? The threatened species algorithm often assumes a 10% reduction.	Changed to 10%
RJ Scholes	40	15		Align and design the route such that hillslope hydrology and soil erosion impacts are minimised	Added
RJ Scholes	40	28		Train the construction workers and inspectors with regards to their responsibilities regarding biodiversity and ecological impacts, and monitor, reward or punish their actions.	Added
RJ Scholes	40	35		Identify unintended subsurface drainage outcomes (such as the desiccation of former wetlands, or the creation of new ones, or the appearance of piping erosion around the former trench, and take remedial action by excavating drains or putting in plugs.	Added to monitoring and operational phase
RJ Scholes	40	50		There should be spatial and temporal monitoring of poaching/livestock theft/illegal plant collection along the line of the pipeline, especially where it passes through private or public protected areas, especially during construction, but also during operation.	Added as suggested

Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa

Appendix C.1.3

Biodiversity and Ecological Impacts
(Terrestrial Ecosystems and Species) - Indian Ocean Coastal Belt Biome

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

INDIAN OCEAN COASTAL BELT BIOME

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ABBREVIATIONS AND ACRONYMS

AIP	Alien Invasive Plant
ASL	above sea level
CB 1	Maputaland Coastal Belt
CB 2	Maputaland Wooded Grassland
CB 3	Kwazulu-Natal Coastal Belt
CB 4	Pondoland-Ugu Sandstone Coastal Sourveld
CB 5	Transkei Coastal Belt
CBA	Critical Biodiversity Area
CR PE	Critically Endangered Possibly Extinct
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
ECBCP	Eastern Cape Biodiversity Conservation Plan
EKZNW	Ezemvelo KZN Wildlife
EN	Endangered
ESA	Ecological Support Area
GIS	Geographic Information System
IOCB	Indian Ocean Coastal Belt Biome
KZN	KwaZulu-Natal
NLC	National Land Cover
NPAES	National Protected Area Expansion Strategy
PCE	Pondoland Centre of Endemism
SANBI	South African National Biodiversity Institute
SAPAD	South African Protected Areas Database
SEA	Strategic Environmental Assessment
VU	Vulnerable

1 SUMMARY

This assessment aims to identify the potential impacts of constructing and maintaining gas transmission pipeline infrastructure (i.e. the gas transmission pipeline and associated infrastructure, such as, but not limited to, block valves, pigging stations and access roads as described in the Project Description Chapter of this SEA Report (i.e. Part 2)) in the Indian Ocean Coastal Belt Biome (IOCB) of South Africa.

This Biome comprises five dominant and six associated azonal and intrazonal vegetation units, some of which are important from ecological and conservation perspectives. Clusters and potential hotspots of threatened plant species appear to be concentrated in or around formally protected areas. The IOCB is characterised by diverse ranges of habitat and a concomitantly diverse faunal assemblage due to the Biome's location in a climatic niche in a topographically diverse environment with a relatively recent history of human settlement.

The purpose of this assessment was to review available GIS data relevant to the IOCB and terrestrial ecology and assign a sensitivity rating to the feature layers, which could then be used to inform a more detailed gas pipeline servitude. The IOCB covers only a small portion of the eastern corridors (Phases 4 and 7), but is diverse in terms of habitat and land use. The study area stretched between the Mozambique border to the Kei River Mouth in the Eastern Cape.

The activities associated with gas pipeline construction and maintenance may pose a risk of disturbance and transformation of natural vegetation; disturbance of fauna; and constraining existing and earmarked conservation initiatives and connection of protected areas. With regards to the latter impact, for example, the Opathe – Imfolozi corridor is a long term initiative to link these two reserves for the benefit of land conservation and migration of larger fauna. If a pipeline route is to be located within or close to the Opathe – Imfolozi corridor, the requirement to maintain the pipeline servitude will create additional disturbances and constraints that may hinder the management of the protected area. A further example specific to the IOCB is the potential for a linkage between the Nseleni Nature Reserve and the New Mouth area near Richards Bay.

The IOCB has extensively been transformed by agriculture, forestry plantations and urban development. Any proposed gas pipeline routes should be planned and placed to align with existing transformed areas as close as possible.

2 INTRODUCTION

The proposed establishment of a gas transmission pipeline corridor that will, in part, traverse portions of the eastern extent of South Africa holds the potential to affect a number of habitats that lie within this region. More specifically the Indian Ocean Coastal Belt (IOCB) is the dominant biome on the east coast of KwaZulu-Natal (KZN) and comprises of a number of vegetation units or veld types, some of which are important from ecological and conservation perspectives. The establishment of a sub-surface structure such as a gas pipeline will potentially, by its very nature, irreversibly affect some of the vegetation units within the IOCB. As such, consideration should be given to the alignment and routing of such pipelines to avoid the most important habitats within the IOCB.

This report forms one of a number of environmental investigations that have been undertaken to evaluate and provide recommendations on the alignment of the proposed Phased Gas Pipeline corridors, and focusses specifically on the IOCB, with some consideration being given to azonal- and intrazonal habitats that may be located within or adjacent to the IOCB.

3 SCOPE OF THIS STRATEGIC ISSUE

The IOCB is a biome driven primarily by its proximity to the shoreline, the ameliorating effects of the coastal climate, and prevailing geophysics of the south eastern coastline of South Africa (Figure 1). The IOCB is one of approximately 9 recognized biomes that have been categorised for the country, based on plant associations and affiliations with climatic and other variables (Box, 1981; Mucina & Rutherford, 2006). The IOCB comprises only 1.1% of the land area of South Africa, extending between Mozambique to a point just north of East London (Eastern Cape), with a maximum inland extent approximating 50 kilometres in the north of KwaZulu-Natal. The scope of this assessment includes the extent of the IOCB as described in the two relevant proposed Phased Gas Pipeline corridors: Phase 4 and Phase 7 (Figure 1).

This strategic environmental assessment of the proposed Phased Gas Pipeline corridors through the IOCB has been compiled to provide a high level approach to the evaluation of the proposed gas pipeline corridors and the potential influence and effect that the construction and maintenance of the gas transmission pipeline and associated infrastructure will have on the various IOCB vegetation units and associated fauna. This study includes an assessment of gas transmission pipelines, servitudes, block valves, pigging stations and access roads as described in the Project Description Chapter of this SEA Report (Part 2 of the Gas Pipeline SEA Report).

This assessment provides guidance from a broad, eco-morphological perspective that can support decision making on and planning for the establishment of the proposed Phased Gas pipeline corridors and associated infrastructure within the extent of the IOCB. Furthermore, an overview of opportunities to avoid impacts or apply alternative mitigation measures is provided, while also offering opportunities to ameliorate technical issues that may arise in the establishment of such infrastructure.

The assessment therefore evaluates a number of available spatial data sets relevant to the IOCB and assigns specific sensitivity ratings to relevant layers and features. Through this analysis, recommendations can be made regarding the potential routing of the proposed gas pipeline within the identified corridors. Relevant data includes readily available Geographic Information System (GIS) data sets provided by the South African National Biodiversity Institute (SANBI), the Council for Scientific and Industrial Research (CSIR), as well as relevant Provincial Nature Conservation Authorities and National Departments. Since this particular study is a broad scale ecological study, datasets highlighting areas of ecological importance and relevant land uses were prioritised. The key focus was the terrestrial environment within the IOCB. Wetlands, watercourses, estuaries, bats and avifauna have been separately assessed in detail by relevant specialists (Appendices C.1.6, C.1.7, C.1.8 and C.1.9 of the Gas Pipeline SEA Report), although this study does touch on some of these aspects where pertinent to the IOCB.

The core area of this study is the eastern extent of two of the proposed Phased Gas pipeline corridors: Phases 4 and 7 between the Mozambique border and Kei River Mouth (Eastern Cape), extending from the coastline to approximately 30 - 50 km inland. As illustrated in Figure 1, the IOCB only comprises a narrow portion of each corridor, in the eastern extent. Although defined as a clear finite area for the purposes of this study, on the ground and in practical terms, the IOCB can be variable and merge with neighbouring biomes and vegetation types, sharing common characteristics, climatic features and biota.

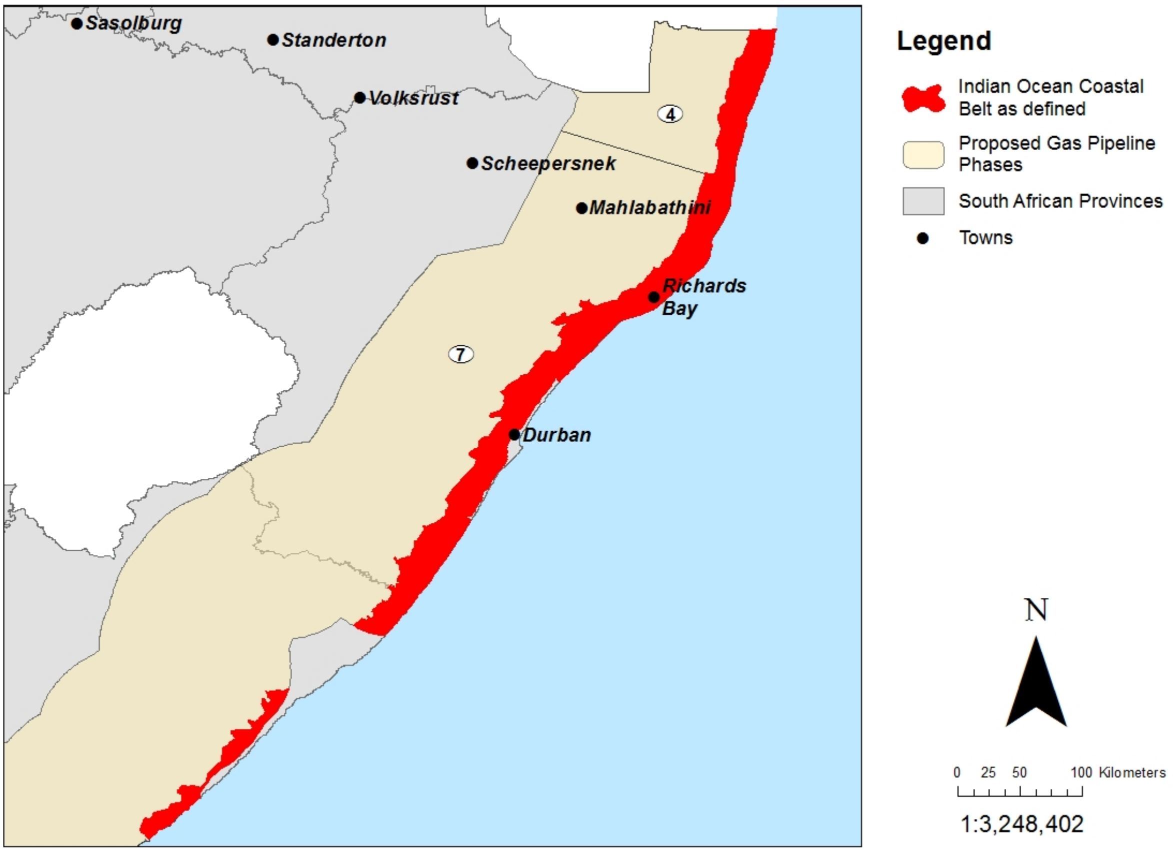

Figure 1: The extent of the IOCB Biome as defined, within the relevant proposed Phased Gas Pipeline Corridors.

3.1 Study Methodology

The assessment of the proposed Phased Gas Pipeline corridors and their relationship to the IOCB was undertaken using the following:

- GIS mapping tools, information and data;
- The review of current and available data and databases (Section 3.1.1. below);
- The analysis and handling of data to align with the IOCB region including the extraction of relevant layers,
- The review of draft environmental sensitivity ratings (provided by SANBI) in relation to the proposed gas pipeline corridors and amendment thereof.
- Designation of sensitivity ratings of new feature layers.

Using the above information specific consideration was given to the alignment of the Phased Gas Pipeline corridors and its intersections with the IOCB. The relevance and refinement of data was undertaken, based on recent aerial imagery (Arc GIS online, Google Earth circa 2015 to 2018) and specific historical imagery (based on 1937 historical imagery for specific areas including the greater Durban area and Isimangaliso Wetland Park). Specialist knowledge of the subject area and high level verification of areas was undertaken where data was deficient or required updating.

The information was then further interrogated against an understanding of the required activities associated with the establishment and maintenance of a gas transmission pipeline and the forecasting and projection of expected changes in the habitat or its drivers.

Note that this Specialist Assessment Report was peer reviewed prior to release to stakeholders for review. The report was updated, as required, following the peer review findings. A copy of the peer review report and responses from the Specialist Team is included in Appendix A of this report.

3.1.1 Data Sources

The data and literature sources presented in Table 1 were considered and assessed in this report.

Table 1: A summary of datasets reviewed and applicable to the IOCB

Data title	Source and date of publication	Data Description
Protected Areas	• National Department of Environmental Affairs (DEA) South African Protected Areas Database (SAPAD), 2017. • SANBI Protected Areas Database, 2011. • Ezemvelo KZN Wildlife Protected Areas, updated 2017 • Critical Biodiversity Areas (CBAs) and Statutory Reserves for the Eastern Cape, 2017	The DEA SAPAD was compared against the SANBI Protected Areas database, and discrepancies were resolved. This data was provided by the CSIR. Provincial data was added for KwaZulu-Natal and the Eastern Cape.
National Protected Area Expansion Strategy focus areas	• DEA Priority areas for protected area expansion, 2016	This data was provided by the CSIR and used without modification.
CBAs	• Ezemvelo KZN Wildlife CBA, 2016 • Eastern Cape Biodiversity Conservation Plan (ECBCP), 2017	A CBA layer was provided by the CSIR, which included national CBA data. This layer was given a default sensitivity rating of "Very High." The updated KZN CBA data was added separately and specific sensitivity ratings assigned to each CBA category within KZN. The draft ECBCP CBA data was assessed in a similar manner. The data was sorted according to CBA category and assigned a sensitivity according to the CBA category.
Private Nature Reserves, game farms and "stewardship areas"	• Ezemvelo KZN Wildlife Private Nature Reserves 2016 • Provincial Game Farm Data	The game reserve data was provided by the CSIR. Additional private nature reserves were added to include any areas not considered to be game farms.
Forest Nature Reserve	• National DEA SAPAD, 2017.	Provided by SANBI/DEA
Ramsar Sites	• National DEA SAPAD, 2017.	Provided by SANBI / DEA.
World Heritage Sites	• National DEA SAPAD, 2017.	Provided by SANBI / DEA.
Vegetation	• SANBI Vegetation Map, 2012. • Ezemvelo KZN Wildlife Vegetation Conservation Status, 2011	The thicket layer was obtained from the SANBI Vegetation Map while the vegetation type conservation status data was included. This data set provides the conservation status of the specific vegetation types within KZN based on various attributes, such as percentage statutorily conserved. This layer was used to derive the vegetation sensitivity ratings.
Landcover	• National Land Cover (NLC) 2013/2014 DEA, 2014 and Habitat Modification Layer SANBI, 2017 • Field Crop Boundaries, Department of Agriculture, Forestry and Fisheries, 2017	The modified and agricultural layers were retained and applied. These indicate the transformed areas that characterise much of the KZN coastal hinterland – sugar cane farms and plantations.
Ecoregion	• SANBI undated (based on Burgess 2004)	Basic ecoregion layer, applied unmodified.
National Forests	• National Forest Inventory, Department of Agriculture, Forestry and Fisheries, 2016.	The extent of the National Forests. This layer complements the vegetation layers above and due to their protected status allow for a higher sensitivity to be applied to relevant areas.

3.2 Assumptions and Limitations

3.2.1 Spatial data

Much of the spatial information utilised in this investigation was sourced from Provincial and National institutions. While the comments below may have to be verified by the institutions concerned, the following factors must be considered:

- As use has been made of primarily secondary data, the verification of accuracy cannot be provided by either the primary source nor the authors, although knowledge of the region has assisted in identifying anomalies;
  The data presented has been collected over an extended time period and has been subject to differing forms of manipulation and evaluation by the various compilers; and
- KZN's coastal environment, and therefore IOCB, is a rapidly growing economic region. The information presented may be subject to change over the short term.
- The IOCB can be considered to be a variable habitat complex and is often found to merge and overlap with neighbouring biomes and vegetation types, sharing common characteristics. On the ground, IOCB aligned habitat may at points be found to lie beyond the western extent indicated in the spatial mapping provided.
- A difference between the available data for KwaZulu-Natal and the Eastern Cape is evident. The inclusion of the Draft ECBCP (2017) provided additional data, comparable to the EKZN Wildlife CBA and improved the available data for interpretation for the Eastern Cape. These two data sets where however not directly comparable due to slight differences in assigned categories.
- Faunal records are limited to primarily, conservation areas and areas where monitoring is safe to undertake e.g. gated residential estates, protected areas.

3.2.2 Intrazonal vegetation

In addition to the above, "intrazonal" forest forms may be evident at points within the IOCB, more specifically Sand Forest (FOz8) and Northern Coastal Forest (FOz7). These forest types are not classified as being part of the IOCB but may be evident at points within the proposed Phased Gas pipeline corridors, particularly in the Maputaland region. The understanding is that the Forest Biomes will largely not be considered for the development of gas pipeline infrastructure and will, in general, be avoided. Consideration is given to them in the context of the IOCB, as discussed below.

3.2.3 Fauna data

Comment and integration with existing faunal population data has been presented in this report, however the integration of such data may be of limited value as such data is based on observation records, which may be over-represented at particular points, in particular protected areas. It is recommended that matters relating to fauna should be considered as an independent and site-specific aspect of the management of the construction and operations of the gas transmission pipeline (i.e. detailed faunal assessments should be conducted on a project specific basis, once a route has been determined). Fauna-related data, presented as point data at the spatial level of evaluation, may be over-represented in protected areas. Due to protected areas being mostly the focus of research and sampling efforts and are thus better represented in data, as such, data representing faunal populations outside of these areas can be expected to be less complete. Therefore, faunal data was not included in the sensitivity mapping, but as supplementary data for descriptive and illustrative purposes. Areas of importance mentioned above have been included / covered or considered by other data sets – Protected areas and KZN CBAs.

3.2.4 The IOCB and neighbouring Biomes

The IOCB makes up only a small portion of the corridors and its review and deduced conclusions must therefore be seen in context. Inconsistencies in interpretations and alignment with neighbouring biomes, vegetation and habitat specialists may arise.

3.2.5 Information deficiencies and spatial contradictions

Available data for the study area is well established and of reasonable accuracy (Jewitt et.al. 2015). The area is however, currently subject to relatively rapid land use changes associated primarily with continuous peri-urban expansion, outside of formal agricultural areas and urban centres. Anthropogenic influences and land use change in the region therefore renders older data a less reliable indicator of the present state. An attempt has thus been made to rationalise this transformation and limit contradiction through the incorporation of land use data and specialist knowledge to provide recommendations that may be more applicable to conditions on the ground.

3.3 Relevant Regulatory Instruments

Various legal instruments that serve to regulate activities within portions of the IOCB and include international, national and provincial, as well as municipal laws and regulations are presented in Table 2.

Table 2: Relevant legislation and regulatory instruments applicable to the IOCB

Instrument	Key objective
International Instrument	
Ramsar Convention (The Convention of Wetlands of International Importance (1971 and amendments)	Protection and conservation of wetlands, particularly those of importance to waterfowl and waterfowl habitat.
Convention concerning the Protection of the World Cultural and Natural Heritage, adopted by UNESCO in 1972 (World Heritage Convention)	Preservation and protection of cultural and natural heritage throughout the world.
National Instrument	
National Environmental Management: Protected Areas Act, (Act Number 57 of 2003)	No development, construction or farming may be permitted in a nature reserve without the prior written approval of the management authority (Section 50 (5)). Also in a 'protected environment' the Minister or MEC may restrict or regulate development that may be inappropriate for the area given the purpose for which the area was declared (Section 5).
National Environmental Management Act (Act Number 107 of 1998), as amended	Restrict and control development and potential harmful activities through the Environmental Impact Assessment (EIA) regulations and the undertaking of relevant assessments prior to commencement of listed activities (Section 24 (5) and 44). Imposes "duty of care" (Section 28) which means that all persons undertaking any activity that may potentially harm the environment must undertake measures to prevent pollution and environmental degradation.
National Water Act (Act Number 36 of 1998)	Restriction of water use activities (Section 21) and disturbance of water resources (wetlands, rivers and ground water).
National Environmental Management: Integrated Coastal Management Act (Act Number 24 of 2008)	To determine the coastal zone of South Africa and to preserve and protect coastal public property. To control use of coastal property (Section 62, 63 and 65) and limitation of marine pollution (Chapter 8).
National Forest Act (Act Number 84 of 1998)	Protection of natural forests and indigenous trees species through gazetted lists of Natural Forests and Protected Trees (Sections 7 (2) and 15 (3) respectively). Disturbance of areas constituting natural forest or the disturbance of a protected tree species requires authorisation from the relevant authority.
National Environmental Management: Biodiversity Act (Act Number 10 of 2004)	Protection of national biodiversity through the regulation of activities that may affect biodiversity including habitat disturbance, culture of and trade in organisms, both exotic and indigenous. Lists of alien invasive organisms, threatened and protected species and threatened ecosystems published and maintained (Sections 97 (1), 56 (1) and 52 (1)(a) respectively).
Provincial Instrument	
Natal Nature Conservation Ordinance No. 15 of 1974 and KwaZulu-Natal Nature Conservation Management Act, (Act 9 of 1997)	According to the Natal Nature Conservation Ordinance No. 15 of 1974 and the KwaZulu-Natal Nature Conservation Management Act, 1992 (Act 9 of 1997), no person shall, among others: damage, destroy, or relocate any specially protected indigenous plant, except under the authority and in accordance with a permit from Ezemvelo KZN Wildlife (EKZNW). A list of

Instrument	Key objective
	protected species has been published in terms of both acts.
Transkei Environmental Conservation Decree (9 of 1992), Ciskei Nature Conservation Act 1987 and Cape Nature and Environmental Conservation Ordinance (19 of 1974)	Three similar items of legislation promulgated for the former Transkei, Ciskei and the Cape Province. All three remain active in the Eastern Cape, within their relevant geographic area. All provide lists of indigenous fauna and flora and outline various management measures such as hunting seasons, bag limits and other recreational activities. Allowances are made for the proclamation of nature reserves and the general protection of the environment.
Municipal Bylaws	Numerous municipalities have promulgated bylaws that relate to conservation of the environment and these may include the application of land uses through the town planning scheme. e.g. eThekwini Municipality's Open Space System as well as the iLembe and uMhlathuze Municipal bylaws. These will need to be considered in more detail during the detailed planning and project specific Environmental Authorisation phases.

4 IMPACT CHARACTERISATION

In order to understand the potential impacts and identify sensitive features that may be affected by the construction and maintenance of the proposed gas pipeline, it is important to consider and characterise the nature and extent of impacts associated with gas pipeline development on relevant features. The following impacts have been identified and are discussed:

4.1 Disturbance and transformation of natural vegetation

A sub-surface pipeline may traverse an extended linear extent of hundreds of kilometres, however, its width is generally constrained to a few metres. In addition, once established, with the exception of some occasional aboveground infrastructure, pipelines are generally hidden from view. Figure 2 below, indicates an image of a gas pipeline that lies proximal to the Hluhluwe-Umfolozi Game Reserve (outside of the IOCB, but relevant for illustration purposes). In this particular portion of pipeline, the route is managed in a manner that seeks to maintain the area in an early seral state (e.g. grass or small shrubs are tolerated but larger trees are removed).

It follows that the impact of the gas pipeline can thus be an enduring feature although the structure itself may be hidden from view.

As a consequence of the excavation for the pipeline, deep excavations below the upper soil horizons are disturbed. Such disturbance may be of little influence on the prevailing habitat where soil horizons and edaphic factors are not a significant driver of habitat form. However in other habitats where edaphic drivers are primary drivers within the ecosystem, such disturbance serves to alter both habitat form and structure. For example, grassland habitats are particularly vulnerable, where soil structure (in addition to factors such as fire and grazing) determines the nature of these graminoid dominated habitats. A change in any one of these factors serves to change the nature of these areas, with evident changes in species diversity or association and often invasion by woody species, such as *Acacia nilotica* and *A. natalitia*, as indicated in Figure 2.

Figure 2: Image showing an area where a gas pipeline has been constructed at Hluhluwe-Umfolozi, KZN. Grasses and shrubs are tolerated, but larger trees are prevented from re-establishment (Photo: SDP)

Under some situations, such change in vegetation form may serve to bisect habitats resulting in altered habitat structure and function.

4.2 Alien invasive plants

As indicated above, the construction of the pipeline will result in extensive changes to soil profiles. Such disturbance is a key driver of exotic and invasive vegetation establishment, where species compete with early seral species that may be naturally associated with the seral processes within the affected habitat. Following construction, and during the operations stage where maintenance or regular inspections of the pipeline may ensue, further disturbance of the area can be expected through the passage of vehicles and other maintenance activities. It follows that low and sustained levels of disturbance along the pipeline servitude presents suitable conditions for the establishment and spread of alien invasive plants (AIPs). As such, servitudes often act as repositories and vector corridors of exotic plant propagules, thereby promoting and facilitating the spread of AIPs.

4.3 Faunal disturbance

Habitat loss and transformation both within the maintained servitude and immediately adjacent areas are likely to affect faunal populations within particular areas, or alternatively give rise to change in species' behaviour. The clearance of large swathes of land, for the gas pipeline infrastructure (including temporary clearance for installation of the pipeline as well as more permanent clearance for ancillary infrastructure and maintenance) is likely to affect faunal populations directly and indirectly and in the medium to long term, and lead to the ousting of specific faunal populations and/or promote the establishment of others. For example, the clearance of treed areas and establishment of scrub or graminoid veld forms within a servitude will favour grazers and may lead to the ousting of frugivorous species that were reliant upon fruiting tree species. In addition, such transformation may also alter transitory niche and migratory routes of certain species or act as physical barriers to others.

4.4 Constraining of conservation initiatives

Within both the IOCB of KZN and the Eastern Cape, initiatives to expand and connect protected areas have been undertaken in the past, with new opportunities likely in the future. An example of a past initiative was the proposed linking of the Nseleni Nature Reserve and the New Mouth area near Richards Bay. This initiative was championed by the uMhlatuze Municipality with the intention of protection marginal habitats such as the "Kwambonambi Grasslands". The placement of pipeline servitudes outside of protected areas, while well intentioned, may however nullify and disrupt initiatives that are presently underway, effectively constraining long term conservation efforts.

5 KEY ATTRIBUTES AND SENSITIVITIES OF THE INDIAN OCEAN COASTAL BELT BIOME

5.1 Vegetation and spatial definition

The IOCB is defined by five dominant vegetation types (Mucina & Rutherford, 2006). These are generally termed:

- CB 1 – Maputaland Coastal Belt;
- CB 2 – Maputaland Wooded Grassland;
- CB 3 – Kwazulu-Natal Coastal Belt;
- CB 4 – Pondoland-Ugu Sandstone Coastal Sourveld; and
- CB 5 – Transkei Coastal Belt.

The drivers, characteristics and conservation significance of the abovementioned five dominant vegetation types are summarised in Table 4 below (adapted from Mucina & Rutherford, 2006). The climate of the east coast of southern Africa is controlled by the presence of a high pressure system lying to the east of the sub-continent and intermittently, the area is influenced by low pressure systems arising from the Southern Ocean, particularly during winter. In the late summer, cyclonic systems moving across the Indian Ocean often lead to catastrophic storm events along the coastline (Tinley, 1985). This meteorological regime plays a significant role in determining the form of habitats that are found within the IOCB (Mucina and Rutherford 2006). As can be seen from Table 3 below, it is clear that there is significant variation and differentiation in the climate regime from the south of the IOCB to the north. This variance gives rise in part, to fundamentally differing habitat types within the biome. For example, within the northern areas, grasslands and forest habitats that are proximal to the coastline, are subject to intensive storm activity associated with cyclonic activities, which play a key role in forest gap dynamics (Yamamoto, 1996) while the high level precipitation associated with these events is an important driver in grassland and woodland communities in the north of KZN. Rainfall in the southern extent of the IOCB is comparatively less than that encountered in the north, although less seasonal with a more bimodal rainfall regime. It is perhaps due to these drivers that these vegetation types are primarily grassland and open woodland-mosaic environments which form an association of habitats within any given range.

Additionally, edaphic form and function within the IOCB can also be considered a primary driver of many of these habitats, tempering growth in woody species through the availability of freshwater and nutrients. The influence of anthropogenic factors, mainly fire but often the grazing of livestock, must also be considered one of the major drivers of the habitat forms within the IOCB, particularly over the last 500 years (McCracken, 2008).

Table 3: Comparative meteorological data from urban centres located in the south, centrally and north of the IOCB.

		St Lucia	Durban	East London
Temperature (˚C)	Maximum.	29.3	28.1	24.5
	Minimum.	17.5	11.3	9.8
	Annual average	21.7	20.9	18.2
	Variance	11.8	7.7	14.7
Rainfall (mm)	Annual average	1129	975	822
	Average maximum	139	125	97
	Average minimum	58	30	36
Wind velocity (km/h)	1954-1963 (15h00)	20	20	17

(Data source: Climate-Data.org, 2018)

Associated with these vegetation types are a number of additional zonal, azonal and intrazonal vegetation units such as “sand forest” and “lowveld riverine forest”. These vegetation units are, from a holistic, ecological perspective, interwoven into the broader eco-type that defines the “KZN and Eastern Cape coastal belt” and, bearing in mind that the definition of “vegetation unit” and “Biome” are fundamentally scientific constructs, these units should also be given recognition and considered holistically in any review of coastal habitat in KZN and the IOCB.

Table 4 indicates the 11 vegetation units that are considered to be primarily “terrestrial” in nature and lie within or adjacent to the definitive IOCB vegetation types, as defined. The 11 vegetation types consist of the five defining vegetation types and six azonal and intrazonal vegetation types that are prominent within the IOCB. Table 5 provides more definitive consideration of the vegetation units that fall within the IOCB Biome. Notably, of the 11 vegetation units under consideration in the south eastern coastal extent, two of the five units within the IOCB are considered to be “endangered”, while three are considered to be “vulnerable”. Comparatively, two of the four forest types are considered “critically endangered”, while the rest are considered to be “least threatened”. These ecological aspects are afforded some further consideration below (Table 4).

The extent and distribution of the IOCB vegetation units and relevant azonal and intrazonal vegetation are mapped in Figure 3 and Figure 4.

Table 4: Summary of the veld types encountered within or proximal to the defining IOCB vegetation types, including azonal and intrazonal vegetation units, and key zonal units (Mucina and Rutherford 2006) that may be encountered within the proposed gas pipeline corridors.

Vegetation Type	Code	Biome/Veg. Unit	Distribution	No. of endemic taxa	Conservation status (NEMBA 2011)	Comment
Sub-tropical dune thicket	AZs3	Eastern strandveld	Azonal, associated with stable secondary dunes and beyond.	2	Least threatened/Not listed	Threatened by heavy metal dune mining - prospecting and extraction. Alien plant invasion is common. Low likelihood of interface with gas pipeline development except where corridor arises close to coastline (Northern KZN)
Sub-tropical seashore vegetation	AZd4	Seashore vegetation	Azonal, associated with frontal coastal dunes.	5	Least threatened/Not listed	Transformed by tourism development. Low likelihood of interface with gas pipeline development.
Maputaland Coastal Belt	CB1	IOCB	Mtunzini in KZN northwards to Southern Mozambique - landward up to 35 km.	6	Least threatened/Not listed	Transformed by plantations. High levels of plant diversity in northern areas around Mozambique border. Highly transformed in RSA, some well-preserved areas iSimangaliso Wetland Park and Mozambique. Probable likelihood of interface with gas pipeline development
Maputaland Wooded Grassland	CB2	IOCB	Southern Mozambique to south of St Lucia. Primarily on coastal plain surrounding inter dune depressions / wetlands.	4	Vulnerable	Exploited primarily for commercial and small scale woodlot plantation. Probable to high likelihood of interface with gas pipeline development
Kwazulu-Natal Coastal Belt	CB3	IOCB	South of the uMlalazi River, near Richards Bay to Port Edward.	1	Vulnerable	Subject to variable impacts including mining, urban settlement and agriculture. Low likelihood of interface with gas pipeline development
Pondoland-Ugu Sandstone Coastal Sourveld	CB4	IOCB	Port Shepstone to Port St Johns. Primarily coastal areas but up to 20 km inland at points.	33	Endangered	Associated with rocky cliff-type environments. May be associated with gas pipeline development inland of Port Shepstone. Possible likelihood of interface with gas pipeline development corridor inland / south coast of KZN

Vegetation Type	Code	Biome/Veg. Unit	Distribution	No. of endemic taxa	Conservation status (NEMBA 2011)	Comment
Transkei Coastal Belt	CB5	IOCB	Coastal areas south of Port St Johns to Kei River. Undulating topography with grassland and valley forests.	0	Least threatened/Not listed	Little likelihood of interface with proposed gas pipeline routings within the corridor
Lowveld Riverine Forest	FOa1	Azonal forest	Azonal forest associated with river systems. Primarily Phongolo, Mkhuze and uSutu Rivers.	0	Vulnerable	Under threat from subsistence agriculture and alien invasion as well as changes to river systems
Scarp Forest	FOz5	Zonal and Intrazonal forest	Forest associated with rocky areas, distributed from Northern KZN to Eastern Cape.	49	Vulnerable	Intermittent across KZN escarpment and coastal environment. Although “niche” type environment, the gas pipeline development poses some, primarily indirect threat to this vegetation unit, where the corridor spans escarpments. Possible points of interface in Northern and Central KZN
Northern Coastal Forest	FOz7	Zonal forest	Extends from Eastern Cape north to Mozambique/Tanzania. Found at 10 -150m.a.s.l.	1	Endangered	Under threat on coastal dunes. Includes "dune forest" (Acocks, 1988) which is under threat from mineral exploitation and settlement. Limited probability of interface with gas pipeline development corridor
Sand Forest	FOz8	Intrazonal forest	Fragmented patches - Mozambique (Tembe region) at between 20 - 160m.a.s.l.	14	Least threatened/Not listed	Associated with paleo dunes in Northern KZN. Interface with proposed gas pipeline corridor likely in northern region of KZN

Table 5: The five defining vegetation groups of the IOCB (Mucina & Rutherford, 2006)

Vegetation Type	Distribution	Vegetation and Landscape Features	Geology and Soils	Climate	Endemic Taxa
CB 1	KZN Province and Southern Mozambique. Mozambique border to Mtunzini	Flat coastal plain. Densely forested in places. Range of non-forest vegetation communities – dry grasslands/palmveld, hygrophilous grasslands and thicket.	18 000 year old Quaternary sediments of marine origin. Berea and Muzi Formations of the Maputaland Group.	Weak rainfall seasonality at the coast. Summer rainfall inland. Up to 1200 mm rain per annum. High humidity. Mean maximum temperature – 35.3°C and Mean minimum temperature 5.5°C.	Herbs: *Helichrysum adenocarpum* subsp. *Ammophilum. Vahlia capensis* subsp. *Vulgaris* var. *longifolia.* Geophytic herbs: *Asclepias gordon-grayae, Kniphofia leucocephala, Raphionacme lucens*. Graminoid: *Restio zuluensis*.
CB 2	KZN Province and Southern Mozambique. Mozambique border to Sileza, Sibaya, Mseleni, Mbazwana, Sodwana Bay, Ozabeni, Eastern and Western Shores of Lake St Lucia, Kwambonambi and Richards Bay.	Flat coastal plain. Sandy grasslands rich in geophytic suffrutices, dwarf shrubs, small trees and rich herbaceous flora.	Quaternary redistributed sands of the Berea formation (Maputaland Group). Shallow water table.	Weak rainfall seasonality at the coast. Summer rainfall inland. Up to 1200 mm rain per annum. High humidity. Mean maximum temperature – 35.3°C and Mean minimum temperature 5.5°C	Geoxylic suffrutices: *Ochna* sp. nov., *Syzigium cordatum*. Succulent herb: *Aloe* sp. nov. Geophytic herb: *Brachystelma vahrmeijeri*.
CB 3	KZN Province. Mtunzini to Margate and Port Edward	Highly dissected undulating coastal plains. Subtropical coastal forest presumed to have been dominant. *Themeda triandra* dominated primary grassland.	Varying Natal Group Sandstone, Dwyka Tillite, Ecca shale and Mapumulo gneiss. Berea Red Sand in places.	Summer rainfall. High humidity. No frost. Mean maximum temperature – 32.6°C and mean minimum temperature – 5.8°C (Durban).	Herb: *Vernonia africana* (extinct). Geophytic herb: *Kniphofia pauciflora.* Low shrub: *Barleria natalensis* (extinct).
CB 4	Eastern Cape and KZN Province. Port St. Johns to Port Shepstone.	Coastal peneplains and undulating hills with flat table lands and very steep slopes of river gorges. Species rich grassland punctuated with scattered low shrubs or small trees.	Restricted to sandstones of the Msikaba Formation	Summer rainfall. No to infrequent frost. Mean maximum temperature – 32.2°C and mean minimum temperature – 5.8°C (Paddock).	Graminoid: *Fimbristylis vareigata*. Herbs: *Eriosema umtamvunense, Geranium sparsiflorum, Lotononis bachmanniana, Selago peduncularis, Senecio erubuscens* var. *incisus.* Geophytic herbs: *Brachystelma austral, B. kerzneri, Watsonia inclinata, W. mtamvunae. Geoxylic suffrutex: Rhus acocksii*. Low shrubs: *Leucadendron spissifolium* subsp. *natalense, L. spissifolium* subsp. *oribinum, Acalypha* sp. nov., *Anthospermum steryi, Erica abbottii, E. cubica var natalensis, Eriosema dregei, E. latifolium, E. luteopetalum, Euryops leiocarpus, Gnidia triplinervis, Leucadendron pondoense,*

Vegetation Type	Distribution	Vegetation and Landscape Features	Geology and Soils	Climate	Endemic Taxa
					Leucospermum innovans, Raspalia trigyna, Struthiola pondoensis, Syncolostemon ramulosus, Tephrosia bachmannii. Tall shrub: *Tephrosia pondoensis.*
CB 5	Eastern Cape Province. Port St. Johns to Great Kei River.	Highly dissected, hilly coastal country. Alternating steep slopes of low reach river valleys and coastal ridges. Grasslands on higher elevations alternative with bush clumps and small forests.	Karoo Supergroup Sediments – sandstone and mudstone of the Adelaide Subgroup. Shale, mudstone and sandstone of the Ecca Group and Dwyka tillite.	Summer rainfall with some winter rain. No frost. Mean minimum temperature of 7.7°C (Bashee Lighthouse).	None listed.

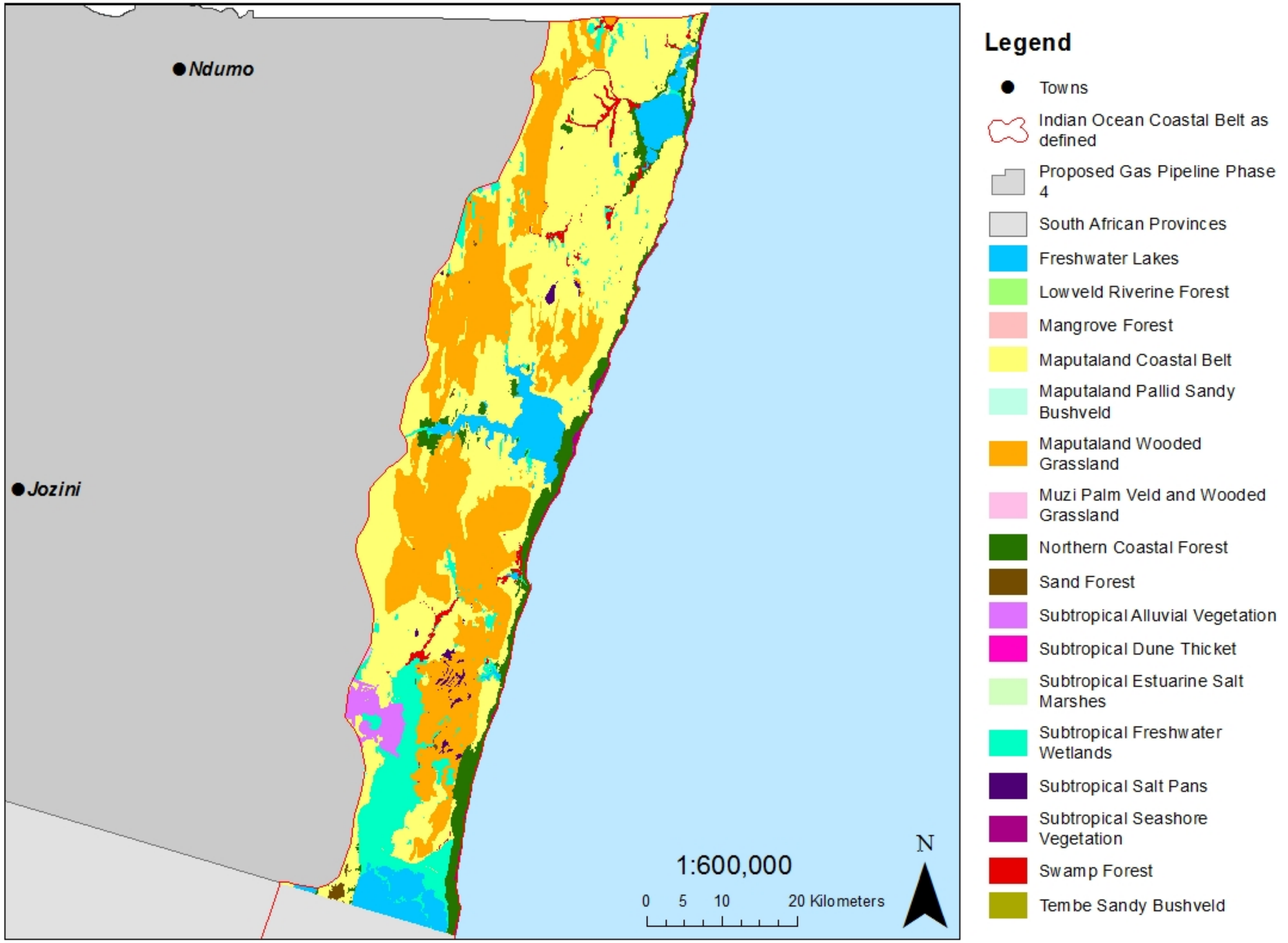

Figure 3: An overview of the vegetation types, including azonal vegetation with the portion of the IOCB affected by the northern portion of the Phase 4 corridor (SANBI 2012).

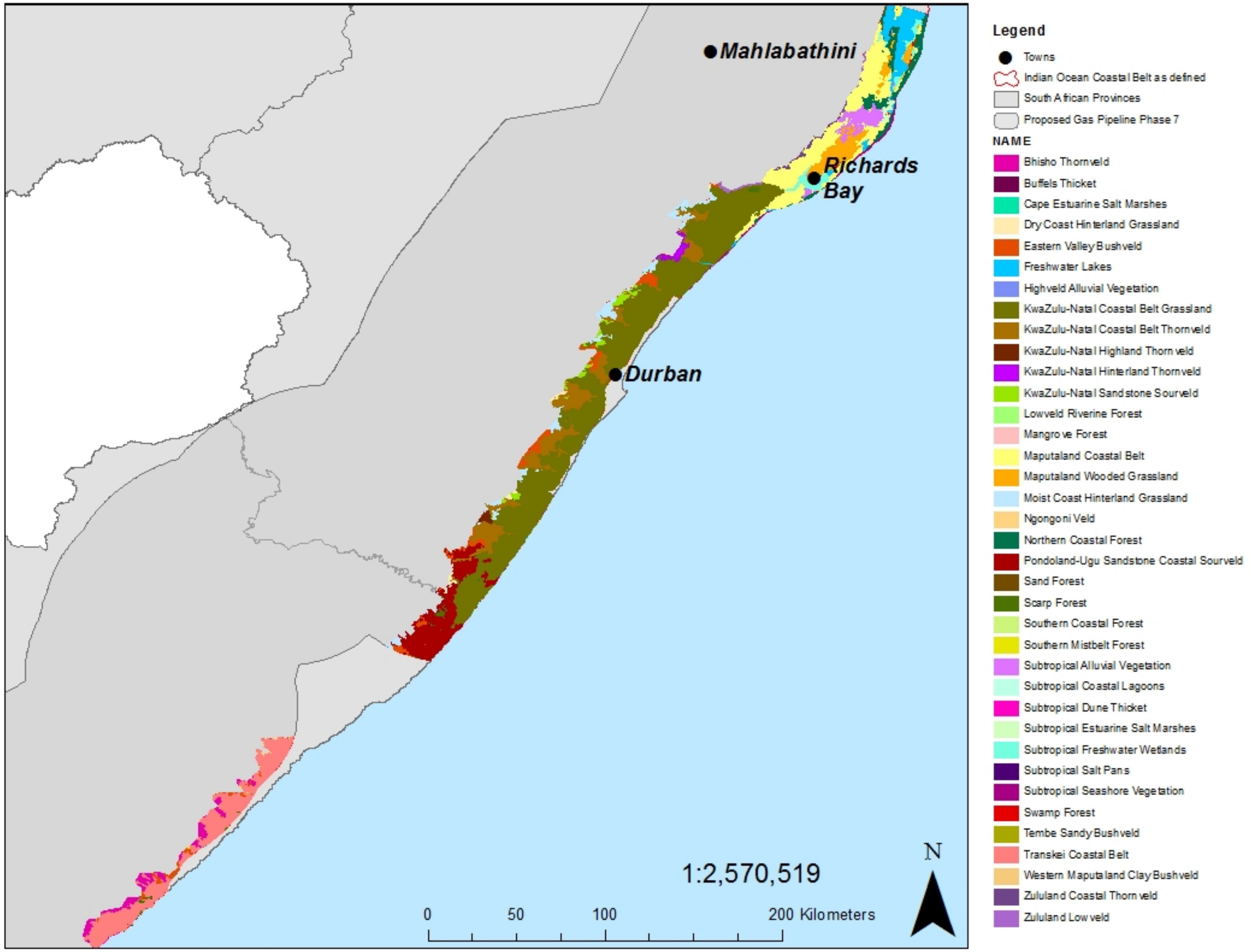

Figure 4: An overview of the vegetation types, including azonal vegetation with the portion of the IOCB affected by the upper section of the Phase 7 corridor (SANBI 2012).

5.1.1 Vegetation types of the IOCB

5.1.1.1 CB 1 – Maputaland Coastal Belt

The Maputaland Coastal Belt vegetation type is restricted to the north of the KZN within Phase 4 of the proposed project areas and is primarily located to areas north of Richards Bay (Figure 3). The habitat comprises of a grassland mosaic and often secondary forest dominated by species such as *Syzigium cordatum, Acacia natalitia* and *Phoenix reclinata* (Figure 5). In northern KZN the habitat type is found primarily within an undulating terrain of sands to clayey sands, often interspersed with shallow depression wetlands which are paleo dune slacks. The veld type is considered to be “vulnerable” from an ecological conservation perspective, although recent review of habitat destruction around the iSimangaliso Wetland Park suggests that settlement in the region has seen a rate of loss of this veld type of up to 105 ha per year (SDP- Isimangaliso WP, 2015), which would suggest that the vegetation unit is under increasing anthropogenic pressures.

Figure 5: Example of Maputaland Coastal Belt vegetation near Mbazwana. (Photo: SDP)

5.1.1.2 CB 2 – Maputaland Wooded Grassland

Maputaland Wooded Grassland has been defined as a “sub-class” of CB1 on account of the absence of wetland environments and variation in species composition (Figure 6). The major threat to this habitat form has been the expansion of the silviculture industry in the north of KZN (primarily *Eucalyptus* spp and in some areas *Pinus* spp) which is the most appropriate economic land use in the nutrient poor sands that dominate this area.

Figure 6: Example of Maputaland Wooded Grassland near Kwandalane. (Photo: SDP)

5.1.1.3 CB 3 – KwaZulu-Natal Coastal Belt

CB3 stretches from south of the uMlalazi River to Port Edward (Transkei) in a broad band that runs parallel to the coastline (Figure 3 and Figure 4). The landscape comprises of a mosaic of grassland and forested habitat, the latter normally associated with lower elevations (Figure 7). Notably, fire and grazing has played a significant role in the establishment of this veld type. Phase 7 of the gas pipeline may interface with this habitat as far north as Richards Bay but is superseded by thornveld, inland of this region.

Significant transformation has taken place within this vegetation unit, attributed primarily to agriculture and urban expansion. Within abandoned agricultural fields, a secondary habitat may arise of similar form but devoid of a number of key graminoid, herbaceous and woody species.

Figure 7: Typical KwaZulu-Natal Coastal Belt located near Mtunzini. (Photo: SDP)

5.1.1.4 CB 4 – Pondoland-Ugu Sandstone Coastal Sourveld

Pondoland-Ugu Sandstone Coastal Sourveld is a highly diverse habitat form found primarily to the south of KZN and associated with sandstone geologies (Figure 8). The azonal Scarp Forest may be encountered in association with this veld type, particularly in the southern extent of the IOCB. CB4 may also be encountered some distance from the coast, although it is primarily associated with the lower to mid elevations, below the KZN escarpment and may interface with the gas pipeline in southern KZN.

5.1.1.5 CB 5 – Transkei Coastal Belt

The Transkei Coastal Belt (Figure 9) is located along the coastline of the northern Eastern Cape southwards to beyond East London. This vegetation unit is unlikely to be affected by the establishment of the gas pipeline, which is likely to be established some distance inland of the coast.


Figure 8: Pondoland-Ugu Sandstone Coastal Sourveld near Margate. (Photo: SDP)


Figure 9: Transkei Coastal Belt located near Gwe Gwe. (Photo: SDP)

5.1.1.6 *Azonal, zonal and intra zonal vegetation types*

Within the IOCB are embedded a number of zone specific and azonal vegetation types (Table 6). Some are unique to the IOCB, and others have a wider distribution. Azonal vegetation types are thus included in the definition of the IOCB and are themselves often considered to be "sensitive" habitats, worthy of conservation. Table 6 below presents the most predominant and significant azonal, terrestrial vegetation types within the IOCB, however most of these vegetation forms are aligned with riverine, wetland or estuarine habitats which are subject to separate review by specific authors covering those habitats. In addition, some consideration and expansion on those vegetation types that are most likely to be encountered in the IOCB is presented below (based on descriptions provided by Mucina and Rutherford 2006), these vegetation forms being:

- FOa 1 Lowveld Riverine Forest;
- FOz 5 Scarp forest;
- FOz 8 Sand Forest;
- FOa 2 Swamp Forest;
- FOz 7 Northern Coastal Forest;
- AZd 4 Subtropical Seashore Vegetation; and
- AZs 3 Subtropical Dune Thicket.

Table 6: Azonal and intrazonal vegetation found within the IOCB (Mucina and Rutherford 2006).

Vegetation type	Description	Conservation status (NEMBA 2011)
FOa 1 Lowveld Riverine Forest	Tall forests fringing larger rivers (gallery forest) and pans. Dominated by *Ficus sycamorus* or *Diospyros mepiliformis*. Forests are dense, tall, structured and with a well-developed shrub layer.	Vulnerable
FOz5 Scarp Forest	Stratified forest with high canopy and shrub strata, with a number of epiphytic species associated with sub canopy.	Vulnerable
FOz7 Northern Coastal Forest	Species rich, tall or medium height subtropical coastal forests that occur on coastal plains and stabilized coastal dunes.	Endangered
FOz8 Sand Forest	Stratified forest in patches associated with paleo dunes – well developed shrub strata and poor herb layer.	Least threatened/Not listed
FOa 2 Swamp Forest	12 – 15 m forests with two main strata (canopy and shrub layer). Dominant trees include: *Ficus trichopoda, Barringtonia racemosa, Casearia gladiiformis, Cassipourea gummiflua, Syzigium cordatum, Phoenix reclinata, Raphia australis*. Understorey poorly developed.	Vulnerable
FOa 3 Mangrove Forest	Species poor and often monospecific, low and dense forests in tidal zones of coastal lagoons.	Endangered
AZe 3 Subtropical Estuarine Salt Marshes	Estuaries and coastal salt-marsh plains supporting complexes of low herbs dominated by succulent chenopods and other flood tolerant halophytes. Salt marsh meadows dominated by Spartina flooded swards and submerged Zostera sea meadows are often present.	Least threatened/Not listed
AZd 4 Subtropical Seashore Vegetation	Open, grassy, herbaceous, dwarf shrubby and often dominated by a single species of pioneer character. Plant communities are representative of the age of the substrate.	Least threatened/Not listed
AZs 3 Subtropical Dune Thicket	Very dense shrubby thickets of spiny shrubs, large leaved mega herbs, dwarfed tree species, abundant vines and with poorly developed undergrowth due to shading by the closed canopy.	Least threatened/Not listed
AZf 6 Subtropical Freshwater Wetlands	Flat topography supporting low beds dominated by reeds, sedges and rushes, water logged meadows dominated by grasses. Typically associated with depressions, alluvial backwater pans and artificial dams.	Least threatened/Not listed
Aza 7 Subtropical Alluvial Vegetation	Flat alluvial riverine terraces supporting an intricate complex or macrophytic vegetation, marginal reed belts as well as extensive flooded grasslands, ephemeral herblands and riverine thickets.	Least threatened/Not listed

5.1.1.7 FOa 1 Lowveld Riverine Forest

Lowveld Riverine Forest is confined primarily to riverine environments in and around the northern regions of KZN, extending into the Mpumalanga Province. The forest type is generally associated with alluvial soils and may be subject to some level of inundation under flood events. The vegetation form comprises of a stratified forest canopy with a number of tall dominant species - in KZN this species being *Ficus sycamorus*. Lowveld Riverine Forest is particularly abundant on the Phongolo River system (Figure 10), but may be encountered further to the south.

This vegetation type has succumbed to significant levels of clearance to make way for agricultural activities in and around floodplains. The clearance of sub canopy layers within forest systems has also led to invasion by exotic plant species. This forest type is considered to be Vulnerable.

Figure 10: Image of Lowveld Riverine Forest on Phongolo River. (Photo: SDP)

5.1.1.8 FOz 5 Scarp forest

Scarp forest is a stratified forest form that is primarily associated with cliffs and rocky krantzes (Figure 11). This forest type extends from the Lebombo Mountain range in Northern KZN through to the southern extent of the IOCB in the Eastern Cape. The vegetation type is considered to be vulnerable from a conservation perspective on account of the fact that it is associated with steep and rocky areas not generally sought after for settlement and other human land use requirements. Notably, Mucina and Rutherford (2006) recognise this as "the most valuable forest form in South Africa", counting important taxa such as *Streptocarpus spp* and *Encephalartos spp* as being endemic to this habitat form.

Due to the association of this habitat form with steep and rocky environments, it is unlikely that Scarp Forest will be affected by the gas pipeline.

Figure 11: Image showing Scarp Forest on uMzimvubu River near Port St Johns. (Photo: SDP)

5.1.1.9 FOz 8 Sand forest

Sand forest does not ostensibly lie within the IOCB as defined in this investigation, however as a highly fragmented and edaphic-driven forest form, Sand Forest is likely to be encountered in small to moderate sized pockets within the IOCB (Figure 12). It is considered to be least threatened from a conservation perspective on account of indiscriminate settlement in northern KZN and its affiliation to ancient aeolian soils. Sand forest is noted as being the "core" of the Maputaland Centre of Endemism (Van Wyk & Smith, 2001). This forest type has a high number of endemic plant species and is also noted to be associated with key faunal species such as the Tonga red squirrel (*Paraxerus palliatus tongensis).* There is a high likelihood that the gas pipeline may intersect with at a minimum, relic pockets of sand forest.

Figure 12: Image of Sand Forest, located near Ndumo (Photo: SDP)

5.1.1.10 FOz 7 Northern Coastal Forest

This forest veld type is particularly well developed in the region between Richards Bay and Kosi Bay, primarily along the upper and landward portions of the high secondary dunes (Figure 13) at the coast (Acocks, 1988). This forest form is common to those areas that have been identified as being subject to the mining of heavy minerals and therefore is presently subject to this and other anthropogenic pressures. As a result of the ongoing clearance and loss of this forest form, Northern Coastal Forest is considered to be “endangered” from a conservation perspective.

The gas pipeline is likely to interface with communities of Northern Coastal Forest in the north of KZN, where the corridor is situated proximal to the coastline, particularly in Phases 4 and 7 of the project.

Figure 13: Northern Coastal Forest within the iSimangaliso Wetland Park (Photo: SDP).

5.1.1.11 AZd 4 Subtropical Seashore Vegetation

This azonal vegetation type is located within the Eastern Cape and KwaZulu-Natal provinces, extending from Kei Mouth in the south to the Mozambique border and is associated with coastal dune features, near the shoreline. Vegetation consists of open, grassy, herbaceous, dwarf shrub vegetation. This vegetation type is considered to be "least threatened"/not listed with sufficient coverage in statutorily protected areas to meet conservation targets (Mucina & Rutherford, 2006; Tinley 1985). Due to the confinement of AZd4 to the near shore environment, this vegetation type may be affected where such pipeline intersects with the shoreline and coastal environment.

5.1.1.12 AZs 3 Subtropical Dune Thicket

The distribution of Subtropical Dune Thicket is similar to AZd 4; however this habitat does differ in species composition and structure. Vegetation within Subtropical Dune Thicket comprises of very dense, shrubby thickets often with dwarf tree species, abundant vines and a poorly developed undergrowth due primarily to shading by the closed canopy. This vegetation type is associated with recent dunes overlying calcretes (Figure 14). Where the pipeline lies proximal to the shoreline, particularly in Northern KZN, this habitat form may be affected by pipeline establishment.

Figure 14: Image of Subtropical Dune Thicket located near Sodwana Bay. (Photo: SDP)

5.1.2 Threatened Plant Species

SANBI point data for threatened plant species was provided by the CSIR, cropped to the IOCB extent and reviewed. Figure 15 provides an overview of the distribution of threatened plant species within the affected portions of the IOCB. Although the data is not exhaustive, it provides an indication of the areas where threatened plant species may be encountered. Clusters and potential hotspots appear to be concentrated in or around formally protected areas – Umlalazi Nature Reserve, Ongoye Forest, Umtamvuna Nature Reserve and Isimangaliso Wetland Park – with isolated occurrences outside of these areas, such in the Durban Metro.

With specific reference to Umtamvuna Nature Reserve (Figure 16) the area supports a number of threatened plant species, many associated with the preserved scarp and grassland habitat. The Umtamvuna Nature Reserve supports 94 threatened plant species from the categories: Declining, Rare, Near Threatened, Vulnerable, Endangered and Critically Endangered (Pondoland CREW, 2016). The Umtamvuna Nature Reserve is the northern extent of the Pondoland Centre of Endemism (PCE), which extends as far south as the Kei River. Phase 7 excludes a significant section of the upper PCE in the Mkambathi and Port St Johns areas.

With the level of transformation that is present within the IOCB, KwaZulu-Natal in particular, the importance of similar isolated pockets of natural vegetation within the IOCB cannot be overstated.

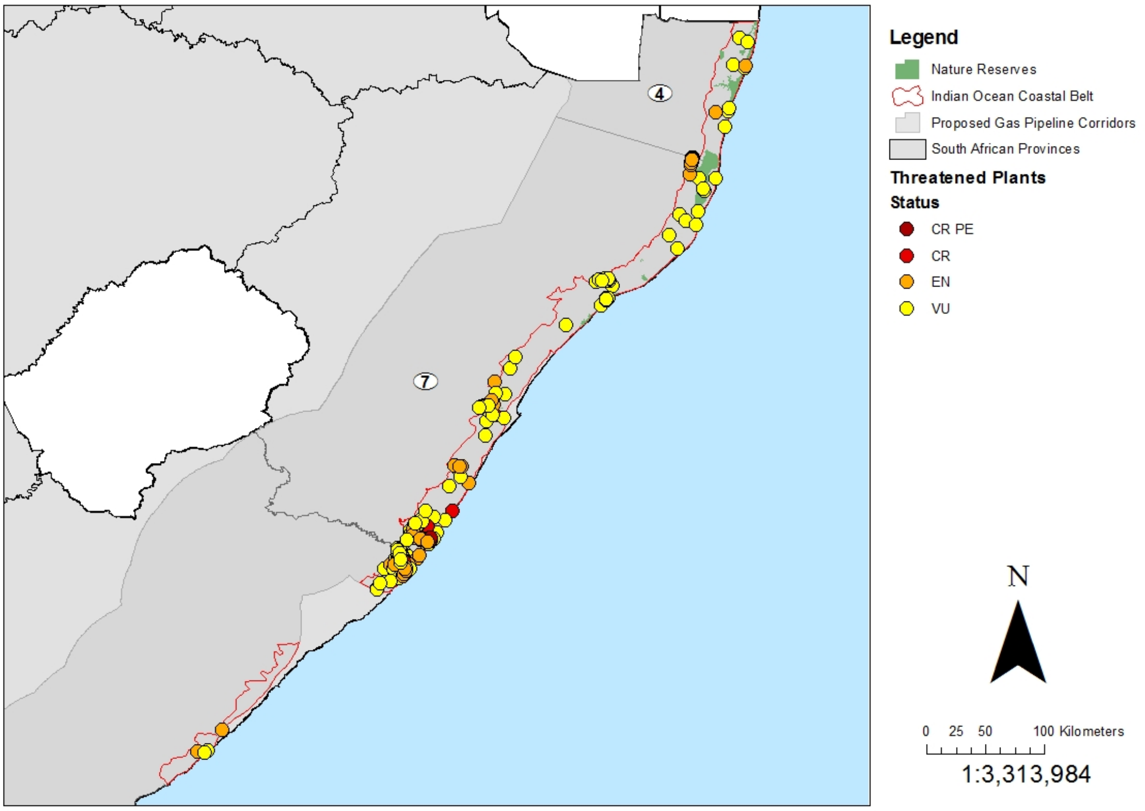

Figure 15: The distribution of recorded threatened plant species within the IOCB portion of the Gas Pipeline Corridors (Phases 4 and 7). Note the dense cluster corresponding with the KZN and Eastern Cape Border. CR PE represents Critically Endangered Possibly Extinct.

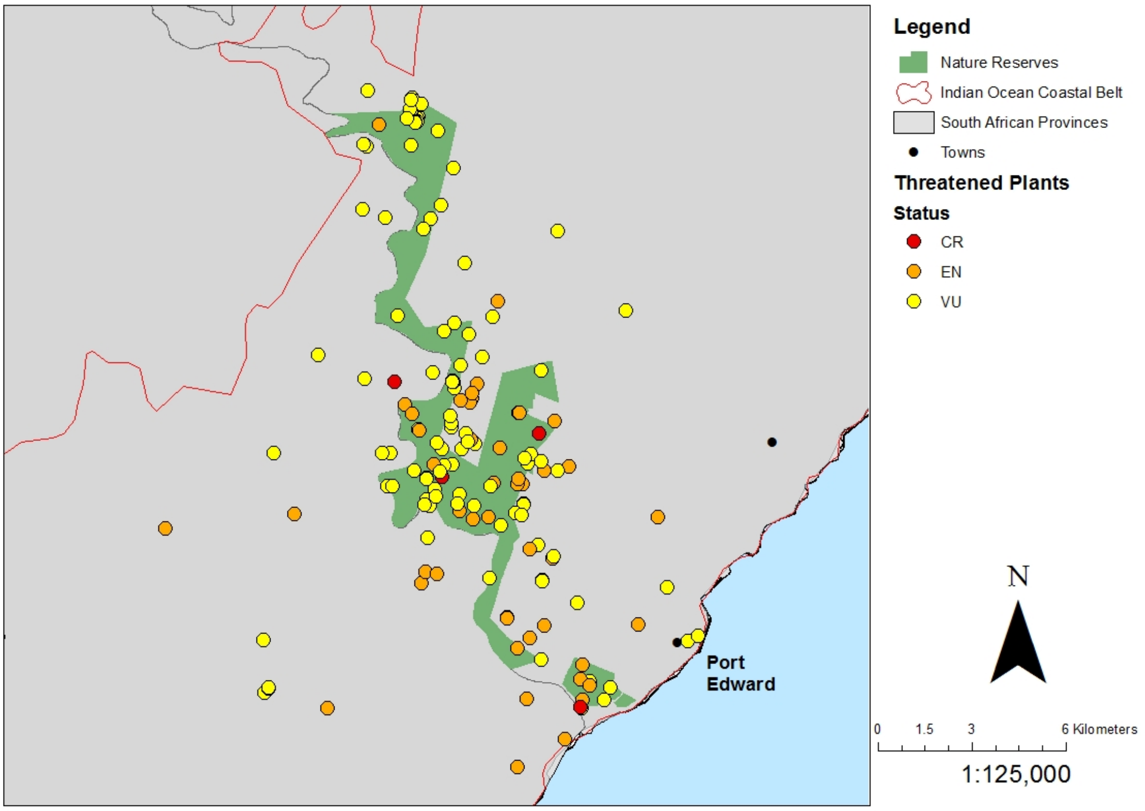

Figure 16: Concentrated distribution of recorded threatened plant species within the Umtamvuna Nature Reserve and immediate surrounds.

5.1.3 Fauna

The IOCB occupies a climatic niche identified using the Koppen – Geiger classification system as Cfa (*warm temperate; fully humid; hot summer*) (Kottek et al., 2006). This climatic regime, as explained above, as well as a topographically diverse environment and a relatively recent history of human settlement has given rise to some diverse ranges of habitat and a concomitantly diverse faunal assemblage. It follows that both **habitat form and structure** and **faunal presence** as well as the interface between these two elements forms the guiding pre-requisites for evaluation of suitable routes for the gas pipeline within the IOCB.

However, the rapid expansion of human settlement in the region, particularly following the nagana of the 1860s has seen the confinement of much of the larger fauna to protected areas and private game farms, while smaller species, including invertebrates are confined to niche environments, such as scarp forest, that are not affected by human activities. Notably, some species have benefitted from human settlement and agricultural activities, at the expense of others.

The subtropical climate experienced by the IOCB, as well as the availability of water, offer suitable habitat for a wide range of fauna. The network of protected areas, particularly in the northern portion of the IOCB are critical for the maintenance of faunal biodiversity, in the wake of the extensive disturbance which has been associated with urbanisation, peri-urban settlement and agriculture in surrounding area with the IOCB.

More specific to the Margate region and the sandstone grasslands of the lower KwaZulu-Natal South Coast in particular, is the presence of two butterfly species, *Lepidochrysops ketsi leucomacula* (white blotched ketsi blue) and *Durbania amakosa albescens* (whitish amakhoza rocksitter). The presence of these two species has been verified by EKZN Wildlife during field reconnaissance undertaken as recently as March 2017 (Armstrong pers comm, 2017). *L. ketsi leucomacula*, according to Armstrong, is endemic to the coastal stretch between Margate and Port Edward and is probably only associated in the Margate region. Due to a complex lifecycle including an association with the presence of formicids (ants) (Woodhall, 2005), the species may be considered to be susceptible to impacts of both a direct and indirect nature. *D. amakosa albescens* is considered to be "vulnerable" from a conservation perspective, primarily on account of a decline in suitable habitat. Habitat includes "rocky ledges" and open lichen-encrusted terrain. Open areas of rugged terrain, unaffected by development, are considered to be important for the continued preservation of the species. This is an example of a faunal species that may be significantly impacted by the disturbance caused by the construction of a pipeline, due to its dependence on specific habitat, interactions and associations. Many larger, more mobile and adaptable fauna species may simply relocate temporarily and remain largely unaffected.

In addition to the above, consideration of the South African Bird Atlas Project 2 (SABAP2, 2018) (Pentad 3050_3020 / QDGC: 3030CD) indicates that a total of 201 bird species have been logged for the lower KZN South Coast including a number of distinctly uncommon species, as well as species associated with grassland environments. Birds and their habitat has also been considered in detail as part of the Avifauna strategic issue of the overarching Strategic Environmental Assessment of the proposed gas pipeline corridors (included in Appendix C.1.8 of the Gas Pipeline SEA Report).

Analysis of available species data for amphibians, reptiles and butterflies (SANBI, 2018) indicated clusters of occurrence correlating with protected areas/more intact habitat areas within the IOCB (Figure 17 - Figure 19). Of the 53 amphibian species present, only two were threatened (near threatened and endangered). The reptile species present (21 in total) were all threatened with only one species being data deficient and the other two not having a listing category. The butterfly data lacked a clear species reference and any indication of the conservation status.

With reference to Figure 17 - Figure 19 below, The Futululu and Dukuduku Forest areas as well as the Umfolozi floodplain between St Lucia and Mtubatuba indicates a concentration of reptile records, indicating a potential “hot spot” that should be avoided. In this instance the majority of records were *Bitis gabonica* (Gaboon adder). This species is common within the intact moist grasslands and forest margins that are present in this area. Another potential “hot spot” is Ongoye Forest inland of Mtunzini. This scarp forest and reserve is shown to support butterfly, amphibian and reptile species as per the SANBI Data. Other areas of importance include Umlalazi Nature Reserve, Vernon Crookes, Oribi Gorge, Margate and Umtamvuna Nature Reserves.

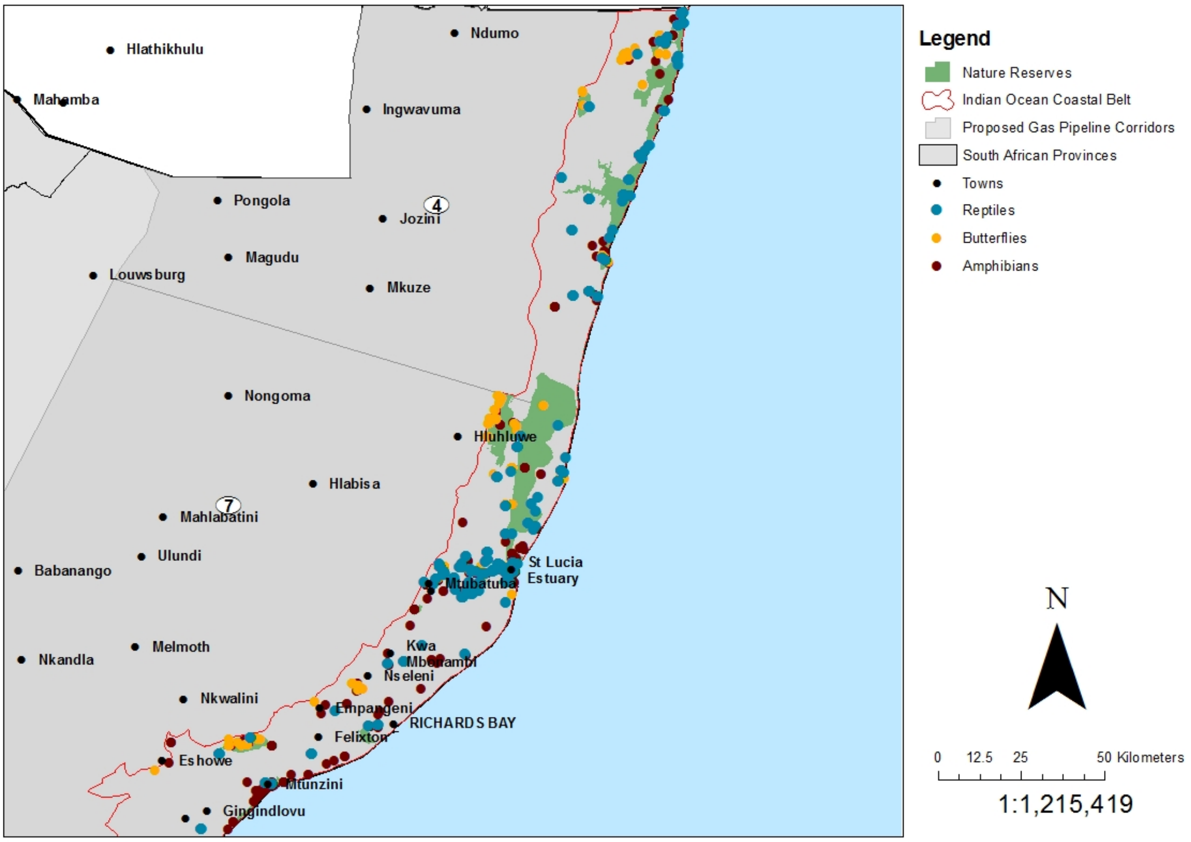

Figure 17: The distribution of recorded threatened reptiles, amphibians and butterflies within the IOCB in the Phases 4 and 7 corridors.

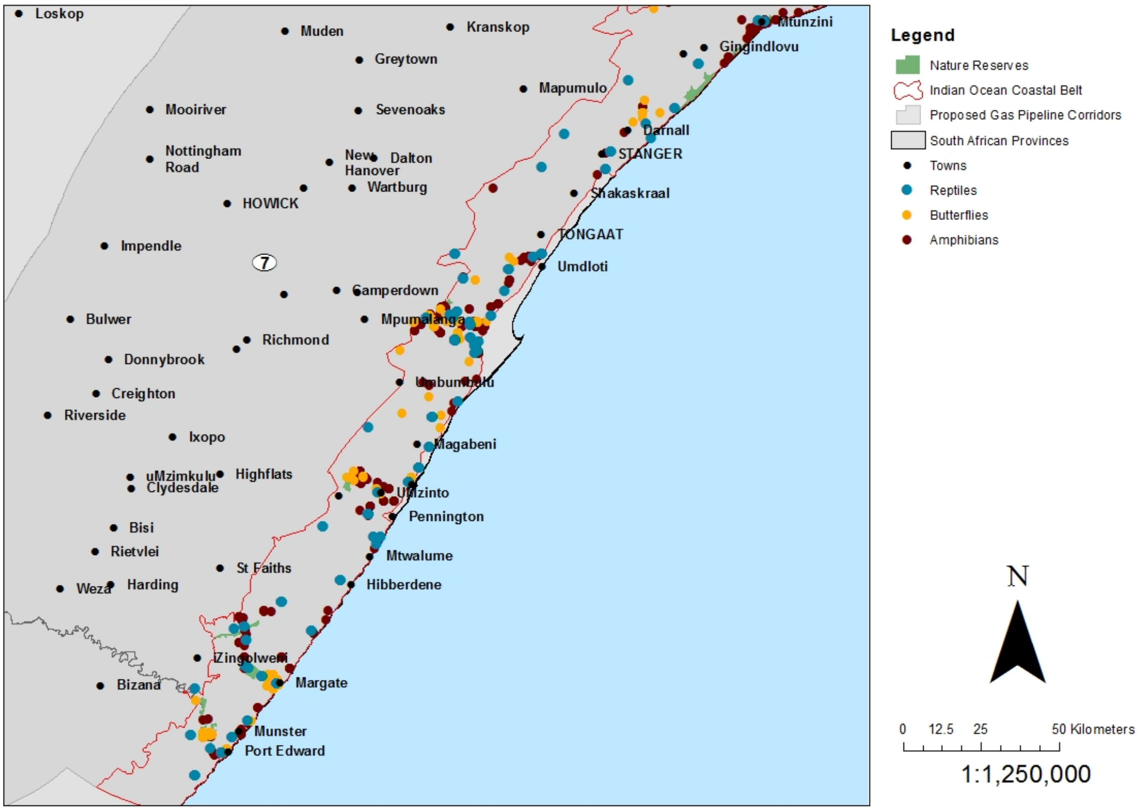

Figure 18: The distribution of recorded threatened reptiles, amphibians and butterflies within the IOCB in the upper portion of the Phase 7 corridor.

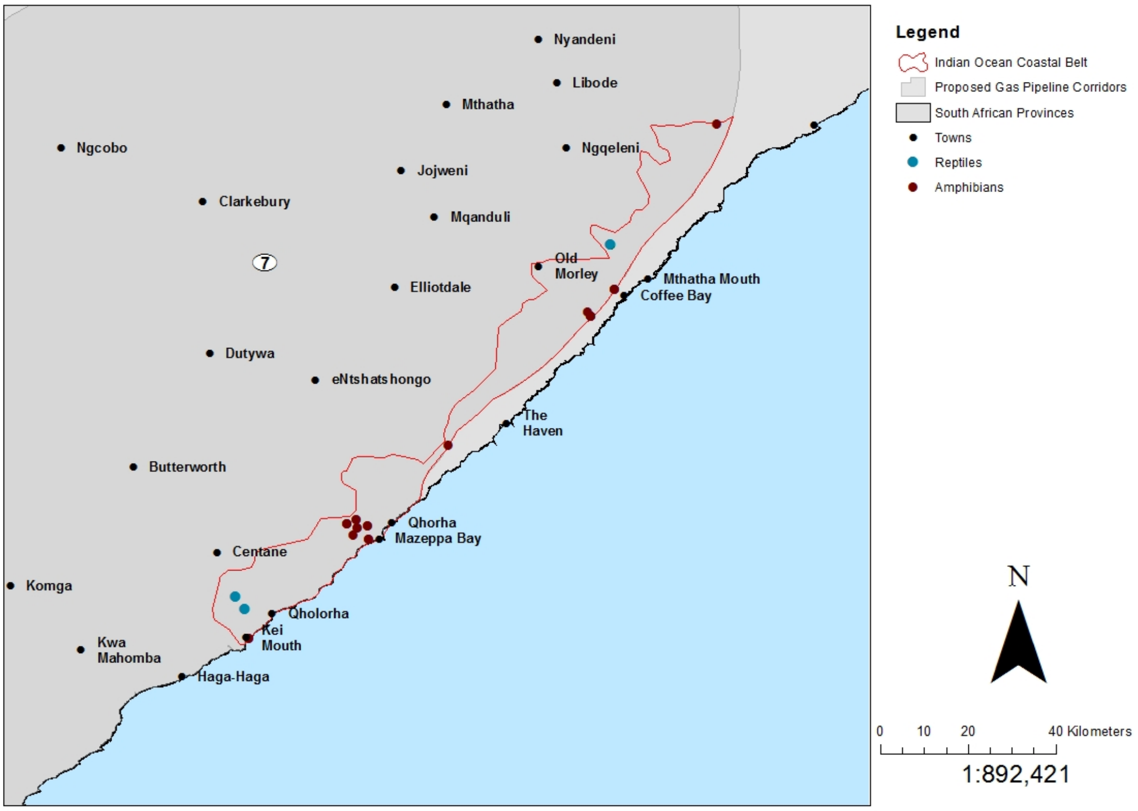

Figure 19: The distribution of recorded threatened reptiles and amphibians within the IOCB in the Eastern Cape section of the Phase 7 corridor. No butterfly data for the IOCB portion of the Eastern Cape was available.

5.2 Corridors Description

Two proposed corridors, namely Phases 4 and 7 fall within the IOCB (refer to Figure 1). These corridors and the nature of the receiving environments within and associated with the IOCB are described below. The corridors are however, very expansive (100 km wide) and the IOCB only constitutes a very narrow band along the eastern seaboard. A description of the features of the IOCB within the three corridors is provided below in Table 7.

Table 7: Summary of the nature of the IOCB in the three proposed gas pipeline corridors, within which the IOCB falls.

Site	Brief description
Phase 4	The Phase 4 corridor is a short linkage which overlaps the eastern most portion of Phase 4 and links with Phase 7. It extends from Richards Bay in the South to the Mozambique border. The IOCB within this corridor is made up of the Maputaland Coastal Belt (CB 1) and Maputaland Wooded Grassland (CB 2). Subtropical Freshwater Wetlands and Lowveld Riverine Forest are two significant azonal vegetation types found within this section of the IOCB. A prominent feature is the Isimangaliso Wetland Park, a significant protected area, Ramsar Site and World Heritage Site. This extends from Maphelane, north of Richards Bay to Kosi Bay and extends inland to the Mkuze Nature Reserve. The bulk of the Isimangaliso Wetland Park, from Lake St. Lucia to Kosi Bay falls within this corridor phase.
Phase 7	The Phase 7 corridor extends along the east coast of the Eastern Cape and KwaZulu-Natal from Coega in the south to Hluhluwe in the north. This corridor affects the largest section of the IOCB, which includes a combination of very sensitive unique habitats associated with the Pondoland area and severely degraded and highly urbanised areas such as the greater Durban area. Between Richards Bay and Hluhluwe, a significant portion of the Isimangaliso Wetland Park associated with Lake St Lucia is located. Outside of this protected area, the landscape is dominated by peri-urban settlement, extensive timber plantations and sugar cane cultivation. Prominent azonal vegetation includes Swamp Forest (FOa 2) which is largely limited to isolated undisturbed areas in the Richards Bay and St Lucia areas. Extensive Northern Coastal Forests (FOz 7) occur, such as Futululu near Monzi. Furthermore, The section of the IOCB affected by this corridor includes the lower extent of the Maputaland Coastal Belt (CB 1), the KwaZulu-Natal Coastal Belt (CB 3), Pondoland-Ugu Sandstone Coastal Sourveld (CB 4) and Transkei Coastal Belt (CB 5) major vegetation types. The Kwazulu-Natal south coast and Pondoland area are traversed by a large number of incised coastal and major river systems and undulating valleys. Where not transformed for agricultural purposes, these support Northern Coastal Forest and scarp forest. A prime example is the Umtamvuna River Valley (Umtamvuna Nature Reserve) on the KZN/EC border. The northern section between Durban and Richards Bay is largely degraded, with the exception of a few pockets of undisturbed and protected habitat, such as the Amatikulu Nature Reserve (Dokodweni/Nyoni area) and The Ongoye Forest, near Mtunzini. The N2 corridor, extensive sugar cane farming and dune mining near Mtunzini are major disturbances within this section of the IOCB.

5.3 Feature Sensitivity Mapping

5.3.1 Identification of feature sensitivity criteria

The following features of the IOCB were selected for further consideration. The rationale behind each feature and the details thereof are discussed below. A summary is available in Table 8.

5.3.1.1 Protected areas

Protected areas are primarily public and in some cases private areas of land that have been set aside for the achievement of conservation objectives. Most of these areas have been statutorily proclaimed under the National Environmental Management: Protected Areas Act or similar legislation. A number of protected areas are private lands that enjoy recognition by the conservation authorities.

A number of statutory protected areas occur within the IOCB. These include the following:

- Isimangaliso Wetland Park (Including Mapelane)
- Nseleni Nature Reserve
- Richards Bay Game Reserve
- Umlalazi Nature Reserve and Siyaya Coastal Park
- Ongoye Nature Reserve
- Amatikulu Nature Reserve
- Harold Johnson Nature Reserve
- Umhlanga Nature Reserve
- Beachwood Nature Reserve
- North Park Nature Reserve
- Kenneth Stainbank Nature Reserve
- Bluff Nature Reserve
- Vernon Crookes Nature Reserve
- Mehlomnyama Nature Reserve
- Oribi Gorge Nature Reserve
- Mbumbazi Nature Reserve
- Trafalgar Nature Reserve
- Umtamvuna Nature Reserve
- Mkambathi Nature Reserve
- Silaka Wildlife Reserve
- Hluleka Nature Reserve
- Dwesa-Cwebe Wildlife Reserve
- Kei Mouth State Reserve

These protected areas are of very high conservation importance, many of them protecting the last remaining primary habitat within the IOCB. The inclusion of these features in the assessment was deemed essential, and recommended for exclusion from pipeline establishment.

In addition to and in recognition of the ecological value of the conservation authorities, municipalities and other statutory organs of state have sought to further enhance and improve the management of the above protected areas through the establishment of a network of important habitats and environments. These areas are discussed below, but can be considered to generally lie outside of the formally established protected areas, but are to be seen as providing specific and important benefits, both from an ecological perspective and a management perspective to protected areas. These areas are considered to have a high level of conservation value.

5.3.1.2 National Protected Area Expansion areas

The National Protected Area Expansion Strategy (NPAES) details the need to consider the expansion of existing protected areas in order to improve ecological sustainability and increase resilience to climate change (Holness et al., 2016). The aim of the strategy is to identify priority areas for expansion and put in place mechanisms for such expansions to happen (facilitation). The most recent version of the spatial data (2016) was utilised and treated as a high level feature.

5.3.1.3 Critical Biodiversity Areas

Critical Biodiversity Area (CBA) data uses the occurrence of numerous "features" (faunal or floral species or vegetation types and habitats) to determine the biodiversity importance or irreplaceability of an area (Escott, 2012). The higher the biodiversity value, the higher the irreplaceability. The updated 2016 version of the KZN CBA (EKZN Wildlife, 2010) uses three categories:

- Irreplaceable — designated in this assessment as high level features
- Optimal — designated in this assessment as medium level features
- Ecological Support Area — designated in this area as low level features

The Eastern Cape CBA data was sourced from the 2017 Draft Eastern Cape Biodiversity Conservation Plan (ECBCP, 2017). The categories utilised in the ECBCP include the following:

- PA - Protected Areas
- CA – Conservation Areas
- CBA 1 – Critical Biodiversity Area 1 (High biodiversity value)
- CBA 2 – Critical Biodiversity Area 2
- ESA 1 – Ecological Support Area 1 (Essential for connectivity within the terrestrial environment)
- ESA 2 - Ecological Support Area 2
- Other Natural Areas - Natural areas not identified as priority areas

5.3.1.4 Private Nature Reserves and game farms

Private Nature Reserves and game farms include formally protected areas that are not managed by a conservation or government authority, but private landowners and companies. Only one occurs in the IOCB, according to the data, this being the Palmiet Nature Reserve near Westville/Pinetown, within the eThekwini Municipal region, which was proclaimed in 2006.

5.3.1.5 Stewardship areas

In addition to managing numerous protected areas, Ezemvelo KZN Wildlife are engaged in a number of stewardship agreements aimed at improving the integrity and conservation status of private land, through the co-operation of private landowners. Examples include the Red Desert Nature Reserve (Port Edward) and the Roosfontein Nature Reserve (Westville).

5.3.1.6 Forest Reserve

A forest reserve layer was provided by the CSIR/SANBI which contained data on forest reserve in the IOCB. Only Mapelane, within the iSimangaliso World Heritage Site can be considered to be a forest reserve.

5.3.1.7 Ramsar Sites

A layer identifying Ramsar Sites within South Africa was provided by the CSIR. Four Ramsar sites occur within the IOCB, these being the following:

- Turtle Beaches/Coral Reefs of Tongaland
- St Lucia System
- Kosi Bay
- Lake Sibaya

All of the above sites fall within the Isimangaliso Wetland Park, a World Heritage Site.

5.3.1.8 World Heritage Sites

One World Heritage site falls within the IOCB, specifically the Isimangaliso Wetland Park which lies between the town of St Lucia in the north coast of KZN and the Mozambique border. The World Heritage Site extends along the coastline between these two areas and some distance inland to include areas such as Mkuze and Makakatana.

5.3.1.9 Vegetation

The updated SANBI Vegetation Map (2012) was utilised as the primary mapping data for the IOCB, including azonal and intra zonal vegetation. Ezemvelo KZN Wildlife (Scott-Shaw and Escott, 2011) compiled an updated vegetation conservation status map for KwaZulu-Natal. This layer classifies the conservation status of the various vegetation types within KwaZulu-Natal in terms of:

- Least Threatened;
- Vulnerable;
- Endangered; and
- Critically Endangered.

The update process was detailed and a full description is provided within the metadata. Essentially the conservation status in this data set has been assigned based on the conservation targets for vegetation types in the Province (Jewitt, 2016).

5.3.1.10 Landcover

The National Land Cover, modified layer, was utilised to determine change across veld types within the IOCB (SANBI, 2017). As well as field crop boundary data (DAFF 2017) which identified current and old agricultural fields and land uses. This information is deemed essential in identifying disturbance and habitat modification the IOCB. The other broad layers for KwaZulu-Natal, with the possible exception of the updated CBA data do not take into consideration the status quo and are often based on theoretical boundaries. Sugar cane cultivation has been a dominant land use for over 100 years and has been a significant factor in influencing the nature of the IOCB in its current form and the changes brought about as a result needs to be considered.

5.3.1.11 Ecoregion

The ecoregion layer forms a base layer that is superseded by other data but captures any areas not included in other feature/sensitivity layers. The ecoregion layer is the least deterministic of the habitat information.

5.3.1.12 National Forests

The National Forest Inventory data (2016) indicates natural forest types and declared natural forests. The following forest types are found within the IOCB:

- Northern Coastal Forest
- Sand Forest
- Scarp Forest
- Swamp Forest
- Mangrove Forest
- Lowveld Riverine Forest

Forest ecosystems are generally highly threatened in the IOCB with large areas having been lost to agriculture and development. Examples of significant natural forests within the IOCB include Ongoye, Futulu and Dukuduku (large area recently lost to peri-urban settlement and subsistence agriculture). This information was refined as some areas (although occurring as outliers) adjacent to or within the IOCB (i.e.

not classified as part of the IOCB), were subject to specific evaluations under different specialist investigations (e.g. swamp forest and mangrove forest).

5.3.1.13 Buffer Zones

Default buffer zones were provided with the SANBI/CSIR data pack. The following were provided:

- A 5 km buffer layer from all Nature Reserves/Protected Areas;
- A 1 km coastal setback;
- A 2500 m buffer around Game Farms;
- A 5000 m buffer around Game Farms; and
- A 10 000 m buffer around Game Farms.

Table 8: A summary of the sensitive features of the IOCB in the proposed Phases 4 and 7 gas pipeline corridors.

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
Protected Areas	• National Department of Environmental Affairs SAPAD, 2017. • SANBI Protected Areas Database, 2011. • Ezemvelo KZN Wildlife Protected Areas updated 2015 • Critical Biodiversity Areas and Statutory Reserves for the Eastern Cape 2007	DEA protected areas database was compared against the SANBI protected areas database discrepancies were resolved. This data was provided by the CSIR. Provincial data was added for Kwazulu-Natal and the Eastern Cape.
Protected Area Expansion Areas	• Department of Environmental Affairs Priority areas for protected area expansion 2016	This data was provided by the CSIR and used without modification.
Critical Biodiversity Areas	• Ezemvelo KZN Wildlife CBA 2016 • Eastern Cape Biodiversity Conservation Plan 2007	A CBA layer was provided by the CSIR, which included national CBA data. This layer was given a default sensitivity rating of "Very High." This was retained however the KZN CBA data was added separately and specific sensitivity ratings assigned to each CBA category within KZN and using the draft ECBCP CBA data. The National data aligned with the "irreplaceable" layer of the KZN CBA. The "Optimal" and "Ecological Support Area" layers provided additional sensitivity contrast.
Private NR and game farms	• Ezemvelo KZN Wildlife Private Nature Reserves 2016 • Provincial Game Farm Data	The game reserve data was provided by the CSIR. Additional private nature reserves were added to include any areas not considered to be game farms.
Stewardship sites	• Ezemvelo KZN Wildlife Stewardship areas (draft) 2016	This layer was added un-modified and reflects the areas actively being pursued by the Ezemvelo KZN Wildlife Stewardship Programme. Although not protected areas, these areas are of conservation importance and are being actively managed as such.
Forest Nature Reserve	• National Department of Environmental Affairs SAPAD, 2017	Provided by SANBI/DEA
Ramsar Sites	• National Department of Environmental Affairs SAPAD, 2017.	Provided by SANBI/DEA
World Heritage sites	• National Department of Environmental Affairs SAPAD, 2017	Provided by SANBI/DEA
Vegetation	• SANBI Vegetation Map 2012. • Ezemvelo KZN Wildlife Vegetation conservation Status 2011	The thicket layer was obtained from the SANBI Vegetation Map while the vegetation type conservation status data was included. This data set provides the conservation status of the specific vegetation types within KZN based on various attributes, such as percentage statutorily conserved. This layer

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
		was used to derive the vegetation sensitivity ratings.
Landcover	• National Land Cover 2013/2014/DEA and Habitat Modification Layer SANBI 2017 • Field Crop Boundaries, Department of Agriculture, Forestry and Fisheries 2017	The modified and agricultural layers were retained and applied. These indicate the transformed areas that characterise much of the KZN coastal hinterland – sugar cane farms and plantations.
Ecoregion	• SANBI (Burgess 2004)	Basic ecoregion layer, applied un modified.
National Forests	• National Forest Inventory, Department of Agriculture, forestry and Fisheries, 2016.	The extent of the National Forests. This layer complements the vegetation layers above and due to their protected status allow for a higher sensitivity to be applied to relevant areas.
Buffer Zones	• Assigned by SANBI/CSIR. Date unknown.	Simple buffer extents for Nature Reserves/Protected Areas, Game Farms and a coastal setback.

All the above features were cropped to the IOCB area. Sourced data sets that did not illustrate any presence with the IOCB were discarded as was data that was not considered to be of ecological importance. Assigning sensitivity ratings to the layers was undertaken based on the 4 tier rating system as specified. Assigning sensitivities to the layers discussed above varied from layer to layer. Complex layers, such as the KZN Vegetation conservation status layer was broken down according to the conservation status ratings of the vegetation types. The data for each of the 4 conservation status layers was extracted and exported to a separate layer and assigned a corresponding sensitivity as “conservation status” was deemed to be a proxy for “sensitivity”. Other simpler layers were assigned sensitivity ratings based on expert knowledge and the nature of the feature. The various ratings have been provided in Table 11 below.

As indicated above all features are displayed with the highest sensitivity category shown in the upper most layer. This shows the most sensitive layers but is not necessarily a reflection of the status quo. The inclusion of the NLC modified areas layer is however considered to be an acceptable representation of the status quo in respect of land use and transformation in the IOCB. Being representative of habitats disturbed by anthropogenic activities, the NLC layer is rated as having a low sensitivity and indicates transformed areas. This layer should be viewed as the upper most layer as many of the other layers do not consider the status quo but are applied based on probabilities, assumptions and theoretical knowledge. Site specific knowledge and observations support the extent of transformation that is illustrated by the modified habitat layer. An example can be seen in the KwaZulu-Natal Coastal Belt, which is highlighted as being “critically endangered” equating to a “very high” sensitivity rating. The majority of the KwaZulu-Natal Coastal Belt has however been converted to sugar cane or urban settlement with a distinct North – South corridor of disturbance associated with the N2 motorway evident up to and beyond Hluhluwe. Very little primary habitat remains in this region and therefore it is not accurate to consider such disturbed areas as “highly sensitive”.

Table 9: Sensitivity ratings of the relevant environmental features of the IOCB.

Corridor	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
Phase 4	Coastline Buffer	Very High	Not applicable
	Protected Areas	Very High	May vary from 0 to 5 km (To be determined based on site specific evaluation). See generic 5 km Nature Reserve Buffer in "Buffer zones" Feature Class.
	World Heritage Site	Very High	None (The identified World Heritage Site falls within a protected area)
	Ramsar Sites	High	None. (as per World Heritage Site above)
	Protected Area Expansion Areas	Medium	None
	National Forests	Very High	Up to 100m (To be determined based on site specific evaluation)
	KZN CBA	CBA Irreplaceable - High	None
		CBA Optimal - Medium	
		ESA - Low	
	Landcover	Modified: Low	Not applicable
		FCB: Low	
		FCB other: Low	
	Vegetation	KZN Veg. Cons. Status "Least Threatened" – Low	None
		KZN Veg. Cons. Status "Vulnerable" - Medium	
		KZN Veg. Cons. Status "Endangered" - High	
		KZN Veg. Cons. Status "Critical" – Very High	
		Thicket Vegetation: High	
	Ecoregion	Medium	None
	Private Nature Reserves and Game farms	Game Farms Title Deeds – Medium	None
	Buffer zones	5 km buffer layer from all Nature Reserves/Protected Areas – Medium	Not applicable
		2500 m buffer around Game Farms - Medium	
		5000 m buffer around Game Farms - Medium	
		10 000 m buffer around Game Farms - Low	
Phase 7	Coastline Buffer	Very High	Not applicable
	Protected Areas	Very High	May vary from 0 to 5 km (To be determined based on site specific evaluation)
	World Heritage Site	Very High	None (The identified World Heritage Site falls within a protected area)

Corridor	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
	Ramsar Sites	High	None. (as per World Heritage Site above)
	Forest Nature Reserve	Very High	None (The only Forest Nature Reserve falls within a protected Area)
	Protected Area Expansion Areas	Medium	None
	National Forests	Very High	Up to 100m (To be determined based on site specific evaluation)
	KZN CBA	CBA Irreplaceable - High	None
		CBA Optimal - Medium	
		ESA – Low	
	ECBCP CBA	PA – Very High	As per Protected Areas above
		CA – High	None
		CBA 1 - High	None
		CBA 2 - Medium	None
		ESA 1 - Low	None
		ESA 2 - Low	None
		Other Natural Areas - Low	None
	Landcover	Modified: Low	Not Applicable
		FCB: Low	
		FCB other: Low	
	Vegetation	KZN Veg. Cons. Status "Least Threatened" – Low	None
		KZN Veg. Cons. Status "Vulnerable" - Medium	
		KZN Veg. Cons. Status "Endangered" - High	
		KZN Veg. Cons. Status "Critical" – Very High	
	Private Nature Reserves and Game farms	Private Nature Reserves – Very High	None
		Game Farms Title Deeds - Medium	
	EKZN Wildlife Stewardship areas	Very High	None
	Ecoregion	Medium	None
	Buffer Zones	5 km buffer layer from all Nature Reserves/Protected Areas – Medium	Not applicable
		2500 m buffer around Game Farms - Medium	
		5000 m buffer around Game Farms - Medium	
		10 000 m buffer around Game Farms - Low	

5.3.2 Feature maps

Feature maps illustrating the relevant characteristics discussed above are provided below for the three corridors. Due to the high number of features and the concentration of these features within the IOCB, some may not be clearly visible on the map. The order of the features displayed in the image is arbitrary with the exception of the National Forest Inventory and Protected Area data which has been prioritised and the more expansive vegetation and biome layers displayed lower so that as many features as possible are visible.

5.3.2.1 Phase 4

With reference to Figure 20, the most prominent feature within Phase 4 is the Isimangaliso Wetland Park, which extends from immediately North of St Lucia, to the Mozambique border (the portion within Phase 4). The width varies, but in places it incorporates the entire width of the IOCB, linking with other Protected areas, such as Mkhuze Nature Reserve. A number of forest outliers or "patches", game farms and threatened vegetation types occur within this section of the IOCB. Although not clearly visible in Figure 20, modified land use and transformed areas are present outside of the Isimangaliso Wetland Park and consideration of this particular layer has been taken in the interpretation of the sensitivity analysis.

5.3.2.2 Phase 7

Phase 7 extends through three sections of the IOCB – the central area north (up to Lake St Lucia) and immediately south of Durban, the KZN South Coast and the Eastern Cape, north of the Kei River Mouth (Figure 21). Prominent features within the KwaZulu-Natal portion include the Ongoye Forest, numerous smaller nature reserves, threatened vegetation types (KwaZulu-Natal Coastal Belt in particular), the 1 km coastal setback and CBA zones. The modified land use layer is another important layer, as with Phase 4. Prominent features within the Eastern Cape include forest patches, CBA zones, the coastal setback (along the lower extent) and the modified land use layer.

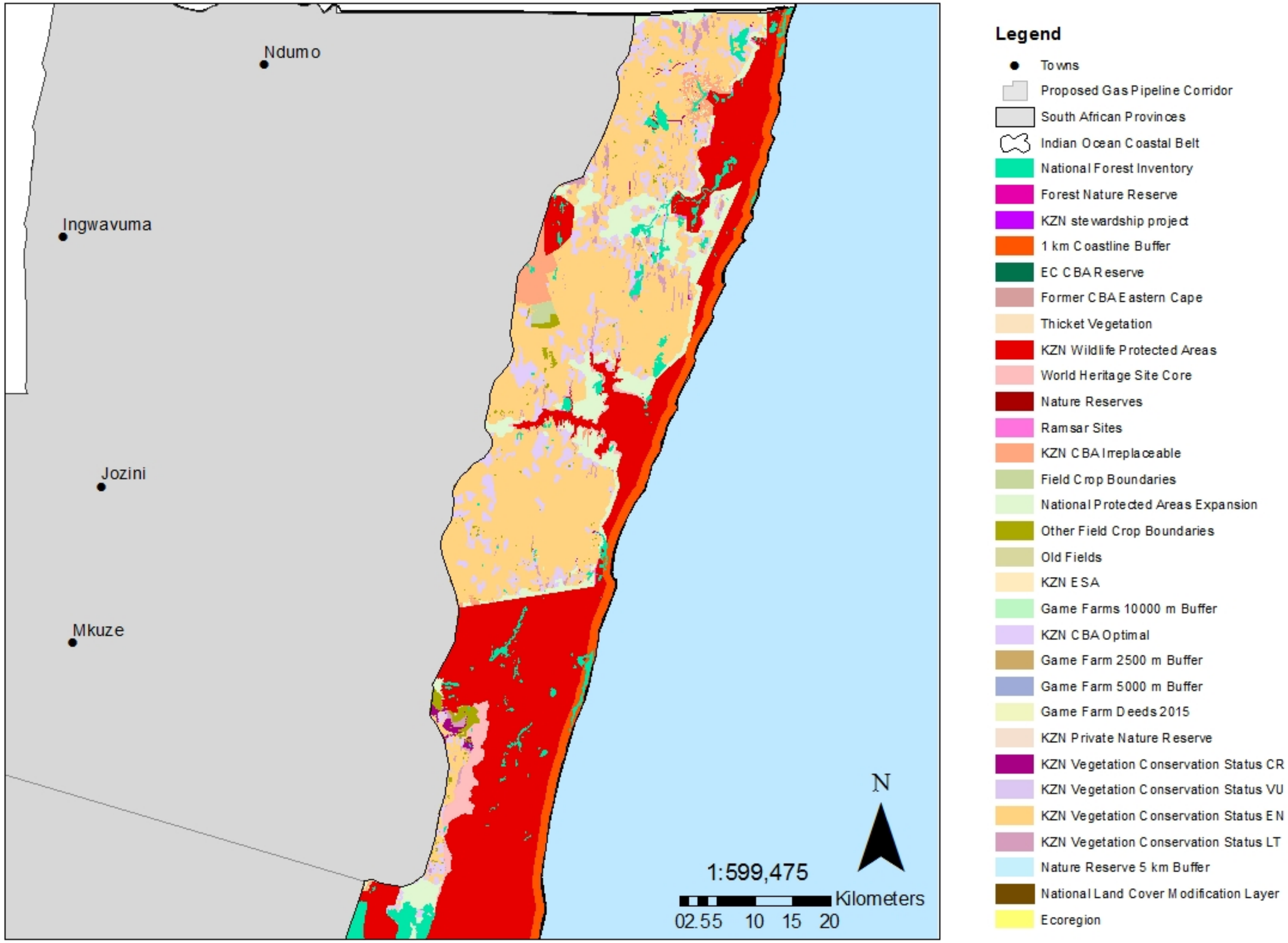

Figure 20: Features within the section of the IOCB affected by the Phase 4 corridor. The Isimangaliso Wetland Park North of St Lucia is a significant feature.

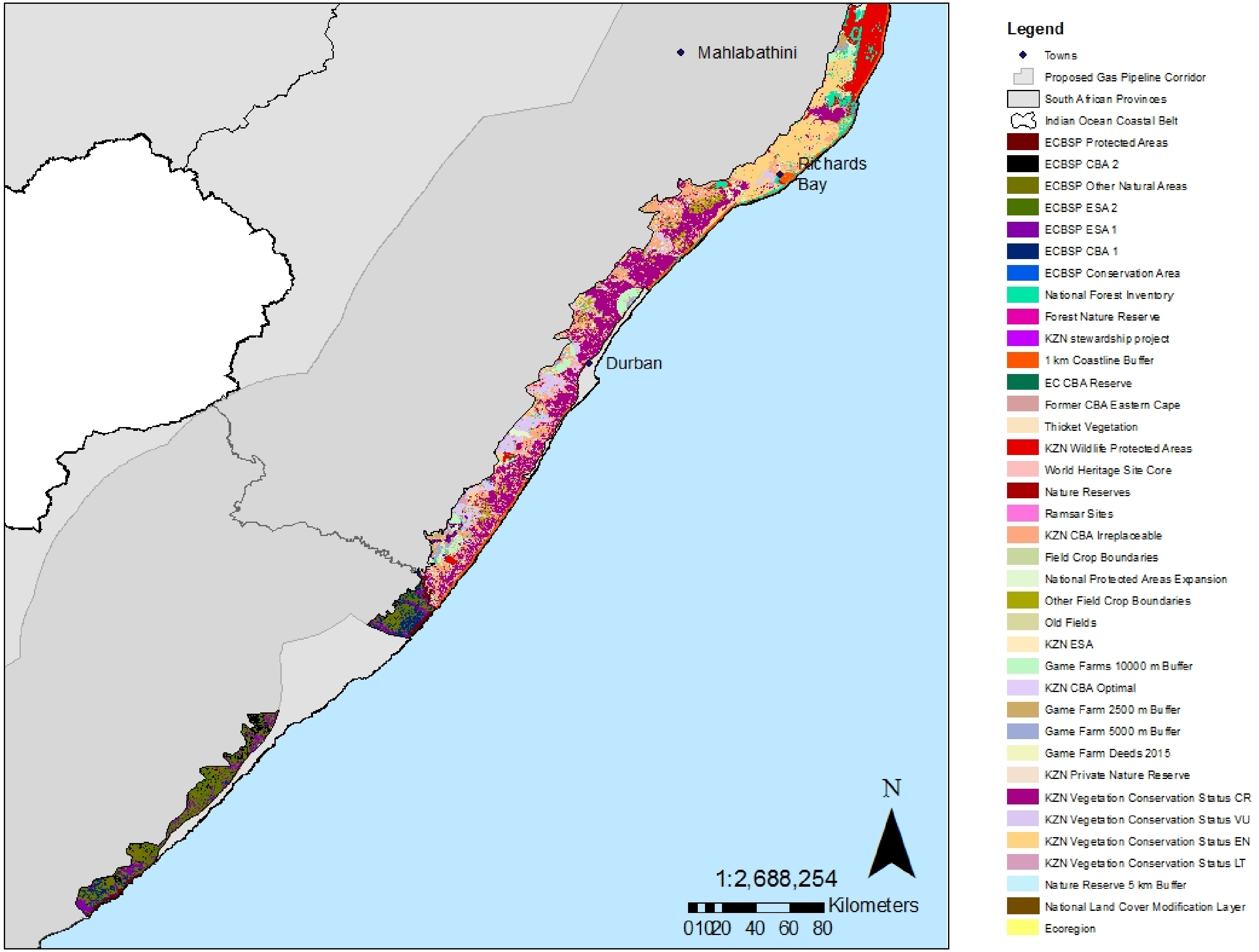

Figure 21: Features within the section of the IOCB affected by the upper portion of the Phase 7 corridor.

5.4 Four- Tier Sensitivity Mapping

5.4.1 Default Sensitivity Map

The default sensitivity maps represent the layers of highest sensitivity, with no prioritisation. This shows the most sensitive layers but is not necessarily a reflection of the status quo. This theoretical importance may become evident when defining triggers during the project specific Environmental Assessment process and determining the extent to which site specific assessment may be required.

The inclusion of the NLC modified areas layer provides a fair representation of the status quo. Being an area subject to disturbance, this layer is rated as having a low sensitivity and indicates transformed areas. This layer should be viewed as the upper most layer as many of the other layers do not consider the *status quo* but are applied based on probabilities, assumptions and theoretical knowledge. Site specific knowledge and observations support the extent of transformation that is illustrated by the modified habitat layer.

An example is the KwaZulu-Natal Coastal Belt, which is highlighted as being “critical” and equates to a “very high” sensitivity rating. This and other extensive vegetation types of “very high” and “high” sensitivity result in the blanket of maroon and red that covers most of the IOCB. The majority of the KwaZulu-Natal Coastal Belt has however been transformed to sugar cane or urban settlement with a distinct north – south corridor of disturbance associated with the N2 up to Hluhluwe. Very little true habitat remains and thus it is not accurate to consider such transformed areas as being of “very high” sensitivity, as the drivers and primary attributes of this habitat have been removed.

Phase 4

Figure 22 illustrates the sensitivity of the section of the IOCB within the Phase 4 Corridor. The majority of the area is rated as having a “high” or “very high” sensitivity. This is due to the prevalence of extensive protected areas, primarily the Isimangaliso Wetland Park, a World Heritage Site, and the inherent sensitivity and conservation threat posed to the prevailing vegetation types due to past and ongoing transformation and loss.

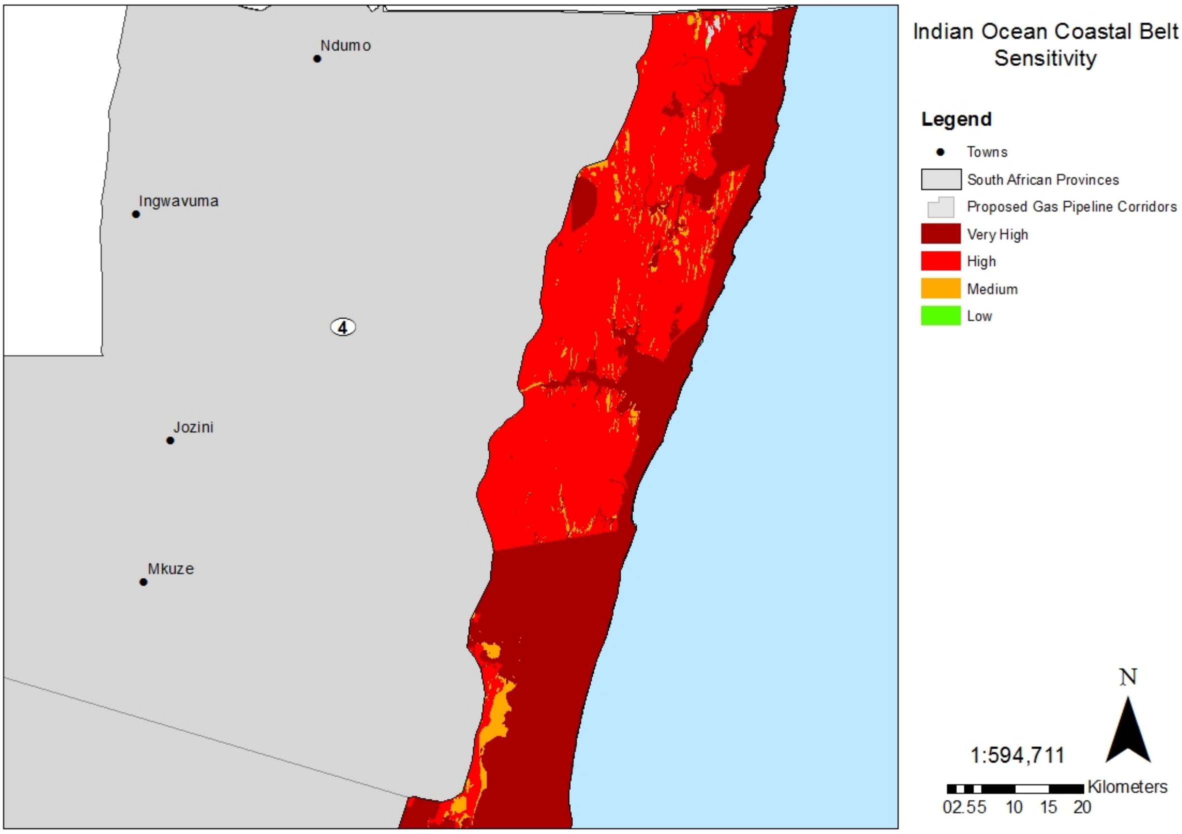

Figure 22: Sensitivity mapping for the portion of the IOCB in the proposed Gas Pipeline Phase 4 corridor.

Phase 7

The Phase 7 corridor covers an extensive area and has been shown as three maps to assist with clarity (Figure 23). The section of the IOCB that falls within KwaZulu-Natal is dominated by the very high sensitivity of the CB 3 vegetation type which is considered to have a conservation status of “critical”. The sensitivity rating does not illustrate the extent of habitat transformation that occurs within this section of the IOCB. Marked differences are visible between the Eastern Cape Portion and the KwaZulu-Natal portion due to a discontinuation of data.

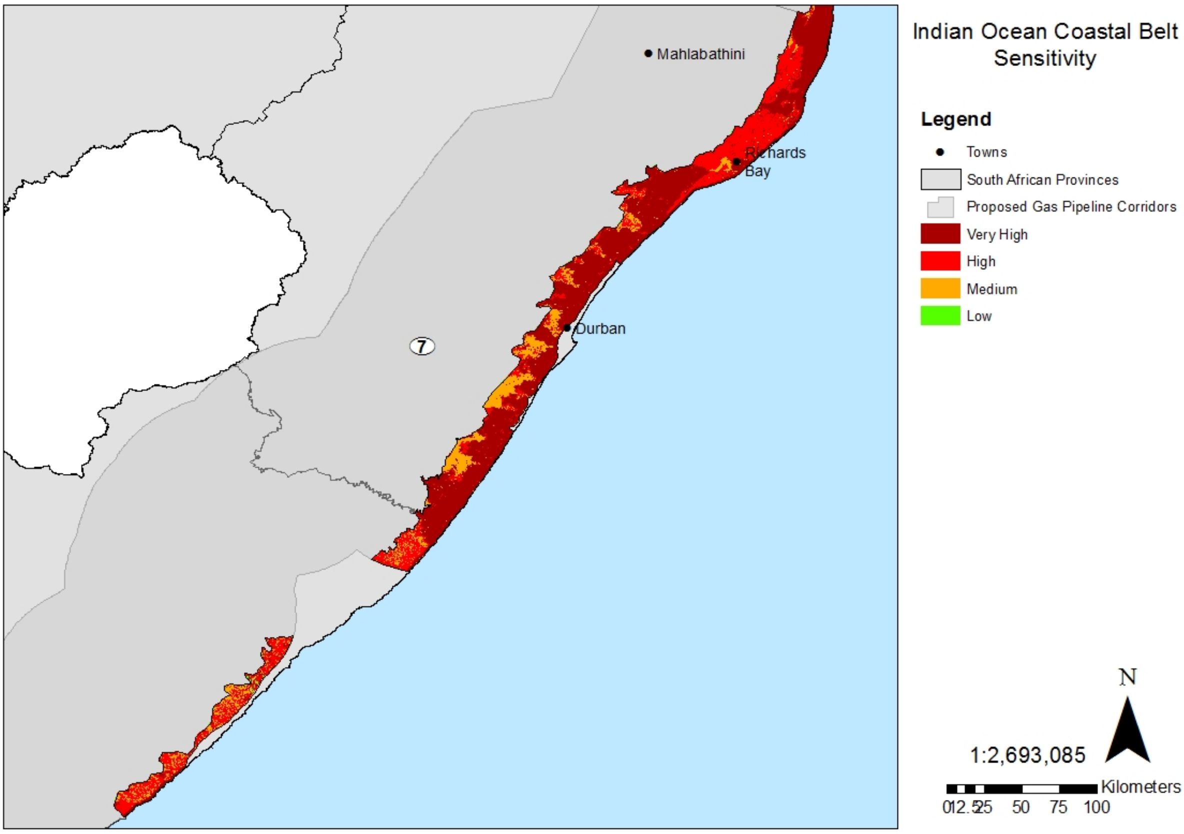

Figure 23: Sensitivity mapping for the portion of the IOCB in the upper portion of the proposed Gas Pipeline Phase 7 corridor.

5.4.2 Land Use (Priority) Map

Figure 24 and Figure 25 below provides a contrast to Section 5.4.1 above as a result of the prioritisation of the National Land Cover (modified and agricultural areas) layer. As noted above, this layer, because it consists of areas that are transformed, is rated “low sensitivity”. This layer provides a more realistic representation of the transformation that has taken place within the IOCB, particularly between Richards Bay and Durban and Durban and Port Edward, which has been extensively transformed for the cultivation of sugar cane. The extent of transformed land decreases slightly north of Richards Bay, primarily due to the existence of the Isimangaliso Wetland Park. Areas that have not been transformed within the portion of the IOCB relevant to the Gas Pipeline Corridors, are either protected, inaccessible or cannot be cultivated.

Phase 4

With reference to Figure 24 below, the modified and transformed areas are apparent outside of the Isimangaliso Wetland Park. The extent of large scale timber plantations can be made out between Lake Sibaya and Kosi Bay as well as smaller irregular subsistence agriculture plots associated with rural and peri-urban settlement.

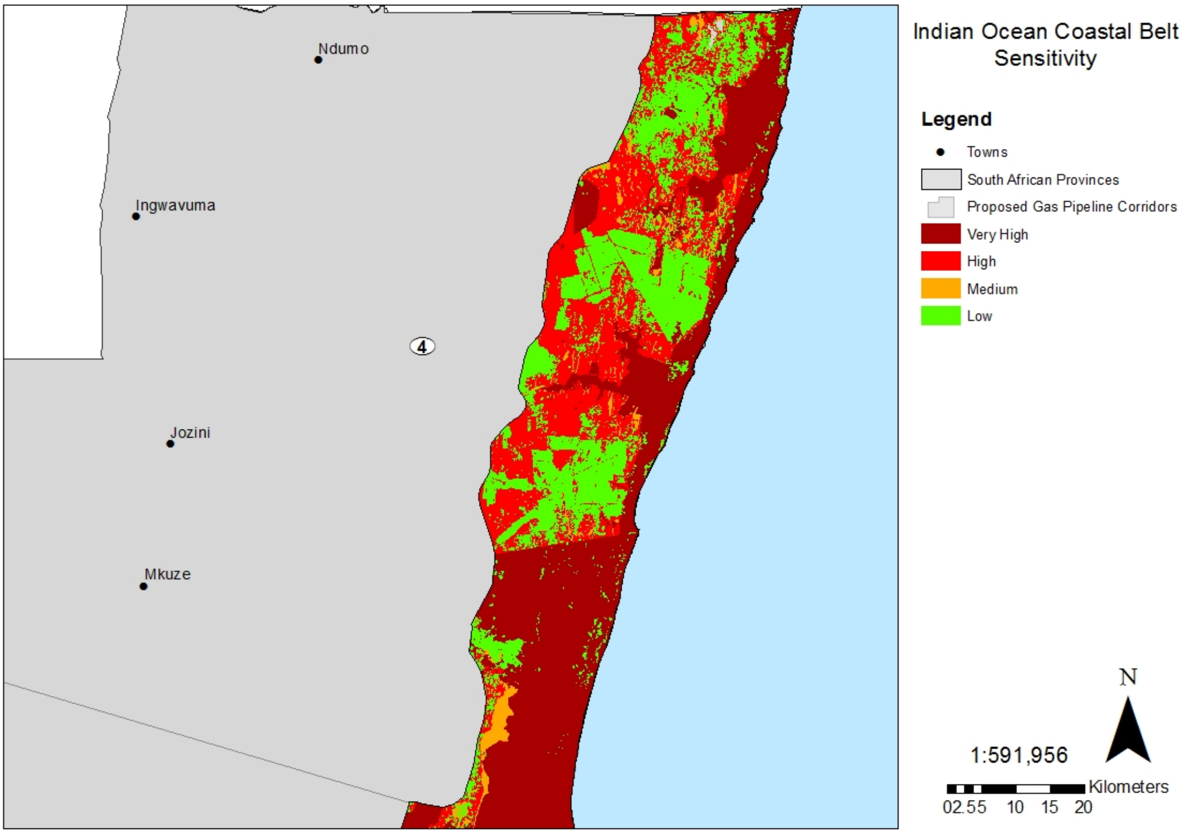

Figure 24: The extent of transformed and modified land within the IOCB (proposed Gas Pipeline Phase 4).

Phase 7

One of the features of the stretch between Durban and Richards Bay, particularly along the R102 and N2 roads, is the extent of sugar cane and timber plantations, both formal and informal. These areas of transformation are densest around Amatikulu, Tongaat and Stanger (Figure 25). These areas have been under cultivation for more than 100 years with only very minor pockets of relict vegetation remaining – usually associated with the coastline, steep areas (cliffs and scarps) and watercourses. The eThekwini Municipal area, which encompasses the city of Durban and extends between Tongaat and Scottburgh is urbanised and consists of an intricate mosaic of formal and informal townships, industrial development, commercial nodes and agricultural land.

South of Scottburgh, extensive agriculture again becomes a feature forming a wide band along the N2 until Margate, where the terrain and topography become a constraint. Urban nodes are concentrated along the coastline with the inland settlement being peri-urban and rural in nature. Within the upper Eastern Cape between Bizana, Port Edward and Mkambathi, transformation is associated with the R61. Major urban nodes are limited and much of the settlement is rural in nature segmented by natural features such as river valleys. The IOCB within the Eastern Cape, based on the National Land Cover Data appears less transformed, with more natural habitat remaining. Although primarily driven by past laws and socio-economic factors, the topography is harsh and a contributing factor to the lack of development within this portion of the IOCB.

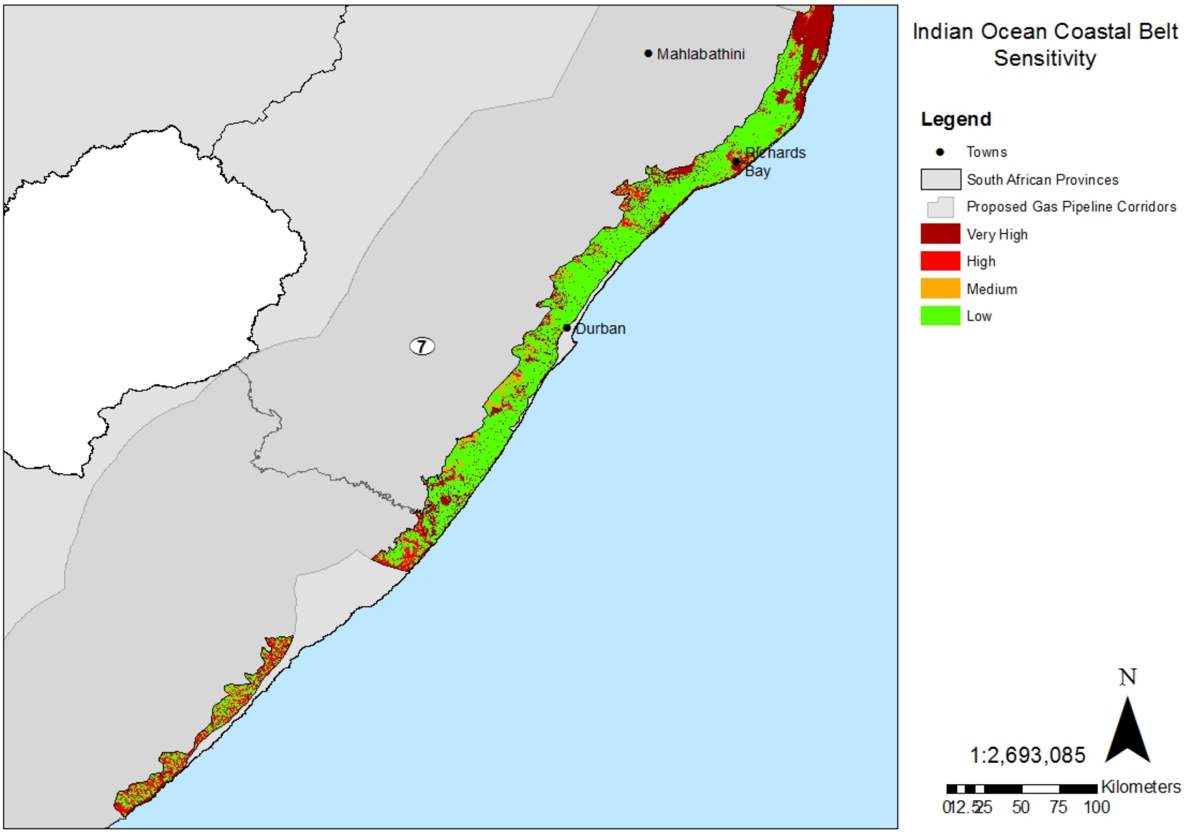

Figure 25: The extent of transformed and modified land within the IOCB (proposed Gas Pipeline Phase 7 between Durban and Richards Bay).

6 KEY POTENTIAL IMPACTS AND THEIR MITIGATION

Establishment of the gas pipeline will entail the following steps and processes (Ephraim, 2017):

- Survey and staking;
- Front-end clearing;
- Right-of-way grading;
- Stringing pipe;
- Bending pipe;
- Line-up, initial weld;
- Trenching;
- Final coating and inspection;
- Lowering pipe into trench;
- Pad, backfill, rough grade;
- Testing and final tie in; and
- Final clean up, full restoration.

During construction, a working servitude of 30 to 50 m will be established which will include space for the stockpiling of excavated soils, piping and equipment as well as the established trench. Trenches will be established using mechanical trench diggers or excavators where terrain is challenging. A site camp area will be established and the pipeline will be constructed in sections, following the steps and work flow listed above.

The following potential broad scale impacts have been identified (Section 6.1- 6.4).

6.1 Disturbance and transformation of natural vegetation

6.1.1 Impact description

Construction of the pipeline will result in the clearance of a "working servitude". Based on the nature of the pipeline, this could be as much as 50 m wide. All vegetation within this working servitude will be removed and as such, "habitat" will be "lost" or transformed. As mentioned, within the IOCB, much of the proposed pipeline route will comprise of cultivated lands or secondary vegetation, although the pipeline will likely pass through pockets of undisturbed and perhaps primary or climax vegetation (Northern Coastal Forest in particular)[1]. Clearance of these areas will result in a significant local impact, as the pipeline is a permanent fixture with a managed servitude, thus the opportunity to reinstate affected vegetation does not realistically exist. Partial revegetation can be undertaken and ground cover may be established. However, it is thus to be accepted that only an early seral state can be accepted as the prevailing management regime. As such, the loss of habitat structure/type can be considered to be permanent.

6.1.2 Mitigation

Ideally, isolated areas of sensitive vegetation within the IOCB should be avoided. Such areas will become evident during detailed surveys. If not possible mitigation options include the following:

- Rehabilitation;
- Revegetation;
- Plant Rescue; and
- Offset.

Rehabilitation may be a misnomer by definition, in that the establishment of particular vegetation forms and particular habitats would be contrary to the management regime that is to be applied to the pipeline (e.g. a forest habitat would affect ongoing management of the pipeline). Within grassland habitats, however rehabilitation or reinstatement may be feasible, provided such management regimen can be implemented. As such, rehabilitation must be undertaken with caution following careful consideration of the objectives that would accompany any rehabilitation procedure and the requirements in respect of pipeline management.

Plant rescue initiatives and the appropriate planting of vegetation are feasible management practices that can be applied across a number of vegetation types within the IOCB, sans the use of larger woody specimens. Plant rescue and relocation initiatives can be undertaken where required during the survey phase, prior to the commencement of construction and "rescued" plants can be either relocated to points outside of the servitude or used in revegetation initiatives during rehabilitation, depending upon the nature of such specimens.

Revegetation can be uniformly applied as a means of ensuring stability along the pipeline route and promoting the re-establishment of biotic activity within the servitude immediately following construction. Such revegetation initiatives can include the use of grass turf or appropriate seed mixes and may be supplemented by the above mentioned repatriation of "rescued" plants.

"Offset:" is often promoted as a means of redressing the apparent disturbance or "loss" of natural habitat or systems. The benefit and success of offsets has yet to be proven (Bull et al., 2013) and is a debatable topic. Offset should be avoided unless absolutely necessary. Calculating, identifying and successfully establishing a suitable offset can be a complex and costly undertaking with no guarantee of success. Other forms of "offset" are also considered by various authorities, including financial contributions and stewardship agreements or partnerships with conservation authorities. Given the strategic importance of

[1] It must be noted that from both environmental and engineering perspective, the gas pipeline routing will avoid forests as far as possible.

the proposed pipeline, the latter option may be the most practical offset strategy, if the offset approach is adopted.

6.2 Alien invasive plants

6.2.1 Impact description

The impact of exotic plants, often described as ‘alien invasive plants” is particularly significant within the IOCB as climatic and edaphic conditions are suitable for their establishment, while regular disturbance and high levels of anthropogenic driven disturbance promotes the establishment of such exotic plants. A number of plants are listed in terms of the National Environmental Management Biodiversity Act (NEMBA), while others are not listed but are considered to be problematic (e.g *Vitex agnus castis* – which is a common invader on coastal dunes). Alien plants act to alter the structure of various natural habitats, with such changes being manifested in the ethos or behaviour of fauna. Alien plants may act to reduce the effective habitat of a number of rare or endangered species. Such species are driven by disturbance including not only high level transformation experienced during the construction phases of projects, but during maintenance and other activities. It follows that a linear development such as a pipeline will act as a repository for propagules of exotic plants and will also serve as a conduit along a particular route for the spread of such species.

6.2.2 Mitigation

Mitigation measures may be set in place within the gas pipeline servitude which can include:

- Regular review of the pipeline servitude and consideration of the species emergent and established within the servitude.

- Regular (at least bi-annual) exotic vegetation control using the most appropriate and specific measures to control exotic species that have established, for example the use of applicable herbicides or in some cases fire or manual removal.

- Regular education programmes for staff to assist in the identification of existing species of invasive plants and to identify other possible species that may affect the servitude.

6.3 Disturbance of fauna

6.3.1 Impact description

Faunal distribution across the IOCB is sporadic but expansive and often associated with differing habitats and niche environments. A number of species have adapted to transformed environments and may be considered to be associated with such environments (e.g cane rat *Thryonomys swinderianus*). Other species are only known from specific sites and are intrinsically associated with these areas (e.g. Whitish Amakosa Rocksitter, *Durbania amakosa albescens).*

It follows that disturbance to habitat will see a response from fauna within the affected area that may range from simple relocation to other habitat or in the case of *D amakhosa albescens*, possible localised extinction.

6.3.2 Mitigation

The management of habitats in and adjacent to the servitude is perhaps the most significant mitigation measure that can be applied in respect of faunal populations affected by the gas pipeline. Such mitigation may commence within the planning and construction phase, where avoidance measures may be practiced to ensure the retention of key species and habitats in or proximal to the pipeline. During construction, the flushing or active capture and removal of species from the working area, may be undertaken. In addition, the management of exotic vegetation within the servitude may act to improve habitat integrity and therefore indirectly promote or preserve the presence of key species.

6.4 Constraining of conservation initiatives

6.4.1 Impact description

The identification of areas outside of the formally protected areas within the IOCB and avoiding other areas of ecological importance in the biome is being identified as an important guideline for the identification of an appropriate route. While such an approach may be a rational one to the identification of such servitude from a contemporaneous perspective, such routing, depending upon where it is located does serve to constrain the expansion and connection of protected areas.

In the declaration of protected areas, it is clear that following the proclamation process, the pipeline and servitude itself will remain the property of a third party with differing management objectives to that of the conservation authority. In practical terms this state would mean that the requirement to maintain the servitude, conduct regular inspections, maintain access and undertake pipeline maintenance will create additional disturbances and constraints that may hinder the management of the protected area. A case in point is the Opathe – Imfolozi corridor, which is a long term initiative to link these two reserves for the benefit of land conservation and migration of larger fauna.

6.4.2 Mitigation

To avoid or reduce the likelihood of constraining protected area expansion, where this may apply, the utilisation or adherence to extensive buffer zones around protected areas may be successful mitigation as would the avoidance of placing the servitude between proximal protected areas, where connection and expansion is likely to form a conservation objective. In addition, it may be useful to align vegetation management programmes and objectives along the servitude with that of the conservation authority, if this is feasible.

7 RISK ASSESSMENT

7.1 Consequence levels

The following Consequence levels have been assigned:

Vegetation Loss	
Extreme	80 to 100 % loss of coverage of an isolated natural habitat, forest or azonal vegetation type
Severe	60 to 80 % loss of coverage of an isolated natural habitat, forest or azonal vegetation type
Substantial	40 to 60 % loss of coverage of an isolated natural habitat, forest or azonal vegetation type
Moderate	20 to 40 % loss of coverage of an isolated natural habitat, forest or azonal vegetation type
Slight	<20 % loss of coverage of an isolated natural habitat, forest or azonal vegetation type or any level of clearance of agricultural land, secondary vegetation and exotic vegetation.

Faunal disturbance	
Extreme	The loss of an isolated natural population where no opportunity exists to save the individuals/trapped individuals cannot be rescued.
Severe	The loss of an isolated natural population where opportunity exists to rescue and relocate up to 50 % of the affected individuals/trapped individuals can be rescued but the potential for survival is <50 %
Substantial	The loss of an isolated natural population where opportunity exists to rescue and relocate more than 50 % of the affected individuals/or the loss of individuals due to the disturbance will be partial/ trapped individuals can be rescued but the potential for survival is 50 %
Moderate	No loss of an isolated population but affected individuals have limited opportunity to move away/trapped individuals can be rescued and survival is >50 %.
Slight	No loss of an isolated population and affected individuals can move away freely/trapped individuals can be rescued and survival is a certainty.

Potential conservation loss	
Extreme	The pipeline passes through a protected area, game farm, nature reserve, and/or stewardship area.
Severe	The pipeline passes along the boundary of a protected area, game farm, nature reserve, stewardship area.
Substantial	The pipeline passes through the buffer zone surrounding a protected area, game farm, nature reserve, stewardship area.
Moderate	The pipeline passes along the edge of the buffer zone surrounding a protected area, game farm, nature reserve, stewardship area.
Slight	The pipeline passes outside the buffer zone of a protected area, game farm, nature reserve, stewardship area.

7.2 Risk assessment results

The risk assessment results are provided below in Table 10. The risks have been maintained for the mitigation/management measures as none of the proposed mitigation or management measures will reduce the risk of the impact, only the severity of the impact. The only way of reducing the risk of the impacts is to practice avoidance. Where the more sensitive areas are avoided, the lower will be the risk of an impact occurring. Should an impact occur (i.e. the risk cannot be reduced through avoidance) mitigation and management will reduce the severity of the impact and ultimately the consequence of the impact. Avoidance can also reduce the likelihood, severity and consequence of an impact. Figure 26 illustrates the importance and effectiveness of using avoidance options as the favoured mitigation option. In this example, a patch of Northern Coastal Forest (near Park Rynie on the KZN South Coast) will be affected by the red alignments. They will also be affected, but to a lesser degree, by the yellow alignment and completely unaffected by the green route alignment. The forest patch is surrounded by sugar cane and any alignment outside of the forest footprint will significantly reduce the likelihood, consequence and risk of an impact occurring. If such avoidance cannot be provided, other mitigation options may reduce the impacts slightly – such as plant rescue, revegetation (not rehabilitation) and AIP management. Rehabilitation is not an option due to the nature of the pipeline. As such, the forest cannot recover and will be permanently lost. This may not necessarily be a serious concern in other vegetation types however, the likelihood of remaining forests being disturbed (outside of protected areas) within the IOCB is considered to be highly likely. For this reason the reliance on rehabilitation based mitigation measures is cautioned, as in many cases they will not effectively mitigate the impact.

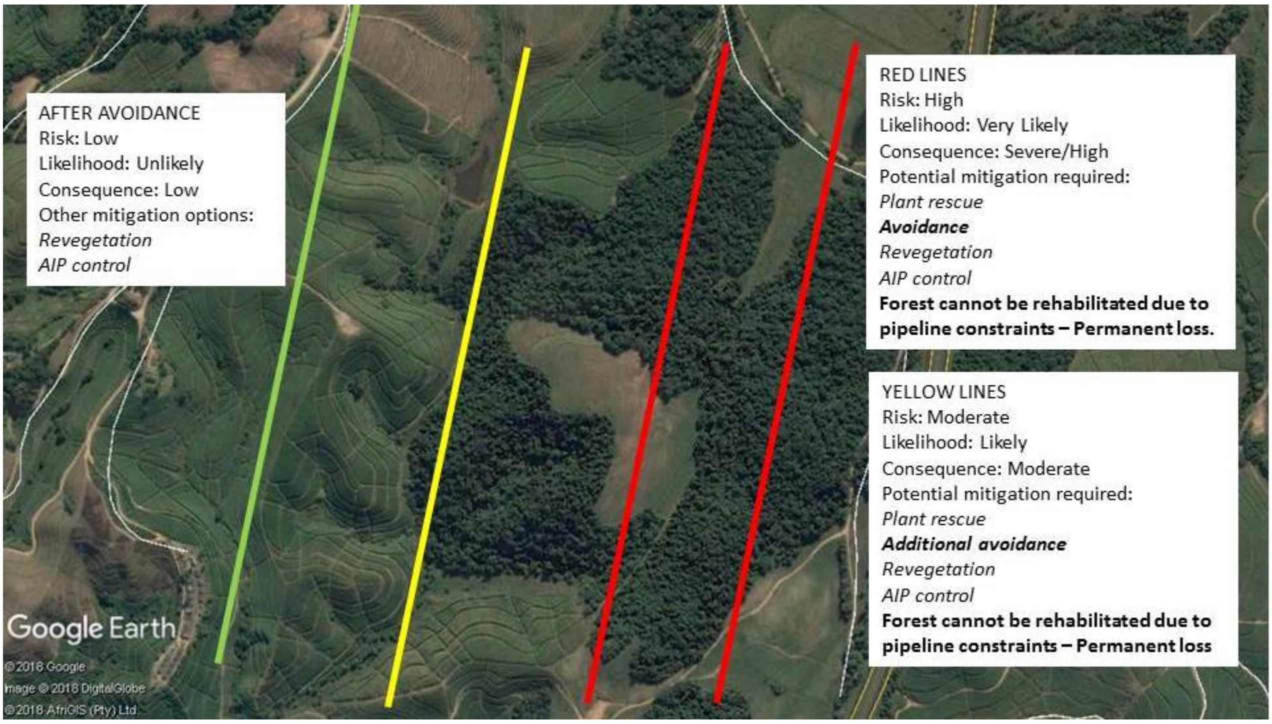

Figure 26: An example of pipeline alignments and associated risk, likelihood and consequence ratings. The image features a very likely scenario, where forest habitat will be impacted within the IOCB.

7.3 Limits of Acceptable Change

Due to the extent of transformation within the IOCB, there is an accepted "no net loss" policy that is applied to remaining natural and intact habitat. Based on this, avoidance should be applied wherever possible with a focus on minimising habitat loss or change wherever it may occur. As such, the limits of acceptable change are very small, with very little leeway. As discussed in the text above, remaining pockets of vegetation that may be considered primary habitat and indeed many areas of secondary habitat, should not be subject to change.

Table 10: Risk assessment of potential impacts associated with gas pipeline development in the IOCB (Gas Pipelines Phases 4 & 7).

Impact	Location /Sensitivity	Without mitigation			With mitigation - Avoidance			With mitigation - Other		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Disturbance and transformation of natural vegetation	Very High	Severe	Likely	High	Slight	Unlikely	Very Low	Severe	Likely	High
	High	Substantial	Likely	Moderate	Slight	Unlikely	Very Low	Substantial	Likely	Moderate
	Medium	Slight	Likely	Very Low	Slight	Likely	Very Low	Slight	Likely	Very Low
	Low	Slight	Very Likely	Very Low	Slight	Likely	Very Low	Slight	Likely	Very Low
Alien invasive plant species	Very High	Severe	Likely	High	Slight	Unlikely	Very Low	Substantial	Not likely (mitigation = AIP control)	Moderate
	High	Substantial	Likely	Moderate	Slight	Unlikely	Very Low	Moderate	Not likely (mitigation = AIP control)	Low
	Medium	Moderate	Likely	Low	Moderate	Likely	Low	Slight	Not likely (mitigation = AIP control)	Very Low
	Low	Moderate	Likely	Low	Moderate	Likely	Low	Slight	Not likely (mitigation = AIP control)	Very Low
Disturbance of fauna	Very High	Substantial	Likely	Moderate	Substantial	Unlikely	Moderate	Substantial	Very Likely	High
	High	Moderate	Likely	Low	Moderate	Not Likely	Low	Moderate	Likely	Low

Impact	Location /Sensitivity	Without mitigation			With mitigation - Avoidance			With mitigation - Other		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
	Medium	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low
	Low	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low
Loss of conservation importance	Very High	Extreme	Very Likely	Very High	Moderate	Likely	Low	Severe	Very Likely	High
	High	Substantial	Likely	Moderate	Moderate	Likely	Low	Substantial	Likely	Moderate
	Medium	Moderate	Likely	Low	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low
	Low	Slight	Likely	Very Low	Slight	Unlikely	Very Low	Slight	Unlikely	Very Low

8 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

In establishing the gas pipeline within the IOCB some broad "best practice" methods should be implemented at the planning, construction and operational stages of the project. These are discussed below.

8.1 Mitigation

As fauna are directly associated with the occurrence of habitat impact on specific species and fauna in general can best be reduced through:

- The avoidance of key habitats – normally those associated with critically endangered vegetation types;
- An understanding of expected fauna within habitat affected by the pipeline;
- Relocation of fauna from site through search and capture operations;
- The flushing of fauna from areas; and
- Exclusion of fauna by the cordoning of habitats in advance of construction operations.

8.2 Planning phase

Evidently this SEA and its associated evaluations are part of the planning process associated with the gas pipeline. The identification and mapping of these areas is considered to be the first stage in employing "best practice" within the project scope. However, during the more advanced levels of planning it would be important to ensure that:

- Routes proposed within the approved corridors are placed as close to existing transformed areas (which include settlement or peri-urban environments, road and rail infrastructure and existing pipelines) as possible, provided there are no incompatibility with current land uses or constraints from a design perspective; and
- Ecological drivers are identified within the routes including edaphics and lithic factors and that habitats that may be irreparably affected by such disturbance through excavation are avoided (e.g. sand forest).

8.3 Construction phase [location, footprint, procedures]

During the construction phase of the project, particular attention should be paid to the following factors:

- The delimiting of working sites and the cordoning thereof. Such actions will prevent the incremental expansion of areas into habitat and environments that lie outside of the working servitude.

- A prudent approach to the siting of construction phase laydown areas, access roads for construction vehicles and similar temporary works should be taken that ensures minimal disturbance to important habitats.

- Sound "housekeeping" of construction areas should be implemented. Such measures include control of solid and liquid materials used in construction, particularly those that may be deemed "hazardous", as well as control of labour and machinery on site. Waste management forms an important aspect of construction, particularly in rural areas where appropriate disposal methods may be problematic.

- Where plant rescue operations have been performed, management and auditing of plants that have been repatriated or are placed in nursery, should be undertaken on a regular basis.

8.4 Operations phase

Once constructed and operational, it is understood that regular maintenance will be undertaken in the pipeline servitude. Appropriate protocols should include:

- A programme for management should be compiled and adhered to that includes:
    - Vegetation management regime. This programme should indicate how and when vegetation growth within the corridor will be undertaken (i.e. mowing with brush cutter or tractor slasher; what season and response to exotic weed invasion).
    - Redress of excavations within pipeline servitudes – the reinstatement of ground once repairs to the pipeline have been instituted, where required.

- Route management should include aspects such as the identification and logging of fauna and faunal activities within the servitude (e.g. records of species active within the corridor – such as active burrowing by aardvark or porcupine). While academic, such monitoring may assist with the identification of problem animals.

8.5 Rehabilitation and post closure [methods, standards]

Post construction methods of stabilising the pipeline route can include:

- Rehabilitation – the planting of a mix of seral related plant species within affected areas and their management towards a climax habitat form.
- Revegetation – the planting of a management aligned habitat that serves the requirements of the pipeline management.

The rehabilitation option may not apply to the pipeline servitude on account of management options, but may be utilised at points such as laydown areas and other disturbed environments. Such areas may be useful for the placement of “rescued” plant species and should be managed to approximate the species composition associated with the relevant habitat.

Revegetation is likely to comprise of the stabilisation of areas using a basic grass mix and perhaps additional factors such as soil stabilising geofabrics and other stormwater management measures. Exotic weed control is considered to also be an important aspect of such measures.

8.6 Monitoring requirements

Due to the extent of the pipeline area, the use of GIS is recommended as an important tool in the long term management of the route. The following methods are recommended in the long term management of the pipeline:

1. The proposed working servitude should be provided as a .shp file, which can be overlain on periodic aerial photography. From this information changes in vegetation form and structure along the line route can be identified and consideration of the origin of such change may be made.
2. Species occurrence, where observed can also be identified and where significant appropriate conservation management approaches can be made in that particular portion of the pipeline.
3. Exotic weed control measures can be managed on a spatial level with such data including areas that have been addressed through weed control measures, as well as areas requiring increased control measures. Exotic species presence or absence may also be identified and measured along the pipeline.
4. Faunal species, where observed, may also be identified using spatial data, with such information including rare or protected species records, as well as possible nuisance animal aspects.

9 GAPS IN KNOWLEDGE

In reviewing the data and information relating to the IOCB, the following important deficits in information are apparent:

- A difference between the available data for KwaZulu-Natal and the Eastern Cape is evident. More data was available for Kwazulu-Natal including detailed spatial data sets and specific point data. The inclusion of the Draft ECBCP (2017) provided additional data, comparable to the EKZN Wildlife CBA and improved the available data for interpretation for the Eastern Cape. These two data sets where however not directly comparable due to slight differences in assigned categories. This creates a lack of connectivity of data between the two provinces and highlights the interpretational challenges faced when comparing the sensitivity of a single biome than split between two provinces with data inconsistencies. Where possible the closest comparisons (categories) were used to apply sensitivity ratings and maintain a level of consistency.
- Faunal records are limited to primarily, conservation areas and areas where monitoring is safe to undertake e.g. gated residential estates, protected areas. As such the presence of larger fauna can only effectively be correlated with habitat, rather than observation. This situation clearly skews the data, rendering its use at a fine scale level of spatial analysis, dubious. The data is however useful for supporting the importance of certain intact habitat, where there is a correlation.
- Transformation across the IOCB region is both rapid and generally pervasive. Such a state renders the accuracy of such spatial information to be of limited temporal duration. In this regard the importance of site specific evaluations during the project specific Environmental Authorisation and detailed planning phases is very high.

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APPENDIX A – PEER REVIEW AND SPECIALIST RESPONSE SHEET

Peer Reviewer: Duncan Hay, Catherine Pringle, and Leo Quayle, Institute of Natural Resources

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
Catherine (Kate) Pringle	3	7-35		The following acronyms are missing from the "List of Acronyms": IOCB; PCE	These acronyms were present
Catherine (Kate) Pringle	6	1-18		The following information is missing from the summary: where is the IOCB, what methods were used in the assessment of potential impacts, what were the key findings, and what are the recommendations?	I have made a minor addition
Catherine (Kate) Pringle	6	25		There are two spaces between "perspectives." and "The establishment of...". This should be changed to a single space	Done
Catherine (Kate) Pringle	6	27		There should be a space between "IOCB" and "As such..."	Done
Catherine (Kate) Pringle	6	31		"Evaluate and recommend" may read better as "evaluate and provide recommendations on.."	Done
Catherine (Kate) Pringle	7	4		"The IOCB is one of the approximately" should read "The IOCB is one of approximately" Remove the "the"	Done
Catherine (Kate) Pringle	7	12		"This strategic *environmental* assessment"?	Done
Catherine (Kate) Pringle	8-11	1-1		Section 3.1. Study Methodology is not clear on the process that was followed. It may be useful to be more specific on the steps that were followed and to cross reference these with the relevant section where a more detailed methodology is provided. For example: Identified key attributes and sensitivities in the IOCB, including vegetation types (Section 5.1.1) and Fauna (Section 5.1.1); Undertook feature sensitivity mapping (Section 5.3), Applied four tier sensitivity rating to identify potential impacts (Section 5.4) etc.	The template which we were asked to follow did not have a detailed methodology section. The methods followed are fairly standard throughout all the specialist studies and I think details thereof will be highlighted in the main report. I have made some minor adjustments.
Catherine (Kate) Pringle	9-11	17-1	Table 1	Check formatting of this table. Should it not be single line spacing?	We used the table formatting that was provided in the template. I assume appropriate formatting will be applied by CSIR? Note from the CSIR: The reports will be formatted.
Catherine (Kate) Pringle	11		Table 1	Re Ecoregion data. The data source is given as SANBI, but no date is provided. Please include the date.	The dataset we were given is undated. The ecoregions are based on Burgess (2004) as described in Mucina and Rutherford (2006).

<table>
<tr><td colspan="5" rowspan="2">EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development</td><td>Change has been effected in the report</td></tr>
<tr><td>No change has been effected in the report (i.e. not required and supported by response by Specialist)</td></tr>
<tr><td>Expert Reviewer Name</td><td>Page Range</td><td>Line/s</td><td>Table/ Figure</td><td>Expert Reviewer Comments</td><td>Response from Specialist</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>11-12</td><td>1-31</td><td></td><td>Section 3.2. Assumptions and limitations. This section should align with the section on "Gaps in knowledge" (Section 9). A couple of limitations have been omitted from this section. For example: the difference in available data between the Eastern Cape and KZN.</td><td>Additions have been made to Section 3.2</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>11</td><td>20-22</td><td></td><td>The text states that “the assumption is the forest biomes will largely not be considered for the development of the gas pipeline”. Has this assumption been agreed? And is the agreement documented somewhere? If so, the relevant reference needs to be provided.</td><td>I think this has come up in discussions during team workshops. There is no forest biome specialist and it is a general understanding that forest habitat will be treated as highly sensitive and be avoided so far as possible. I don’t think anything has been specifically put in writing. I have reworded slightly.</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>12</td><td>4</td><td></td><td>Replace "around" with "on"</td><td>Done</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>12</td><td>1-12</td><td></td><td>Section 3.2.3 is a bit misleading as it implies that data on fauna was not considered, when in fact it was. I would suggest that you start this section by saying that fauna were considered using xxxx data. However, other data on fauna, such as direct observations were excluded from the assessment as this data is based on observation records which are skewed to particular places such as protected areas etc.</td><td>Faunal point data provided was not considered in the sensitivity assessment, only as supporting evidence when considering specific areas - i.e. the importance of protected areas, certain CBA areas, forest reserves etc. The faunal data was supplementary and not a focal point of this study.</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>12</td><td>15</td><td></td><td>The first sentence in this paragraph is very long and confusing. I suggest shortening and re-wording.</td><td>Addressed</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>12</td><td>18</td><td></td><td>I presume the second sentence relates to the impact of rapid land transformation on the accuracy of the data? I suggest that you re-word this sentence to make this more explicit.</td><td rowspan="2">I have given these two sections an overhaul. There was overlap. The revised version should make more sense. 3.2.4. refers only to the limited extent of the IOCB and potential issues with neighbouring biomes, while 3.2.5 now refers only to data deficiencies, transformation and spatial contradictions.</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>12</td><td>24</td><td></td><td>It is not clear how section 3.2.4 and section 3.2.5 differ from one another. Do they both relate to the impact of rapid land transformation on the accuracy of the data?</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>12</td><td>26</td><td></td><td>This sentence requires a reference. I suggest Jewitt D, Goodman PS, Erasmus BFN, O’Connor TG, Witkowski ETF. Systematic land-cover change in KwaZulu-Natal, South Africa: Implications for biodiversity. S Afr J Sci. 2015;111(9/10), Art. #2015-0019, 9 pages. http://dx.doi.org/10.17159/sajs.2015/20150019</td><td>Added, thank you!</td></tr>
<tr><td>Catherine (Kate) Pringle</td><td>13</td><td></td><td>Table 2</td><td>All Acts in this table should have the Act No and date included e.g. National Environmental Management:</td><td>Added for NEMPA</td></tr>
</table>

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
				Protected Areas Act 57 of 2003.	
Catherine (Kate) Pringle	13		Table 2	There are several instruments which are relevant but have been omitted from this table. For example, the Convention on Biodiversity should be included under international instruments. At a National level, the Constitution should be listed, with specific reference to Section 24. NEMA should then be listed first as it gives effect to the Constitution. Following NEMA should be all the specific environmental management acts (SEMAs). These include the ones that you have listed plus the Integrated Coastal Management Act 26 of 2008. I think you also need to list some other key national laws which have relevance e.g. National Forests Act, Sea Shore Act(?), National Heritage Resources Act.	National Forest Act was included. The coastal zone is not considered in this report. The estuarine specialist with deal with the ICMA. Any references to seashore vegetation, estuaries or coastal dynamics are purely descriptive. Not sure I follow the inclusion of the constitution? I am also not entirely sure of the applicability of the NHRA to this study - cultural and heritage resources are being covered in another study. Note from the CSIR: Relevant legislation will be detailed in the Integrated Biodiversity Assessment Report and SEA Report (including the chapter on Additional Impacts, which deal with Heritage Impacts (amongst other issues)).
Catherine (Kate) Pringle	14		Table 2	The KwaZulu-Natal Nature Conservation Management Act 29 of 1992 has been replaced by the KwaZulu-Natal Nature Conservation Management Act 9 of 1997.	Corrected
Catherine (Kate) Pringle	14		Table 2	The nature conservation laws for the Eastern Cape are not included. I think that the Cape Ordinance 19 of 1974 and the Nature Conservation Act 10 of 1987 still apply, but this should be checked.	Added
Catherine (Kate) Pringle	15	1		"As a consequence of the excavation of the pipeline, deep excavations below..." may read better as "As a consequence of the excavation *for* the pipeline, the upper soils horizons will be disturbed"	Done
Catherine (Kate) Pringle	15	3		The sentence starting "Such disturbance..." should be split in two. "....habitat form. However, in other habitats...."	Done
Catherine (Kate) Pringle	15	6-7		I would suggest putting the following brackets to improve the readability of the sentence (in addition to factors such as fire and grazing)	Done
Catherine (Kate) Pringle	15	17		This sentence doesn't make sense.	I think I have cleaned it up.
Catherine (Kate) Pringle	16	16		I am not sure what you mean by "species ethos"?	Behaviour - I have changed this for clarity
Catherine (Kate) Pringle	16	28		Diceros bicornis should be in italics	This section has been removed and replaced
Catherine (Kate) Pringle	16	30		"we" should be "are"	Done
Catherine (Kate) Pringle	18	8		Will cessation of the fire regime really occur? Surely with an	I have proposed removing this entire sentence as it does

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
				increase in grass rather than shrub species, fire could increase?	not make sense in hind sight.
Catherine (Kate) Pringle	18	22		5 and 6 should be written in full	Done
Catherine (Kate) Pringle	18	27		I am not sure what the (5) is there for?	Neither am I. Removed.
Catherine (Kate) Pringle	19		Table 4	Is Table 4 adapted from Mucina and Rutherford 2006. If so, the citation should be included in the table heading	Done
Catherine (Kate) Pringle	19		Table 4	For consistency, all sentences in the "distribution" column should end with a full stop.	Noted
Catherine (Kate) Pringle	22		Table 5	All species names should be italicised	Noted
Catherine (Kate) Pringle	25		Figure 3	I presume this data is based on Mucina and Rutherford 2006. The citation should be included in the figure heading.	SANBI (2012) vegetation map. Citation added.
Catherine (Kate) Pringle	25		Figure 4	I presume this data is based on Mucina and Rutherford 2006. The citation should be included in the figure heading.	
Catherine (Kate) Pringle	31	1		I presume that section 5.1.1.6 summarises data from Mucina and Rutherford 2006. This should be referenced accordingly.	Done
Catherine (Kate) Pringle	31		Table 6	All descriptions in the table should end with a full stop. The relevant citation should also be included in the table heading.	Noted
Catherine (Kate) Pringle	36	21		Figure 144 should be Figure 14	Fixed
Catherine (Kate) Pringle	37	18		Figure 166 should be Figure 16	
Catherine (Kate) Pringle	45	11		NPAES should be in full followed by the acronym in brackets	Done
Catherine (Kate) Pringle	45	32-36		This section only discusses private nature reserves. What about game farms? These may fall outside of the IOCB but if not should be included. They are very important, particularly in northern KZN where they form part of corridors and part of the black rhino expansion project.	Game farms are included. I have made this clear.
Catherine (Kate) Pringle	46	4		Programmes should be agreements. As I understand it, there is only one overarching Stewardship Programme in KZN.	Noted
Catherine (Kate) Pringle	47	8		The date of the National Land Cover should be included.	Provided by SANBI 2017
Catherine (Kate) Pringle	47	7-15		This section 5.3.1.10 does not discuss the field crop boundaries which are listed under land cover in Table 8. A description of this layer should be provided.	Noted. Practically the FCB data was included in the National Landcover, so although used was not significant data.

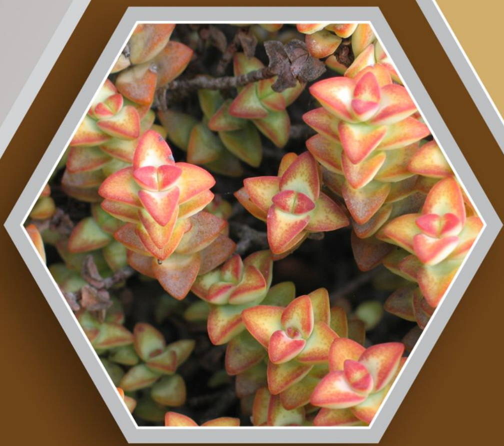
EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
Catherine (Kate) Pringle	48	8		"A 5km buffer layer.." should be bulleted.	Done
Catherine (Kate) Pringle	49		Table 8	Ecoregion feature class. A date should be provided for the SANBI layer.	Noted
Catherine (Kate) Pringle	51		Table 9	KZN CBA Irreplaceable have only been scored as "High". I would suggest that these should be "Very high" as they are areas that are required to meet biodiversity targets.	In other areas of KZN, I agree, but, within the IOCB much of these "irreplaceable" areas have been transformed or are isolated. This particular point is being investigated further through more detailed scrutiny of the transformed and CBA data layers.
Catherine (Kate) Pringle	51		Table 9	Private nature reserves and game farms. Game farms are listed as being considered but this is not expressed in the text.	Addressed
Catherine (Kate) Pringle	62	22-23		There should be a space between the sections.	The word version I have shows a gap (?)
Catherine (Kate) Pringle	64	28		Double space after "environments"	Corrected
Catherine (Kate) Pringle	65	16		"While such approach…." may read better as "While such an approach may be a rational one…"	Corrected
Catherine (Kate) Pringle	66	1		How did you arrive at the thresholds for your consequence levels?	These were based on the methodology for the risk assessment provided in the report template. Apart from specialist knowledge these were derived fairly arbitrarily.
Catherine (Kate) Pringle	67	3		Areas should be area	Corrected
Catherine (Kate) Pringle	69		Table 10	It is not clear how you integrated sensitivity, consequence and likelihood to arrive at the risk category. For example, why does a high sensitivity coupled with a moderate consequence and a likely likelihood have a low risk category? This integration approach needs to be made explicit.	This was completed based on methodology provided in the template. See below table taken from methodology - the scenario appears acceptable based on the method. The particular comment you raised is for disturbance of fauna - larger fauna will simple move from the track of the impending disturbance, thus although the area might be rated as sensitive, the actual risk to fauna will be low. It is likely that the fauna will be disturbed, but it is unlikely that they will be killed, or their behaviour altered (apart from avoiding the area).
Catherine (Kate) Pringle	73	5		This sentence should be bulleted.	Done
Catherine (Kate) Pringle	74	27		This space should be deleted.	Done
Catherine (Kate) Pringle	75-76			There are inconsistencies in the referencing styles. For example, some references include the dates in brackets others don't, the publisher name is missing from all book references. These require a thorough check.	Hopefully corrected

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
Catherine (Kate) Pringle	75-76	1-36		The following references are included in the reference list but not cited in the text: Little & Jansen 1995, van Aard et al 1998, van Aarde 2009, Zonneveld et al 1990.	Removed
Catherine (Kate) Pringle	General query			Has Mucina and Rutherford 2006 been used synonymously with the SANBI vegetation Map 2012 throughout the report? If so, this should be made explicit.	No, separately
Catherine (Kate) Pringle	General query			The TOR requires that ground-truthing of specific areas within the corridors be undertaken. Has this been done? If so, how have the datasets been updated to include this information? This is not included in the text.	Yes. The transformed land use layer is being reviewed in detail. Due to the nature of the IOCB, there has been a lot of interest in it an there is a lot of available data, more so KZN than the EC. One of the issues was overlap of data, more so than gaps. From early on it was clear that the IOCB is highly transformed and prioritising the transformed layer will guide and naturally refine the sensitivity layers – what is not transformed, must then be sensitive. Ground-truthing – through review of recent aerial photography and driving up and down the IOCB (not all dedicated field trips specifically for this purpose) the extent of transformation became clear as did areas where the transformation layer needed to be adjusted – basically expanded. These adjustments were minor relative to the total area i.e. closing up a small gap, or changing the shape of a polygon slightly to improve the accuracy. When viewed at the biome scale these changes are barely noticeable – an area that had small specs of red showing through small gaps, now shows fewer small specs, or no specs. As a result, the ground truthing did not add any significant data, it purely resulted in minor adjustments (and in most cases no adjustments) to existing data. Most of the results of ground-truthing have not been directly mentioned in the report as they have not resulted in anything new being presented, only confirming what is already represented or inadvertently clarifying queries or concerns raised through the review process.
Catherine (Kate) Pringle	General query			The ToR requires the "Identification of additional features". Are there any relevant planning tools, such as Environmental Management Frameworks (EMFs) which may provide additional insights?	None that we are aware of for the IOCB

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from Specialist**
Catherine (Kate) Pringle	General query			The TOR requires that the National Biodiversity Assessment 2011 is considered. How has this been done?	Specific consideration was taken of the gazetted Threatened Ecosystems 2011
Catherine (Kate) Pringle	General query			It is assumed that soil and agriculture are considered elsewhere. If not, this is a major oversight.	This is considered by other relevant specialists.

Impact	Study area	Location	*Without mitigation*			*With mitigation*		
			Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Impact 1: Ecological and biodiversity impacts	1	Very high sensitivity area	Slight	Likely	Very low	Slight	Likely	Very low
		High sensitivity area	Moderate	Likely	Low	Slight	Not likely	Very low
							(mitigation = avoid)	
		Medium sensitivity area	Severe	Likely	High	Severe	Not likely	Moderate
							(mitigation = avoid)	
		Low sensitivity area	Extreme	Very Likely	Very high	Extreme	Not likely	Moderate
							(mitigation = avoid)	
	2	Very high sensitivity area	Slight	Likely	Very low	Slight	Likely	Very low
		High sensitivity area	Moderate	Likely	Low	Slight	Likely	Very low
		Medium sensitivity area	Substantial	Likely	Moderate	Substantial	Not likely	Low
							(mitigation = avoid or offset)	
		Low sensitivity area	Severe	Very likely	High	Severe	Not likely	Moderate
							(mitigation = avoid or offset)	

Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa



Appendix C.1.4

Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Succulent and Nama Karoo Biomes

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

NAMA KAROO, SUCCULENT KAROO AND DESERT BIOMES

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ABBREVIATIONS AND ACRONYMS

AIS	Alien Invasive Species
BOTSOC	Botanical Society of South Africa
CBA	Critical Biodiversity Area
CESA	Critical Ecological Support Area
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DEADP	Department of Environmental Affairs and Development Planning
DWA	Department of Water Affairs
ECPAES	Eastern Cape Protected Area Expansion Strategy
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
EN	Endangered
ESA	Ecological Support Area
IUCN	International Union for Conservation of Nature
LM	Local Municipality
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Areas
NPAES	National Protected Area Expansion Strategy
ONA	Other Natural Area
PA	Protected Area
REDZ	Renewable Energy Development Zone
SANBI	South African National Biodiversity Institute
SAPAD	South African Protected Areas Database
SCC	Species of Conservation Concern
SEA	Strategic Environmental Assessment
UCT	University of Cape Town
VU	Vulnerable
WCBSP	Western Cape Biodiversity Spatial Plan

1 SUMMARY

This assessment aims to identify the potential impacts of constructing and maintaining gas pipeline infrastructure in the Nama and Succulent Karoo biomes, as well as the Desert biome of South Africa.

Key environmental attributes of the Nama and Succulent Karoo biomes (including the Desert biome) in the proposed Phased Gas Pipeline corridors include:

- High diversity and endemism for succulent plants;
- High diversity and endemism for fauna, especially reptiles;
- Extensive degradation due to overgrazing (e.g. sheep, goats and ostrich);
- Habitat destruction due to large scale crop cultivation and surface mining;
- Increased desertification due to unsustainable land use and climate change; and
- Establishment of alien invasive (plant) species.

The activities associated with gas pipeline construction and maintenance may pose a risk of habitat destruction and degradation, establishment and spread of invasive plants, increased soil erosion, faunal displacement, poaching of rare and endangered fauna and flora, as well as cumulative impacts on broad-scale ecological processes.

2 INTRODUCTION

The purpose of this assessment is to identify the potential impacts of gas pipeline construction and maintenance to the Nama Karoo, Succulent Karoo and Desert biomes of South Africa. Furthermore, it recommends management actions and best practice mechanisms to avoid and minimise any potential impacts to sensitive Karoo and Desert ecosystems.

This assessment forms part of an overarching Strategic Environmental Assessment (SEA) which ultimately aims to guide sustainable development and environmental decision-making on proposed phased gas pipeline construction and maintenance in South Africa.

Note that this Specialist Assessment Report was peer reviewed prior to release to stakeholders for review. The report was updated, as required, following the peer review findings. A copy of the peer review report and responses from the Specialist Team is included in Appendix A of this report.

3 SCOPE OF THIS STRATEGIC ISSUE

3.1 Data Sources

This analysis has made extensive use of data resources arising from the following datasets listed below in Table 1:

Table 1. Available spatial datasets used to assess terrestrial ecological features in this assessment.

Data Source	Summary
Northern Cape Department of Nature and Conservation (DENC). (2016). Critical Biodiversity Areas (CBAs) of the Northern Cape. http://bgis.sanbi.org/.	The Northern Cape CBA Map identifies biodiversity priority areas, CBAs and Ecological Support Areas (ESAs), which, together with Protected Areas, are important for the persistence of a viable representative sample of all ecosystem types and species, as well as the long-term ecological functioning of the landscape as a whole.
CapeNature. (2017). Western Cape Biodiversity Spatial Plan 2017. http://bgis.sanbi.org/.	The Western Cape Biodiversity Spatial Plan (WCBSP) is the product of a systematic biodiversity planning assessment that delineates CBAs and ESAs which require safeguarding to ensure the continued existence and functioning of species and ecosystems, including the delivery of ecosystem services, across terrestrial and freshwater realms. These spatial priorities (i.e. CBAs and ESAs) are used to inform sustainable development in the Western Cape Province.
Eastern Cape Department of Economic Development, Environmental Affairs and Tourism (DEDEAT). (2017). Eastern Cape Biodiversity Conservation Plan Handbook. DEDEAT: King Williams Town. Compiled by G. Hawley, P. Desmet and D. Berliner. Draft version, December 2017.	Significant strides have been made with respect to refining the spatial representation of biodiversity pattern and biodiversity processes, as well as establishing standardised minimum requirements for spatial biodiversity planning that ensure a level of consistency throughout the country (SANBI, 2017). The Eastern Cape Biodiversity Conservation Plan 2017 is a tool that guides and informs land use and resource-use planning and decision-making in the Eastern Cape by a full range of sectors whose policies, programmes and decisions impact on biodiversity, in order to preserve long-term functioning and health of priority areas, i.e. CBAs and ESAs.
Department of Environmental Affairs (DEA). (2018). South African Protected Areas Database (SAPAD). Q2, 2018. https://egis.environment.gov.za/.	Protected areas as defined in the National Environmental Management: Protected Areas Act, (Act 57 of 2003) (NEM:PAA). Protected areas: • Special nature reserves; • National parks; • Nature reserves; • Protected environments (1-4 declared in terms of the National Environmental Management: Protected Areas Act, 2003); • World heritage sites declared in terms of the World Heritage Convention Act; • Marine protected areas declared in terms of the Marine Living Resources Act; • Specially protected forest areas, forest nature reserves, and forest wilderness areas declared in terms of the National Forests Act, 1998 (Act No. 84 of 1998); • Mountain catchment areas declared in terms of the Mountain Catchment Areas Act, 1970 (Act No. 63 of 1970).

Data Source	Summary
DEA. 2016. National Protected Areas Expansion Strategy for South Africa.	The goal of the NPAES is to identify focus areas for land-based protected area expansion and to achieve cost effective protected area expansion for improved ecosystem representation, ecological sustainability and resilience to climate change. It sets protected area targets, maps priority areas for protected area expansion, and makes recommendations on mechanisms to achieve this.
South African National Biodiversity Institute (SANBI). (2018). Vegetation Map of South Africa, Lesotho and Swaziland. http://bgis.sanbi.org/.	Update of the Vegetation Map of South Africa, Lesotho and Swaziland (Mucina & Rutherford 2006) based on decisions made by the National Vegetation map Committee and contributions by various partners.
RAMSAR Sites Information Services www.ramsar.wetlands.org	Distribution and extent of areas that contain wetlands of international importance in South Africa.
Geoterraimage. (2015). 2013-2014 South African National Land-Cover. DEA. Geospatial Data. https://egis.environment.gov.za/.	Recent global availability of Landsat 8 satellite imagery enabled the generation of new, national land-cover dataset1 for South Africa, circa 2013-14, replacing and updating the previous 1994 and 2000 South African National Landcover datasets. The 2013-14 national land-cover dataset is based on 30x30m raster cells, and is ideally suited for ± 1:75,000 - 1:250,000 scale GIS-based mapping and modelling applications. Land cover are categorised into different classes, which broadly include: • Bare none vegetated • Cultivated • Erosion • Grassland • Indigenous Forest • Low shrubland • Mines/mining • Plantation • Shrubland fynbos • Thicket /Dense bush • Urban • Water • Woodland/Open bush
Nel *et al.* (2011). Technical Report for the National Freshwater Ecosystem Priority Areas (NFEPA) project. Pretoria: Water Research Commission, WRC Report No. K5/1801.	The NFEPA coverages provide specific spatial information for rivers according to the Department of Water and Sanitation (DWS) 1:250 000 rivers coverage, including river condition, river ecosystem types, fish sanctuaries, and flagship/free-flowing rivers. The NFEPA coverages also provide specific information for wetlands such as wetland ecosystem types and condition (note: wetland delineations were based largely on remotely-sensed imagery and therefore did not include historic wetlands lost through transformation and land use activities).
Nel and Driver, A. (2012). South African National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component. Stellenbosch: Council for Scientific and Industrial Research. CSIR Report Number: CSIR/NRE/ECO/IR/2012/0022/A.	A vector layer was developed during the 2011 NBA to define wetland vegetation groups to classify wetlands according to Level 2 of the national wetland classification system. The wetland vegetation groups provide the regional context within which wetlands occur, and are the latest available classification of threat status of wetlands that are broadly defined by the associated wetland vegetation

Data Source	Summary
	group. This is considered more practical level of classification to the Level 4 wetland types owing to the inherent low confidence in the desktop classification of hydrogeomorphic units (HGM) that was used at the time of the 2011 NBA.
Collins, N. (2017). National Biodiversity Assessment (NBA) 2018 Wetland Probability Map. https://csir.maps.arcgis.com/apps/MapJournal/index.html?appid=8832bd2cbc0d4a5486a52c843daebcba#	Mapping of wetland areas based on a concept of water accumulation in the lowest position of the landscape, which is likely to support wetlands assuming sufficient availability water to allow for the development of the indicators and criteria used for identifying and delineating wetlands. This method of predicting wetlands in a landscape setting is more suitable for certain regions of the country than in others.
DEA (2011). South African Government Gazette. National Environmental Management: Biodiversity Act: National list of ecosystems that are threatened and in need of protection. Government Gazette, 558(34809). http://bgis.sanbi.org/.	The Biodiversity Act (Act 10 of 2004) provides for listing of threatened or protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or protected. The purpose of listing threatened ecosystems is primarily to reduce the rate of ecosystem and species extinction. This includes preventing further degradation and loss of structure, function and composition of threatened ecosystems. The purpose of listing protected ecosystems is primarily to preserve witness sites of exceptionally high conservation value.
Holness *et al*. (2016). Shale Gas Development in the Central Karoo: A Scientific Assessment of the Opportunities and Risks. CSIR/IU/021MH/EXP/2016/003/A, ISBN 978-0-7988-5631-7, Pretoria: CSIR. Available at http://seasgd.csir.co.za/scientific-assessment-chapters/	Terrestrial and aquatic ecosystem sensitivities specific to Karoo ecology and biodiversity, including fauna and flora that were mapped in the Shale Gas Strategic Environmental Assessment (SEA) are specific to that SEA and Shale Gas development as such, and these are not considered directly transferrable to the current Gas Pipeline Corridor study. But areas that were mapped as Very High sensitivity are considered in this study to represent biodiversity priority areas and are also used here within the area of overlap of these two assessments.
Skowno *et al*. 2015. Terrestrial and Aquatic Biodiversity Scoping Assessment. In: Van der Westhuizen, C., Cape-Ducluzeau, L. and Lochner, P. (eds.). (2015). Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa. Department of Environmental Affairs, 2015. CSIR Report Number: CSIR/CAS/EMS/ER/2015/0001/B. Stellenbosch. Available at https://redzs.csir.co.za/wp-content/uploads/2017/04/Wind-and-Solar-SEA-Report-Appendix-C-Specialist-Studies.pdf	Terrestrial and aquatic ecosystems sensitivities specific to Karoo ecology and biodiversity, including fauna and flora that were mapped in the Wind and Solar SEA (REDZ) are specific to that SEA and renewable energy development as such, and these are not considered directly transferrable to the current gas pipeline corridor study. But areas that were mapped as **Very High** sensitivity are considered in this study to represent biodiversity priority areas and are also used here within the area of overlap of these two assessments.
Child *et al.* (2016). (Eds). The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho. SANBI & EWT: South Africa	Known spatial locations for recorded Red Listed mammals in South Africa.
Bates *et al*. (2014) (Eds). Atlas and red data list of the reptiles of South Africa, Lesotho and Swaziland. SANBI: Pretoria (Suricata series; no. 1).	Known spatial locations for recorded Red Listed reptiles in South Africa.
Minter, L.R. (2004). Atlas and red data book of the frogs of South Africa, Lesotho, and Swaziland. Avian Demography Unit: UCT.	Known spatial locations for recorded Red Listed amphibians in South Africa.
Raimondo *et al.* (2009, as updated in 2018). Red list of South African plants 2009, 2018 update. SANBI.	Known spatial locations for recorded Red Listed terrestrial and aquatic plant species in South Africa.
International Union for Conservation of Nature (IUCN). (2017). The IUCN Red List of Threatened Species, 2017. http://www.iucnredlist.org/	Distribution data for selected fauna and flora species where point data was found to be lacking/insufficient was obtained from the IUCN Red List of Threatened Species Map Viewer with data presented as Quarter Degree Grid distributions.

Data Source	Summary
University of Cape Town (UCT). (1997). The Southern African Bird Atlas 1 (SABAP1). Animal Demography Unit, UCT.	The Southern African Bird Atlas Project (SABAP) was conducted between 1987 and 1993.Because a new bird atlas was started in southern Africa in 2007, the earlier project is now referred to as SABAP1. SABAP1 covered six countries: Botswana, Lesotho, Namibia, South Africa, Swaziland and Zimbabwe. Fieldwork was undertaken mainly by birders, and most of it was done on a volunteer basis. Fieldwork consisted of compiling bird lists for the QDGCs. All the checklists were fully captured into a database.
University of Cape Town (UCT). (2007) - Present. The Southern African Bird Atlas 2 (SABAP2). Animal Demography Unit, UCT.	SABAP2 is the follow-up project to the Southern African Bird Atlas Project (for which the acronym was SABAP, and which is now referred to as SABAP1). The current project is a joint venture between the Animal Demography Unit at the University of Cape Town, BirdLife South Africa and SANBI. The project aims to map the distribution and relative abundance of birds in southern Africa and the atlas area includes South Africa, Lesotho and Swaziland. The field work for this project is done by more than one thousand five hundred volunteer birders. The unit of data collection is the pentad, five minutes of latitude by five minutes of longitude, squares with sides of roughly 9km.

3.2 Assumptions and Limitations

The following assumptions and limitations are relevant to this study:

- This is a strategic-level desktop assessment of the sensitivity of the terrestrial ecosystems, including fauna, flora and ecological processes, characteristic of the Nama Karoo and Succulent Karoo, as well as Desert biomes of South Africa, to potential gas pipeline construction and maintenance. No field assessment was undertaken.
- The scale of input data used in these maps was variable ranging from occurrence points for species populations to graded data at different special resolutions (e.g. 30 m x 30 m for land cover to units mapped at approximately 1:250 000 scale such as vegetation types). This heterogeneity is inappropriate for fine-scale analysis and interpretation such as provisional routes.
- Species of least conservation concern or widely distributed species were excluded due to the paucity in their occurrence data i.e. their distributions are considered too broad to usefully inform the sensitivity mapping.
- The potential presence of fauna species, in particular terrestrial invertebrate groups in each of the assessed biomes was evaluated based on existing literature and available databases. However, data contained within some of these species databases are coarse and insufficient to be able to identify endemics with any certainty, and the threat status of most invertebrate groups has not been assessed according to the IUCN criteria. A further limitation was that some datasets are outdated, or lacking data for certain areas of ecological importance within each biome.

3.3 Relevant Regulations and Legislation

Table 2. Key legislation, policies and plans pertaining to conservation management and planning in the Northern, Western and Eastern Cape provinces.

Year	Legislation
International	
1971	Convention on Wetlands of International Importance (Ramsar Convention)
1975	Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES)
1993	Convention on Biological Diversity, including the CBD's Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets
1994	United Nations Framework Convention on Climate Change (UNFCC)
National	
1970	Mountain Catchment Areas Act (No. 63 of 1970)
1970	Subdivision of Agricultural Land Act (No. 70 of 1970)
1983	Conservation of Agricultural Resources Act (No. 43 of 1983)
1998	National Forest Act (No. 84 of 1998)
1998	National Water Act (No. 36 of 1998)
1998	National Forests Act (No. 84 of 1998)
1998	National Environmental Management Act (No. 107 of 1998)
1999	National Heritage Resources Act (No. 25 of 1999)
2002	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
2003	National Environmental Management: Protected Areas Act (No. 57 of 2003, as amended)
2004	National Environmental Management: Biodiversity Act (No. 10 of 2004)
2004	National Environmental Management: Air Quality Act (No. 39 of 2004)
2008	National Environmental Management: Waste Act (No. 59 of 2008, as amended)
2013	Threatened or Protected Species Regulations of 2013 (ToPS)
2013	Spatial Planning and Land Use Management Act (No. 16 of 2013)
2016	Alien and Invasive Species Regulations of 2016 (AIS)
2017	National Environmental Management Act, Environmental Impact Assessment 2014 Regulations, as amended in 2017
In progress	Draft National Biodiversity Offset Policy

Year	Legislation
Provincial	
1974	Eastern Cape Nature and Environmental Conservation Ordinance (No. 19 of 1974)
1974	Cape Nature Conservation Ordinance, No. 19 of 1974 (still in force)
1987	Ciskei Nature Conservation Act 1987
1987	Land Use Regulation Act (No. 15 of 1987) (governing former Ciskei)
1985	Land Use Planning Ordinance (Ordinance 15 of 1985) (governing former old Cape Province)
1992	Transkei Environmental Conservation Decree (No. 9 of 1992)
1998	Western Cape Nature Conservation Board Act, 1998 (Act 15 of 1998)
2000	Western Cape Nature Conservation Laws Amendment Act, 2000. (Act 3 of 2000)
2007	Provincial guideline on biodiversity offsets (Western Cape DEA&DP)
2009	Northern Cape Nature Conservation Act (Act No. 9 of 2009)
2010	Eastern Cape Parks and Tourism Agency Act (No. 2 of 2010)
Regional / Municipal	
2000	Municipal Systems Act (No. 32 of 2000)

4 BASELINE DESCRIPTION

4.1 Demarcation of study areas

The six gas pipeline corridors that contain elements characteristic of the Nama and Succulent Karoo, as well as Desert biomes are shown in Table 3 and Figure 1 below.

Table 3. Distribution of the Nama Karoo, Succulent Karoo and Desert biomes in each of the six gas pipeline corridors relevant to this assessment, where applicable.

Phase	Biome	Province	Relevant Local Municipalities
Inland	Nama Karoo Succulent Karoo	Eastern Cape Northern Cape Western Cape	Hantam, Witzenberg, Karoo Hoogland, Laingsburg, Prince Albert, Beaufort West, Ubuntu, Camdeboo, Blue Crane Route and Ikwezi
Phase 1	Nama Karoo Succulent Karoo	Northern Cape Western Cape	Hantam, Witzenberg, Breede Valley, Langeberg, Laingsburg, Swellendam, Kannaland and Prince Albert
Phase 2	Nama Karoo Succulent Karoo	Eastern Cape Western Cape	Oudtshoorn, George, Prince Albert, Beaufort West, Baviaans, Camdeboo, Ikwezi, Blue Crane Route and Sundays River Valley
Phase 5	Succulent Karoo	Northern Cape Western Cape	Hantam, Matzikama, Cederberg, Bergrivier, Saldanha Bay and Witzenberg
Phase 6	Desert Nama Karoo Succulent Karoo	Northern Cape Western Cape	Kamiesberg, Nama Khoi, Richtersveld and Matzikama
Phase 7	Nama Karoo	Eastern Cape	Blue Crane Route, Makana and Sundays River Valley

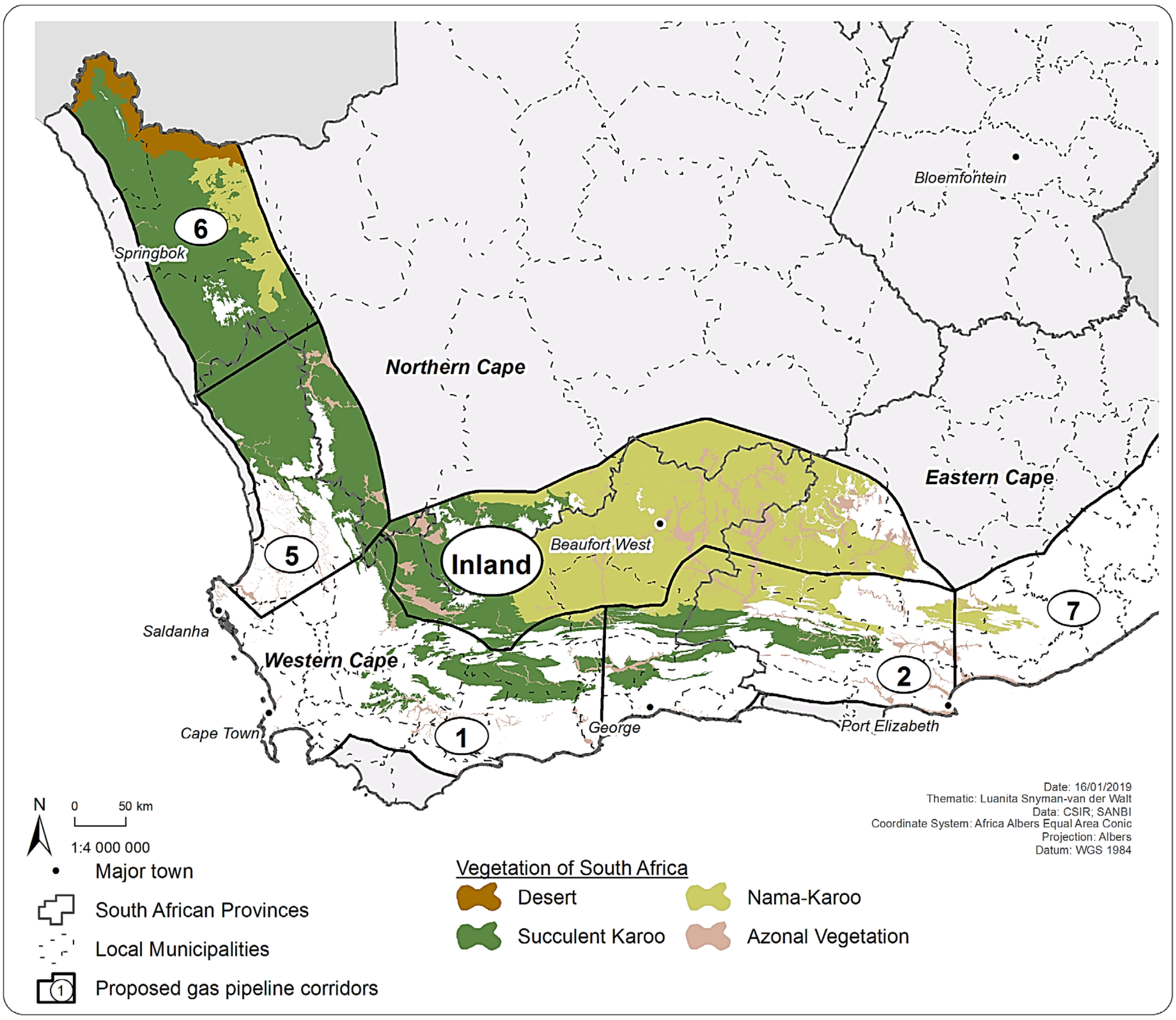

Figure 1. Map showing the distribution of the Nama Karoo, Succulent Karoo and Desert biomes in each of the six gas pipeline corridors relevant to this assessment.

4.2 Baseline environmental description of the Nama Karoo biome

4.2.1 What and where is the Nama Karoo biome in South Africa?

The Nama Karoo biome occurs on the central plateau of the western half of South Africa and is the largest of the three biomes that comprise the semi-arid Karoo-Namib Region covering about 23% of the interior of southern Africa (Ndhlovu *et al.*, 2011; Walker *et al.*, 2018). The word 'Karoo' comes from the Khoi-San word *kuru* which means dry, an apt description for this vast, open, arid thirstland. The Nama Karoo interfaces with the Succulent Karoo biome to the west, the Desert biome in the extreme northwest, the Savanna biome to the north and northeast, the Fynbos and Albany Thicket biomes in its southern and south-eastern extremities, and the Grassland biome infringing on its eastern border (Mucina *et al.*, 2006a).

The geology underlying the Nama Karoo biome is exceptionally varied and consists of a 3 km thick succession of millennia old sedimentary rocks rich in fossils (Lloyd, 1999; Mucina *et al.*, 2006a). Shallow, weakly developed lime-rich soils with high erodibility cover more than 80% of the Nama Karoo landscape (Watkeys, 1999). The climate is typically harsh with considerable fluctuations in both seasonal and daily temperatures. Droughts are common with frost a frequent occurrence during winter. Rainfall is highly seasonal, peaking in summer with a mean annual precipitation (MAP) ranging from 100 mm in the west to about 500 mm in the east, decreasing from east to west and from north to south (Palmer and Hoffmann, 1997; Desmet and Cowling, 1999; Mucina *et al.*, 2006a; Walker *et al.*, 2018).

The Nama Karoo is mostly a complex of extensive, flat to undulating gravel plains dominated by grassy, dwarf shrubland vegetation of which its relative abundances are dictated mainly by rainfall and soil type (Cowling and Roux, 1987; Palmer and Hoffmann, 1997; Mucina *et al.*, 2006a). Towards the Great Escarpment in the south and west, a much dissected landscape exists characteristic of isolated hills, koppies, butts, mesas, low mountain ridges and dolerite dykes supporting sparse dwarf Karoo scrub and small trees (Dean and Milton, 1999; Mucina *et al.*, 2006a; Jacobs and Jangle, 2008).

Nama Karoo vegetation is not particularly species-rich and the biome does not contain any centres of endemism (Van Wyk and Smith, 2001). There are also very few rare or endangered indigenous plant species occurring in the biome. Dwarf shrubs (generally <1 m tall) and grasses dominate the current vegetation that is intermixed with succulents, geophytes and annual forbs. As a result, the amount and nature of the fuel load is insufficient to carry fires and fires are rare within the biome. Grasses tend to be more common in depressions and on sandy soils, whereas small trees occur mainly along drainage lines and on rocky outcrops (Palmer and Hoffmann, 1997; Mucina *et al.*, 2006a).

Some of the more abundant shrubs include species of *Drosanthemum, Eriocephalus, Galenia, Lycium, Pentzia, Pteronia*, *Rhigozum*, and *Ruschia*, while the principal perennial grasses are *Aristida, Digitaria, Enneapogon*, and *Stipagrostis* species. Trees and taller woody shrubs are mostly restricted to watercourses such as rivers and wetlands, and include *Boscia albitrunca, B. foetida, Diospyros lycioides, Grewia robusta, Searsia lancea, Senegalia mellifera, Tamarix usneoides* and *Vachellia karroo* (Palmer and Hoffmann, 1997; Mucina *et al.*, 2006a).

4.2.2 Vegetation types of the Nama Karoo

The Nama Karoo biome originally contained five distinct veld types in its entirety as described by Acocks (1953), namely Central Upper Karoo, Central Lower Karoo, Orange River Broken Veld, Arid Karoo and False Arid Karoo. However, large parts of the False Upper Karoo and Karroid Broken Veld, as well as smaller portions of four more arid veld types with similar climatic and floristic characteristics were enclosed in this biome. In 1996, Low and Rebelo regrouped these veld types into only six different vegetation types. Then in 1997, Palmer and Hoffmann reclassified the Nama Karoo biome into three geographically distinct bioregions; (i) the Griqualand West and Bushmanland, (ii) the Great Karoo and Central Lower Karoo, and (iii) the Upper Karoo and Eastern Cape Midlands.

The main drivers for defining these bioregions were rainfall, temperature and topography. Mucina *et al.* (2006a) have subsequently approximated these bioregions into the (i) Bushmanland – a region dominated by arid grass- and shrublands; (ii) Lower Karoo – which mainly consists of grassy scrub, arid shrubland and riparian woodland along drainage lines; and (iii) Upper Karoo – which comprises montane shrubland at higher elevations with grassy and succulent dwarf shrublands dominating the vast, open plains (Figure 2). These three bioregions collectively boast 14 unique Nama Karoo vegetation types, nine of which are present in the proposed gas pipeline corridors (Figure 3).

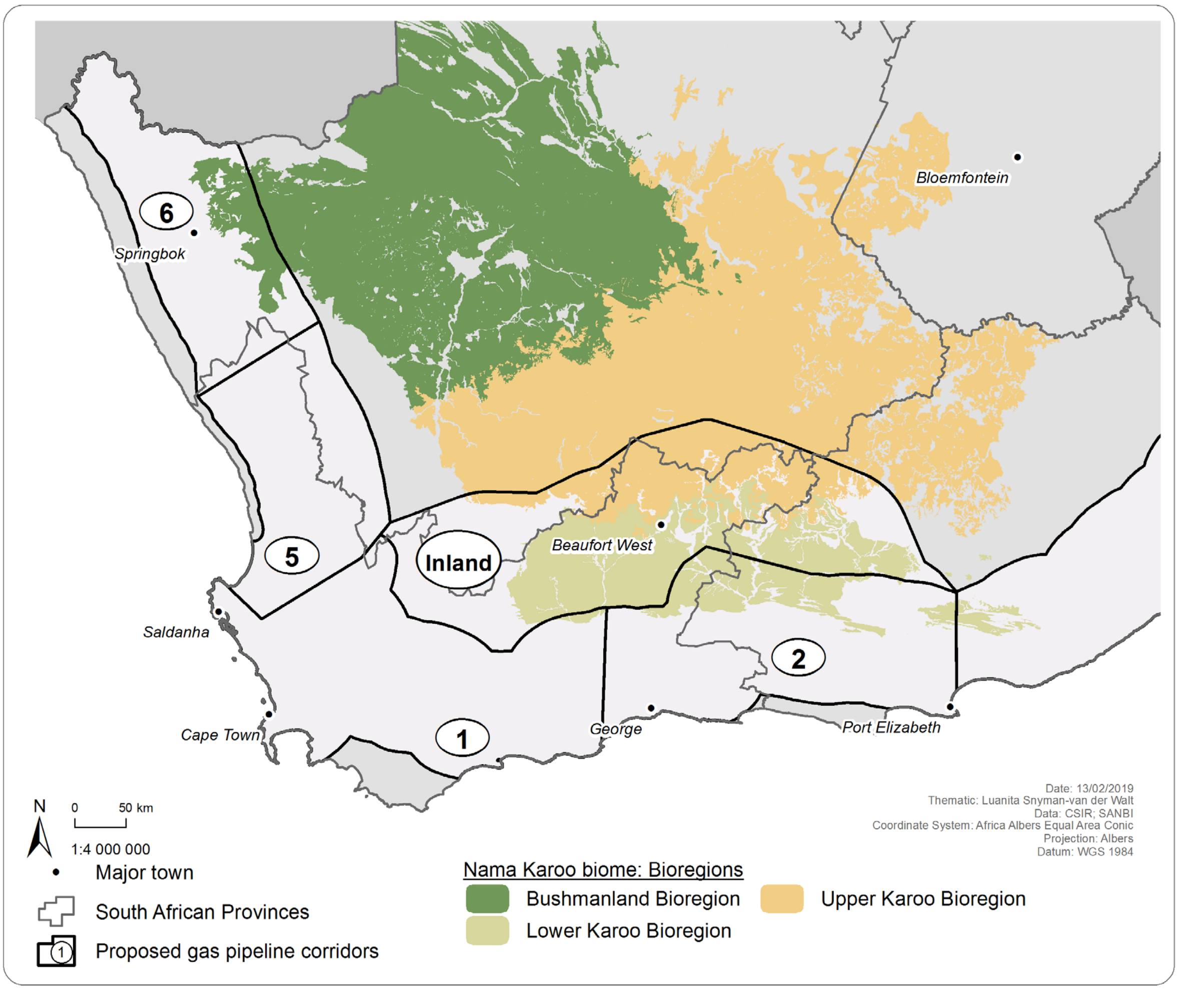

Figure 2. The Nama Karoo biome consists of three different bioregions.

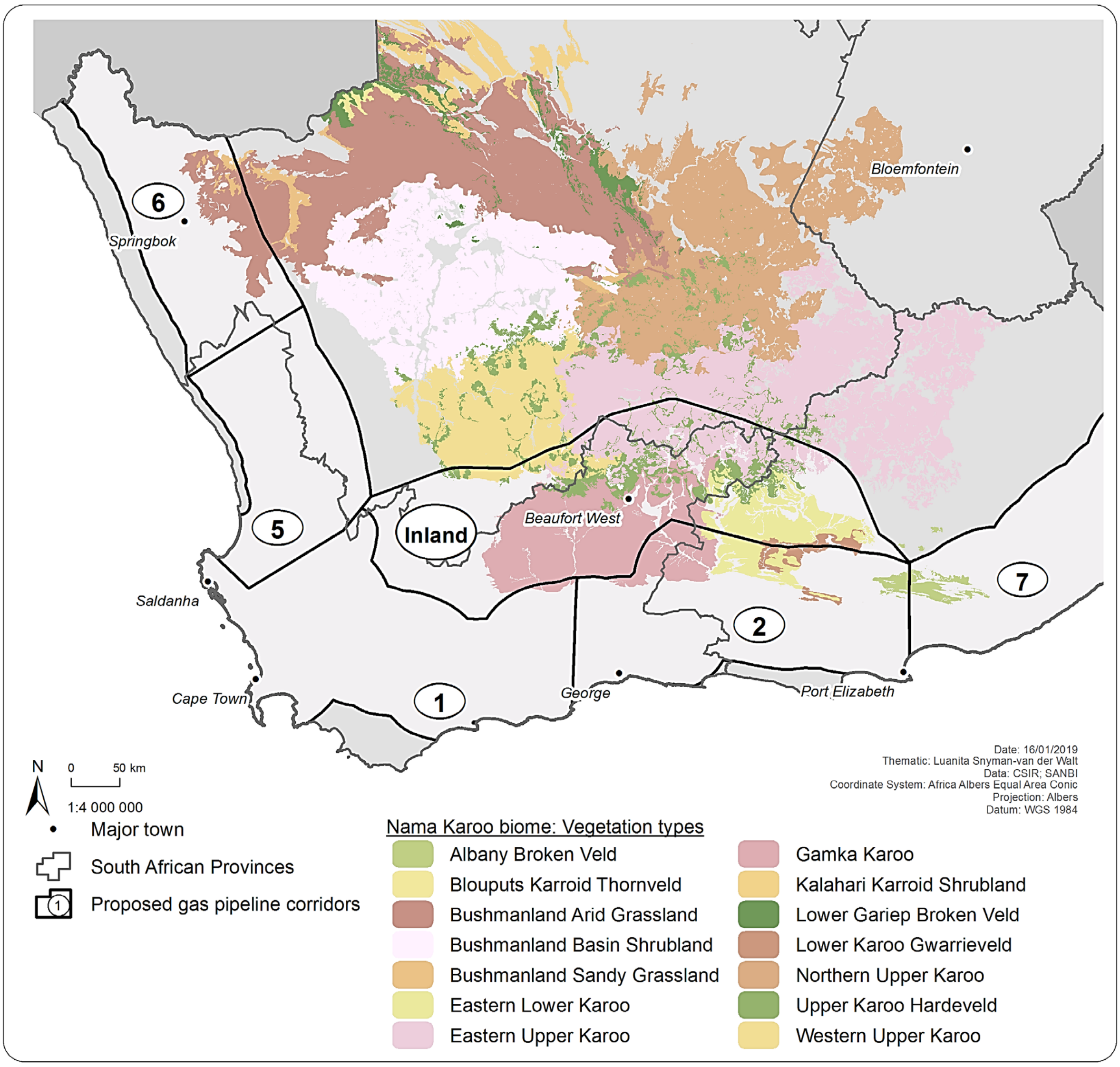

Figure 3. The Nama Karoo biome consists of 14 unique vegetation types.

4.2.3 What is the state of the Nama Karoo?

The Nama Karoo biome, considered the third largest biome in South Africa after the Grassland and Savanna biomes, comprises an area of approximately 248 278 km² of which only approximately 1.6% is formally protected in statutory reserves such as the Augrabies and Karoo National Parks (Hoffmann *et al.*, 2018). About 5% of the Nama Karoo has been transformed by human impact relative to other biomes in South Africa, leaving the majority of the land still in a state classified as Natural (Mucina *et al.*, 2006a; Hoffmann *et al.*, 2018). However, according to Hoffmann and Ashwell (2001) approximately 60% of the Nama Karoo landscape is characterised by moderately to severely degraded soils and vegetation cover (Mucina *et al.*, 2006a). Despite the increasing impact of mainly soil erosion and overgrazing (Atkinson, 2007), the ecosystem threat status of all 14 Nama Karoo vegetation types are considered least threatened (South African Government Gazette, 2011).

The large historical herds of Springbok (*Antidorcas marsupialis*) and other game native to the Nama Karoo no longer exist as most of the Nama Karoo has been converted to fenced rangeland for livestock grazing during the past century, in particular sheep and mohair goats (Hoffmann *et al.*, 1999). Although the habitat is mostly intact, heavy grazing has left certain parts of the Nama Karoo seriously degraded (Lloyd, 1999; Milton, 2009; Ndhlovu *et al.*, 2011; Ndhlovu *et al.*, 2015). Vegetation recovery following drought can be delayed due to increased stocking rates that in turn exacerbate the effects of subsequent drought periods. Under conditions of overgrazing many indigenous shrubs may proliferate, while several grasses and other palatable species may be lost (Mucina *et al.*, 2006a), contributing to the gradual increase of land degradation in the Nama Karoo (Milton and Dean, 2012; Walker *et al*., 2018).

In addition to pastoralism, alien plant infestation, anthropogenic climate change, agricultural expansion, construction of linear structures, urban sprawl, the collection of rare succulents and reptiles for illegal trade, as well as the construction and failure of dams also threaten the Nama Karoo's biodiversity (Lovegrove, 1993; Lloyd, 1999; Rutherford *et al.*, 1999; Mucina *et al.*, 2006a; Milton, 2009; Dean *et al.,* 2018). The introduction of a number of alien, drought-hardy ornamental and forage plants have the potential to seriously alter the biome's ecology and hydrology (Milton *et al.* 1999). Alien invasive plants currently common in the Nama Karoo region include *Argemone ochroleuca*, *Arundo donax*, *Atriplex* spp., *Limonium sinuatum*, *Opuntia* spp., *Pennisetum setaceum*, *Phragmites australis, Prosopis* spp., *Salsola kali and Schkuhria pinnata,* as well as various members of the Cactaceae family such as *Echinopsis* spp. and *Tephrocactus articulates* (Van Wilgen *et al.,* 2008; Walker *et al*., 2018).

The Nama Karoo is also threatened by increased mining activities such as open-cast zinc mining at Black Mountain and the Gamsberg near Aggeneys, as well as the potential threat of uranium mining around Beaufort West and the greater Lower Karoo region. The possibility of large scale shale gas fracking presents a further threat to the Nama Karoo biodiversity (Khavhagali, 2010; Milton and Dean, 2012; Cramer, 2016). An increased need for renewable energy has already seen the impact of several wind farms being developed in the Karoo region and along its margins, as well as planning and construction of a number of solar power projects (Walker *et al*., 2018).

Furthermore, the increased clearing of natural vegetation for cultivation along the lower Orange River destroys the natural habitat of many Nama Karoo fauna and flora. Pesticides used to control Brown Locust (*Locustana pardalina*) and Karoo Caterpillar (*Loxostege frustalis*) outbreaks also impact wildlife habitat severely, with the highest concentration of pesticides particularly within the avifauna, specifically raptors (Lovegrove, 1993; Khavhagali, 2010; Walker *et al*., 2018).

The overall improvement of ecosystem health and to ensure ecological sustainability of the Nama Karoo biome will require a dedicated effort and strategic collaboration from a wide range of stakeholders to achieve the preservation, conservation and management of its biodiversity.

4.2.4 Value of the Nama Karoo

4.2.4.1 Biodiversity value

a) Flora

The Nama Karoo biome does not boast the same level of plant diversity and species richness that is unique to the adjacent Succulent Karoo biome (see Section 4.3.4) and yet, the Nama Karoo flora consists of nearly 2 200 plant species of which about 450 are distinctive to the region (Milton, 2009). The level of endemism in the biome is very low with the majority of endemic species occurring in the Upper Karoo Hardeveld vegetation type. Plant families dominating the Nama Karoo veld are *Asteraceae* (daisies), *Fabaceae* (legumes) and *Poaceae* (grasses). Where the Nama Karoo interfaces with the Fynbos and Succulent Karoo biomes to the south and west, taxa in the *Aizoaceae* (vygies) and *Asteraceae* families are prominent, while elements of summer rainfall floras typical of the Grassland and Savanna biomes become prevalent in the north and east (Mucina and Rutherford, 2006). The presence of succulent taxa representative of the plant families *Aizoaceae*, *Crassulaceae* and *Euphorbiaceae* adds to the species richness of Nama Karoo vegetation.

b) Fauna

The Nama Karoo never had the variety of wildlife that can be found for example in the Savanna biome; however, before pastoralism brought along fenced rangelands, vast herds of Springbok used to migrate through the region in search of water and grazing. Today, these free roaming herds are mostly replaced with livestock and game ranching. The majority of mammals in the Nama Karoo are species with a widespread distribution that originate in the Savanna and Grassland biomes (Dean *et al.,* 2018). The Nama Karoo boasts a mammal diversity of approximately 177 species of which more than 10 threatened species are known to occur in this biome. Common animals include the Bat-Eared Fox, Black-Backed Jackal, Spring Hare, Springbok, Gemsbok, Kudu, Eland and Hartebeest. Most noteworthy is the Critically Endangered Riverine Rabbit (*Bunolagus monticularis*) which is an endemic species of the central Nama Karoo (Holness *et al*., 2016; UCT, 2018a).

Other mammal species of conservation concern include the Endangered Southern Tree Hyrax (*Dendrohyrax arboreus*), as well as the Vulnerable Hartmann's Zebra (*Equus zebra hartmannae*), Cheetah (*Acinonyx jubatus*), Leopard (*Panthera pardus*), Black-footed Cat (*Felis nigripes*) and White-tailed Mouse (*Mystromys albicaudatus*). The Grey Rhebok *(Pelea capreolus*), Mountain Reedbuck (*Redunca fulvorufula* subsp. *fulvorufula*), Brown Hyena (*Hyaena brunnea*) and the Southern African Hedgehog (*Atelerix frontalis*) are all listed as Near-Threatened (UCT, 2018a).

The avifauna of the Nama Karoo is characterised by typically ground-dwelling species of open habitats, although watercourses with prevalent riparian vegetation have allowed several tree-living species to penetrate the interior of this biome (Walker *et al*., 2018). Up to 217 bird species have been recorded to occur in the Nama Karoo of which 23 species are considered threatened (Taylor and Peacock, 2018). Birds such as the Black-headed and White-throated canaries, Red Lark and Sclater's Lark, Karoo Chat, Karoo Korhaan, Layard's Tit-babbler and the Cinnamon-breasted Warbler are characteristic of this arid, harsh landscape. Many of the bird species occurring in the Nama Karoo are highly nomadic and are able to respond quickly to rainfall events and insect irruptions such as Brown Locust outbreaks (UCT, 2007 – Present; Dean *et al.,* 2018).

Reptile diversity of the Nama Karoo is moderately high with nearly 221 species that can be found in this arid to semi-arid environment (UCT, 2018b). Important tortoise species include the Vulnerable Speckled Padloper (*Chersobius signatus*) and the Near-Threatened Karoo Padloper (*Chersobius boulengeri*). The Plain Mountain Adder (*Bitis inornata*), which is restricted to the Nuweveldberge, is the only snake species that is endemic to the Nama Karoo and it is categorised as Endangered. Also, the Elandsberg Dwarf Chameleon (*Bradypodion taeniabronchum*) is currently listed as endangered and the Braack's Pygmy Gecko (*Goggia braacki*) is considered Near-Threatened. Three other lizard species, the Dwarf Karoo Girdled Lizard (*Cordylus aridus*), the Karoo Flat Gecko (*Afroedura karroica*) and Thin-skinned Gecko (*Pachydactylus kladaroderma*) have much of their distribution in the Karoo.

The Nama Karoo boasts a fairly moderate diversity of Amphibia with about 50 frog species that could be found in this biome. Noteworthy species include the endemic Karoo Caco (*Cacosternum karooicum*) and the Near-Threatened Giant Bull Frog (*Pyxicephalus adspersus*) (Minter, 2004).

Terrestrial invertebrate diversity in the Nama Karoo is considerably high with up to 575 species of Lepidoptera (moths and butterflies), 84 species of dragonflies, 115 species of lacewings and more than 80 different species of dung beetle. Five butterfly species are wholly endemic to the Central Karoo (*Aloeides pringlei, Lepidochrysops victori, Thestor compassbergae, T. camdeboo* and *Cassionympha camdeboo*). The butterfly species, *Lepidochrysops victori* is categorised as Vulnerable (Mecenero *et al.* 2013; Holness *et al.,* 2016). Nearly 40 species of scorpions could occur in the Nama Karoo region (Holness *et al.,* 2016).

4.2.4.2 Socio-economic value

The Nama Karoo provides natural resources for a wide array of business activities; however, social wellbeing and economic viability of these enterprises greatly rely on the availability and spatial distribution of water. The main industry sectors underpinning economic growth in the Nama Karoo are agriculture (including game and livestock ranching, and crop cultivation), mining (including diamonds, granite, heavy metals and marble, as well as the potential for shale gas and uranium) and tourism (including ecotourism). All three of these sectors have potential to contribute to socio-economic growth of the region but are heavily dependent on sustainable water resources to exist (Hoffmann *et al.*, 1999; Mucina *et al.*, 2006a; Milton, 2009; Walker *et al*., 2018).

Other economic opportunities characteristic of the Nama Karoo relates to the development and commercial exploitation of medicinal plants (such as *Hoodia gordonii*), horticulture, manufacturing, biodiversity conservation (e.g. National Parks, Nature Reserves, game farms) and the significance of cultural heritage (Milton, 2009; Todd *et al.*, 2016; Dean *et al.,* 2018; Walker *et al*., 2018). A recent increase in renewable energy installations (solar and wind) in the Nama Karoo has shown a total land cover of about 3.6% to date (Hoffmann *et al.,* 2018).

4.3 Baseline environmental description of the Succulent Karoo biome

4.3.1 What and where is the Succulent Karoo biome in South Africa?

The Succulent Karoo biome covers an area of approximately 103 000 km² and extends from the coastal regions of southern Namibia through the western parts of the Northern Cape and Western Cape provinces of South Africa, as well as inland of the Fynbos biome to the Little Karoo in the south (Rundel and Cowling, 2013). The Succulent Karoo biome interfaces with the Albany Thicket to the east, the Nama Karoo to the north and west, and the Desert biome to the north (Jonas, 2004; Mucina *et al.*, 2006a).

The Succulent Karoo biome is a semi-desert region that is characterised by the presence of low winter rainfall, with a mean annual precipitation of between 100 and 200 mm, and daily temperature maxima in summer in excess of 40°C the norm. Fog is a common occurrence in the coastal region and frost is infrequent. Desiccating, hot berg winds may occur throughout the year (Desmet and Cowling, 1999; Jonas, 2004; Mucina *et al.*, 2006b; Walker *et al*., 2018).

Topographically the Succulent Karoo varies from flat to gently undulating plains at altitudes generally below 800 m that are situated to the west and south of the escarpment and are typical of the Knersvlakte and Hantam/Roggeveld/Tanqua Karoo, towards a more hilly and rugged mountainous terrain characteristic of the Namaqualand, Robertson Karoo and Little Karoo at higher elevations reaching up to 1 500 m in the east. The geology of the Succulent Karoo is ancient and complex with weakly developed, lime-rich sandy soils that easily erode and are derived from weathering of sandstone and quartzite (Allsopp, 1999). An unusual but abundant feature of the Succulent Karoo soils are low, circular mounds called 'heuweltjies' which were created by harvester termites thousands of years ago (McAuliffe *et.al*., 2018; McAuliffe *et.al*., in press). Their rich soils support an entirely different vegetation from the surrounding land cover making them truly unique (Jonas, 2004; Mucina *et al*., 2006b; Jacobs and Jangle, 2008).

The Doring, Olifants and Tanqua rivers are the major drainage systems in the west, with the Breede and Gouritz rivers and its relevant tributaries in the south-east of the biome, all derived from catchments located within the bordering Fynbos biome. The majority of other river courses are small, short-lived and seasonal west-flowing systems, including a relatively short section of the lower Orange River in the north (Jonas, 2004; Mucina *et al.*, 2006b; Le Maitre *et al.* 2009).

The Succulent Karoo is an arid to semi-arid biome which is known for its exceptional succulent and bulbous plant species richness, high reptile and invertebrate diversity, as well as its unique bird and mammal life (Rundel and Cowling, 2013). It is also recognised as one of three global biodiversity hotspots in southern Africa with unrivalled levels of diversity and endemism for an arid region (Cowling *et al.*, 1999; Desmet, 2007; Hayes and Crane, 2008). The Succulent Karoo vegetation is dominated by dwarf leaf-succulent shrublands with a matrix of succulent shrubs and very few grasses, except in some sandy areas. Species of the plant families *Aizoaceae* (formerly the *Mesembryanthemaceae*), *Crassulaceae* and *Euphorbiaceae*, as well as succulent members of the *Asteraceae*, *Iridaceae* and *Hyacinthaceae* are particularly prominent. Mass flowering displays of annuals (mainly *Asteraceae* species), often on degraded or fallow agricultural lands are a characteristic occurrence in spring.

The varied Succulent Karoo landscape lends itself to the adaptation of a diversity of plant growth forms, ranging from extensive plains often littered with rocks or pebbles such as the Knersvlakte to rocky areas occasionally dotted with solitary trees and tall bush clumps (e.g. *Ficus ilicina, Pappea capensis, Searsia undulata, Schotia afra* and *Vachellia karroo*) often found in deeper valleys and along drainage lines. In some higher altitude areas of the Succulent Karoo, particularly on rain shadow mountain slopes, the vegetation contains elements similar to an arid daisy-type fynbos (Mucina *et al*., 2006b; Jacobs and Jangle, 2008).

4.3.2 Vegetation types of the Succulent Karoo

In 1991, the then Succulent Karoo Floristic Region was divided by Jürgens into two distinct sub-regions, namely the Namaqualand-Namib Domain, which extends north from the west coast of South Africa into Southern Namibia, and the Southern Karoo Domain that lies inland of the great escarpment. Key drivers motivating this subdivision were rainfall patterns and temperature regimes, with the Namaqualand-Namib mainly characterised by winter rainfall and the Southern Karoo by summer rainfall (Low & Rebelo, 1996).

Subsequently the Succulent Karoo biome was further diversified into six broadly defined bioregions (Figure 4) comprising a total of 63 vegetation types (Figure 5). The six bioregions constitute the Richtersveld (with 19 vegetation types), Namaqualand Hardeveld (with six vegetation types), Namaqualand Sandveld (with 13 vegetation types), Knersvlakte (with eight vegetation types), Trans-Escarpment Succulent Karoo (with three vegetation types) and the Rainshadow Valley Karoo (with 14 vegetation types) (Mucina *et al.*, 2006b). Forty-six of these 63 Succulent Karoo vegetation types are all, or partly present within the proposed gas pipeline corridors. Despite a general lack of structural diversity, plant species diversity at both the local and regional scales in the Succulent Karoo is undoubtedly the highest recorded for any arid region in the world (Cowling *et al.,* 1999).

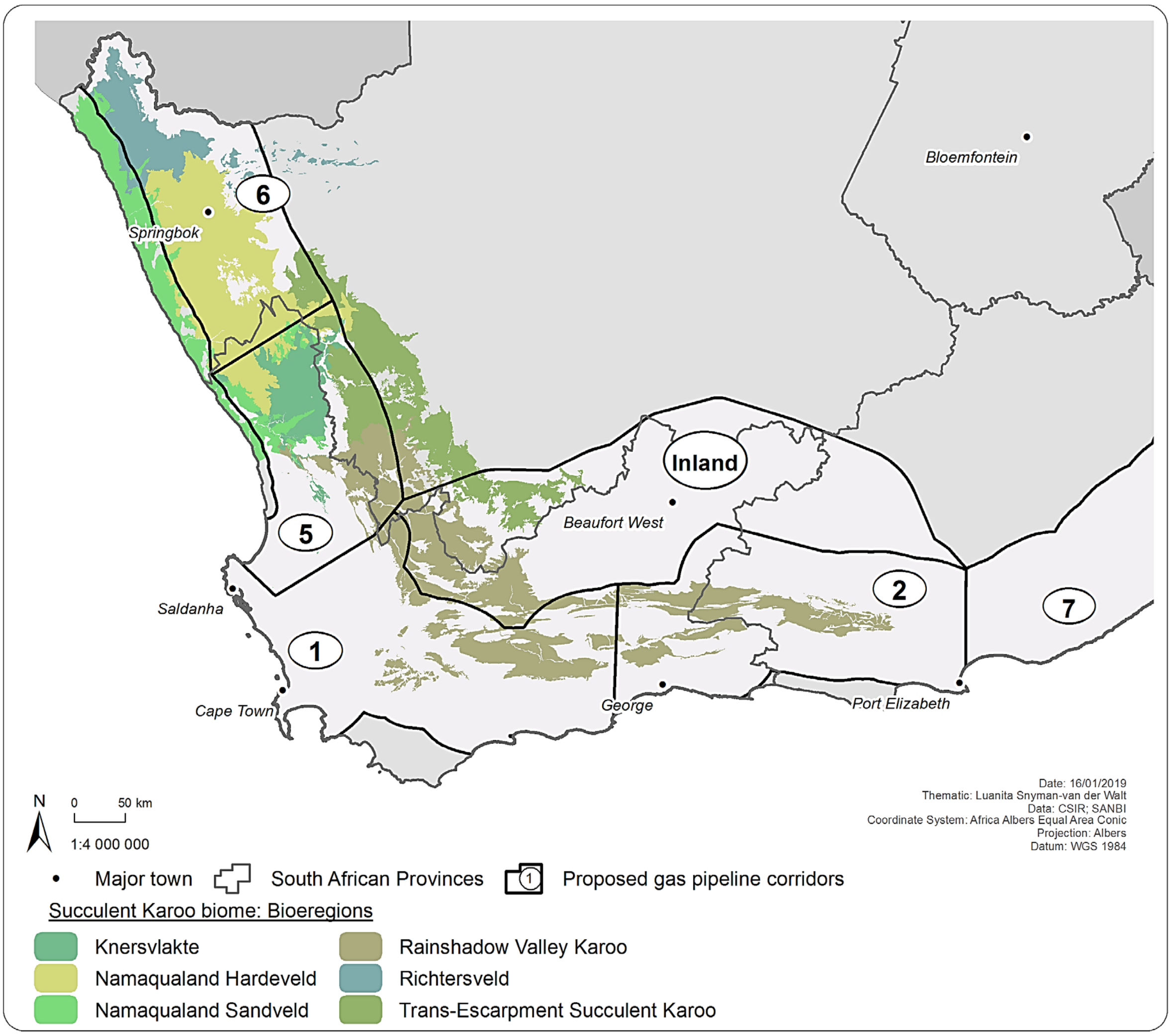

Figure 4. The Succulent Karoo biome consists of six different bioregions.

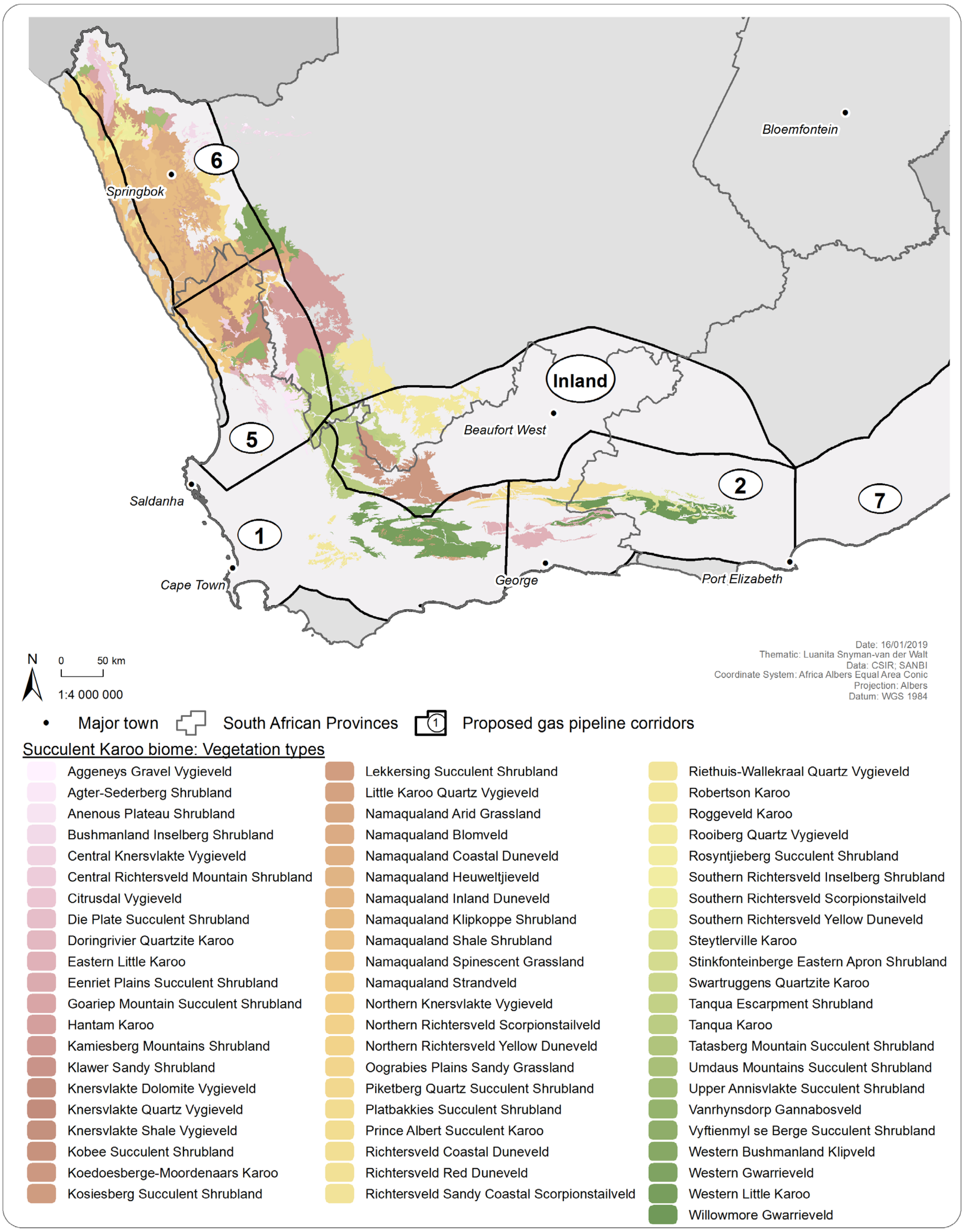

Figure 5. The Succulent Karoo biome comprises a total of 63 unique vegetation types.

4.3.3 What is the state of the Succulent Karoo?

The Succulent Karoo biome is recognised as one of 25 internationally acclaimed biodiversity hotspots due to its exceptional abundance and rich diversity of unusual succulent plants and animal life (Myers *et al.,* 2000; Jonas, 2004; Noroozi *et al.,* 2018). Despite its amazing ecological and socio-economic diversity, the hotspot is a vulnerable ecosystem with about 8% of the Succulent Karoo biome formally protected in statutory and non-statutory reserves, including the Richtersveld, Namaqua and Tankwa Karoo National Parks, as well as the Goegap, Nababieps and Oorlogskloof Provincial Nature Reserves (Mucina *et al.*, 2006b; Hoffmann *et al.,* 2018).

The predominant land use is agriculture with about 90% of the region subjected to livestock grazing (mainly sheep, goats and ostrich farming). Although crop farming is limited due to nutrient-poor soils with low agricultural potential and the lack of sufficient irrigation water, severe overgrazing and unsustainable cultivation practices have contributed to widespread loss of topsoil through sheet erosion and the accelerated degradation of veld condition reducing the overall species diversity in this arid environment (Mucina *et al.*, 2006b; Le Maitre *et al.*, 2009; Walker *et al*., 2018).

Mining for diamonds, gypsum and heavy metals, although an important economic driver which is only affecting about 1% of the biome, is another major threat to biodiversity in the Succulent Karoo as it irreversibly transforms landscapes making ecological restoration extremely challenging (Jonas, 2004; Milton and Dean, 2012). An increase in urban settlements due to a growing population, in addition to overharvesting of fuel wood and the illegal harvesting of plants for the medicinal and horticultural trades, further threatens conservation efforts of the Succulent Karoo biome (Milton *et al.*, 1999; Walker *et al*., 2018).

Cropping, mining, linear structures such as fences, roads, railways and power lines, and the eutrophication of water further exacerbate the spread and establishment of alien invasive plant species in the Succulent Karoo such as *Arundo donax*, *Atriplex lindleyi*, *Atriplex nummularia*, *Nerium oleander*, *Pennisetum setaceum*, *Prosopis glandulosa* and *Tamarix ramossissima* (Van Wilgen *et.al.,* 2008; Rahlao *et.al.,* 2009; Le Maitre *et.al.,* 2016; Dean *et al.,* 2018; Walker *et al*., 2018). The invasion of members of the Cactaceae family such as the Bilberry cactus (*Myrtillocactus geometrizans*) is becoming an increasing conservation concern especially in the southern Karoo (Dean and Milton, 2019).

Furthermore, climate change has been identified as one of the most significant threats to biodiversity as increasing temperature levels and decreasing rainfall over the next five decades could exacerbate desertification of the Succulent Karoo biome (Hoffmann *et al.*, 1999; Rutherford *et al.,* 1999; Walker *et al*., 2018). Also, a recent increase in renewable energy developments (solar and wind) in the Succulent Karoo has seen approval of about 160 applications for environmental authorisation to date of which another almost 50 are currently in process (DEA, 2019). Notwithstanding the effect of the aforementioned impacts on Succulent Karoo ecosystems, to date approximately 4% of the biome has been transformed (Mucina *et al.*, 2006b).

4.3.4 Value of the Succulent Karoo

4.3.4.1 Biodiversity value

a) Flora

The Succulent Karoo biome claims its place amongst the world's biodiversity hotspots housing an extraordinarily high floral diversity exceeding 6 356 plant species in more than 1 000 genera and representative of almost 170 plant families. Of this number about 450 taxa are considered threatened i.e. species that are facing a high risk of extinction, and a further 816 species that are of conservation concern i.e. species that have a high conservation importance in terms of preserving South Africa's rich floristic diversity (SANBI, 2017).

Nearly 40% (~2 535 species) are considered endemic to the Succulent Karoo vegetation of which the majority are either succulents or geophytes (Jonas, 2004; Mucina *et al.*, 2006b). Some 269 endemic taxa are threatened and a further 536 endemic species are of conservation concern (SANBI, 2017). Many endemics have very limited spatial ranges and are vulnerable to extinction through localised habitat damage. Also noteworthy is the occurrence of approximately 16% (~1 590 species) of the world's 10 000 succulent species within this biome (Cowling and Hilton-Taylor, 1999; Mucina *et al.*, 2006b).

Species of the plant families *Aizoaceae* (formerly the *Mesembryanthemaceae*), *Crassulaceae* and *Euphorbiaceae,* as well as succulent members of the *Asteraceae*, *Iridaceae* and *Hyacinthaceae* are particularly prominent in this biome (Mucina *et al.*, 2006b). This exceptional plant diversity, combined with high levels of endemism and intense land use pressures means the biome is also a recognised conservation priority as per the objectives and conservation targets of the Succulent Karoo Ecosystem Programme (SKEP) (Hayes and Crane, 2008).

SKEP focuses on eight geographic priority areas within the Succulent Karoo biome that contain important habitats vulnerable to land use pressures and are in need of conservation (Table 4) (Hayes and Crane, 2008).

Table 4. A summary of the floristic value of each of the eight SKEP priority focus areas

SKEP Priority Focus Area	Area (ha)	# of Plant Species	# of Endemic Plant Species	# of Red Data Plant Species
Greater Richtersveld	2 071 054	2 700 (>80% succulents)	560	194
Bushmanland Inselbergs	31 400	429	67	87
Namaqualand Uplands	361 127	1 109	286	71
Central Namaqualand Coast	372 587	432	85	74
Knersvlakte	522 234	1 324	266	121
Bokkeveld-Tanqua-Roggeveld	932 717	1 767	357	102
Central Breede River Valley	206 808	1 500	115	19
Central Little Karoo	548 430	1 325	182	73

Adding to the Succulent Karoo's exceptional high level of plant diversity, it boasts five centres of plant endemism (Table 5); one centre typical of the Cape Floristic Region with elements characteristic of fynbos, and four more centres characterised of the Succulent Karoo Region dominated by dwarf, succulent shrubland with the stem- and leaf succulent species particularly prominent (Van Wyk and Smith, 2001).

Table 5. The five centres of plant endemism contained within the Succulent Karoo biome

Region	Cape Floristic	Succulent Karoo	Succulent Karoo	Succulent Karoo	Succulent Karoo
Centre	***Kamiesberg***	***Knersvlakte***	***Little Karoo***	***Worcester-Robertson Karoo***	***Hantam-Roggeveld***
Approximate location	Entire Kamiesberg Mountain Range east of Kamieskroon	Low-lying plain north of Vanrhynsdorp	Broad intermountain valley from Montagu to Uniondale	Middle Breede River Valley from Worcester to Swellendam	High-lying plateau between Loeriesfontein and Sutherland
Number of vascular plant spp.	±1 000	±1 000	±2 000	±1 500	±2 500
Number of endemics	>80	>150	>250	>115	>250
Percentage succulents among endemics	~7.5%	~74%	~82%	~78%	~23%

b) Fauna

The fauna of the Succulent Karoo biome does not reflect the same level of diversity or endemism shown by the flora (Vernon, 1999; Mucina *et al.*, 2006b; Rundel and Cowling, 2013).

Mammal diversity in the Succulent Karoo biome is relatively high with about 75 species of mammals (UCT, 2018a) of which two are endemic, namely the Critically Endangered De Winton's golden mole (*Cryptochloris wintoni*) and the Namaqua dune mole rat (*Bathyergus janetta*). Another important species of conservation concern in the region is the Critically Endangered riverine rabbit (*Bunolagus monticularis*), the Near-

Threatened brown hyena (*Hyaena brunnea*), the Vulnerable Hartmann's mountain zebra (*Equus zebra hartmannae*), the Vulnerable Cape leopard (*Panthera pardus*) and the Vulnerable Grant's golden mole (*Eremitalpa granti*) (Rundel and Cowling, 2013; Child *et al.* 2016).

Major concentrations of large mammals, including the African elephant (*Loxodonta africana*), the Critically Endangered black rhinoceros *(Diceros bicornis*), the hippopotamus (*Hippopotamus amphibious*) and the African buffalo (*Syncerus caffer*), used to roam the riverine forests along major rivers in the Succulent Karoo, but these populations have now all disappeared from this hotspot. Today, only smaller herds of gemsbok (*Oryx gazella*), mountain zebra (*Equus zebra*) and springbok (*Antidorcas marsupialis*) are commonly found mainly within the confines of formally protected areas and privately owned game farms (Williamson, 2010; Walker *et al*., 2018).

The avifauna of the Succulent Karoo includes nearly 230 species (UCT, 2007–present) with 13 threatened birds, one of which are endemic to the region, namely the Barlow's lark (*Certhilauda barlowi*). Other notable species of conservation concern in the region include the Endangered black harrier (*Circus maurus*), which has the most restricted range of the world's 13 harrier species, and the Endangered Ludwig's bustard (*Neotis ludwigii*), as well as the Lanner Falcon (*Falco biarmicus*), Southern Black Korhaan (*Afrotis afra*), Secretarybird (*Sagittarius serpentarius*) and the Verreaux's Eagle (*Aquila verreauxii*), all of which are considered Vulnerable (Rundel and Cowling, 2013; Taylor and Peacock, 2018; Arcus, 2018).

Reptile diversity is relatively high in the Succulent Karoo with approximately 94 species of which about 15 are endemic (UCT, 2018b). All of the endemics are geckos and lizards, representing about 25% of the nearly 60 gecko and lizard species in the biome. These endemics include seven species of girdled lizards of the genus *Cordylus*, including the armadillo girdled lizard (*Cordylus cataphractus*) that is endemic to the region. Tortoise diversity is very high in the Succulent Karoo with seven taxa of which two are endemic, namely the Namaqualand tent tortoise (*Psammobates tentorius trimeni*) and the Namaqualand speckled padloper (*Homopus signatus signatus*) (Bates *et al.,* 2014).

Amphibians are poorly represented in the Succulent Karoo with just over 20 species (UCT, 2018d). All of these species are frogs of which one is endemic, namely the Desert Rain Frog (*Breviceps macrops*). This frog species occurs along the Namaqualand coast of South Africa northwards to Lüderitz in the coastal south-west of Namibia. Also noteworthy is the Namaqua Stream Frog (*Strongylopus springbokensis*) that has a Near-Threatened status (Minter, 2004).

Invertebrate diversity is quite high in the Succulent Karoo biome and evidence suggests that more than half of the species in some insect groups are endemic to this biodiversity hotspot. These include amongst others monkey beetles (*Clania glenlyonensis*), bee flies, long-tongued flies and bees, as well as a variety of masarid and vespid wasps (Rundel and Cowling, 2013). The Succulent Karoo also boasts 50 scorpion species of which nearly 22 species are endemic to the biome (Rundel and Cowling, 2013; UCT, 2018c).

4.3.4.2 Socio-economic value

Historically, the Succulent Karoo biome has mainly supported livestock farming, mostly sheep and goats, but it was not until the late 1700's that land occupation and urban settlement by colonial pioneers expanded throughout most of the area. By late 1800's both cattle and ostrich farming also became an important agricultural revenue stream and today almost 90% of the Succulent Karoo supports commercial and subsistence pastoralism, in addition to cropland farming in areas where irrigation water is readily available (Hoffmann *et al.*, 1999; Smith, 1999; Jonas, 2004; Hoffmann *et al.,* 2018; Walker *et al*., 2018).

A study by Jonas in 2004 revealed the following economic land uses in the Succulent Karoo:

- Agriculture – Livestock farming (e.g. sheep, goats, cattle and ostrich);
- Agriculture – Cropland farming (barley, lucern, dates, vineyards, etc.);
- Conservation (e.g. National Parks and Nature Reserves);
- Fuel wood (e.g. *Prosopis* spp).
- Game farming (e.g. trophy hunting, live game sales, venison sales, etc.);

- Horticulture (e.g. succulents);
- Medicinal bioprospecting (e.g. cancer bush and kougoed);
- Mining (e.g. diamonds, copper, zinc, etc.); and
- Tourism (including ecotourism).

Recent statistics have shown that wind and solar energy installations cover approximately 5.2% of land in the Succulent Karoo of which the largest percentage of affected areas is situated in the Namaqualand bioregions (Hoffmann *et al.,* 2018).

All life and economic activities occurring within the Succulent Karoo are highly driven by the availability of water. Both surface and groundwater are generally very limited and often of naturally poor quality, especially in the driest regions of the biome. Exacerbated by climate change and compounded by increased pressure from human demand, sufficient water quality and quantity pose serious challenges to current and future land use and development opportunities in the Succulent Karoo (Hoffmann *et al.*, 2009; Le Maitre *et al.,* 2009; Milton, 2009; Hoffmann *et al.,* 2018; Walker *et al*., 2018).

4.4 Baseline environmental description of the Desert biome

4.4.1 What and where is the Desert biome in South Africa?

The Desert biome of South Africa is broadly divided into two bioregions, namely (i) the Southern Namib Desert bioregion and (ii) the Gariep Desert bioregion. The former comprises the desert areas stretching from the Atlantic coast near the mouth of the Orange River penetrating inland along the course of the lower Orange River to Sendelingsdrift and is characteristic of winter rainfall. The Gariep Desert is characterised by summer rainfall and includes the desert areas from Sendelingsdrift further east to the vicinity of Onseepkans and Pofadder in northern Bushmanland. The Desert biome borders the Nama Karoo biome to the east, and the Succulent Karoo biome in its western parts (Jürgens, 2006).

This arid environment is characteristic of extreme ecological conditions with erratic rainfall across the area (MAP <70 mm), high maximum daily temperatures (>48°C), high incidence of coastal fog, strong winds and frequent sandstorms. The desert landscape is highly dissected ranging from tall, rugged mountains with deep gorges to broad, sloping valley plains. The desert substrate is generally very rocky with little to no soil present. Desert soils, where present, are slow-forming, shallow alluvial sands created from a variety of rock types that are easily eroded by wind and high-impact rainfall from thunderstorms (Jürgens, 2006).

The Southern Namib Desert vegetation is characteristic of stem- and leaf-succulent trees and shrubs such as the Quiver tree (*Aloidendron dichotomum*) and the Giant Quiver tree (*Aloidendron pillansii*), with species from key genera including *Euphorbia, Fenestraria, Mesembryanthemum* (formerly *Brownanthus*)*, Monsonia* (formerly *Sarcocaulon*), *Salsola, Stoeberia* and *Tylecodon* dominating the desert plains and rocky hilly landscape. The Gariep Desert, in addition to the presence of stem- and leaf-succulents such as *Aloidendron dichotomum, Commiphora* species*, Euphorbia* species and *Pachypodium namaquanum* ('halfmens'), is typified by non-succulent woody perennials such as *Boscia albitrunca* (Shepherds tree), *Parkinsonia africana* (Green-hair thorn tree) and *Schotia afra* (Karoo boer-bean tree) with grasses like *Stipagostis* and *Enneapogon* species being distinctive of the sandy plains (Van Jaarsveld, 1987; Jürgens, 2006).

4.4.2 Vegetation types of the Desert biome

Rutherford and Westfall (1986) and Rutherford (1997) have differentiated between arid conditions characteristic of the eastern and western parts of the Karoo biomes, respectively, which led to the recognition of various types of deserts present in north-western South Africa by Jürgens in 1991. The Desert biome was subsequently defined by including a wide arid zone along the lower Orange River stretching from the Richtersveld in the west to the surrounds of the Pofadder region in the east. This biome was further demarcated into two bioregions (Figure 6), namely the Gariep Desert (located mostly within the borders of South Africa) and the Southern Namib Desert (Jürgens, 2006). The Gariep Desert includes a tally of 10 different vegetation types, whereas the Southern Namib Desert is characterised by only five distinct vegetation types (Figure 7). Eleven of these Desert vegetation types are wholly or partly present in the proposed gas pipeline corridors.

The Gariep Desert flora is dominated by ephemeral plants, often annual grasses and non-woody forbs, especially after a good rainy season. Normally the vast desert plains appear barren and desolated with aboveground vegetation persisting underground in the form of seed, but following abundant rainfall in winter the desert plains and lower mountain slopes can be covered with a sea of short annual grasses and striking mass flowering displays of short-lived forbs and succulents in spring. Perennial plants such as stem- and leaf succulent trees and shrubs, including some non-succulent plants, are usually encountered in specialised habitats associated with local concentrations of water, like dry river beds, drainage lines and rock crevices. Lichen fields are also a conspicuous marvel of the open coastal belt utilising the moisture-filled fog originating from the adjoining Atlantic Ocean (Van Jaarsveld, 1987; Jürgens, 2006).

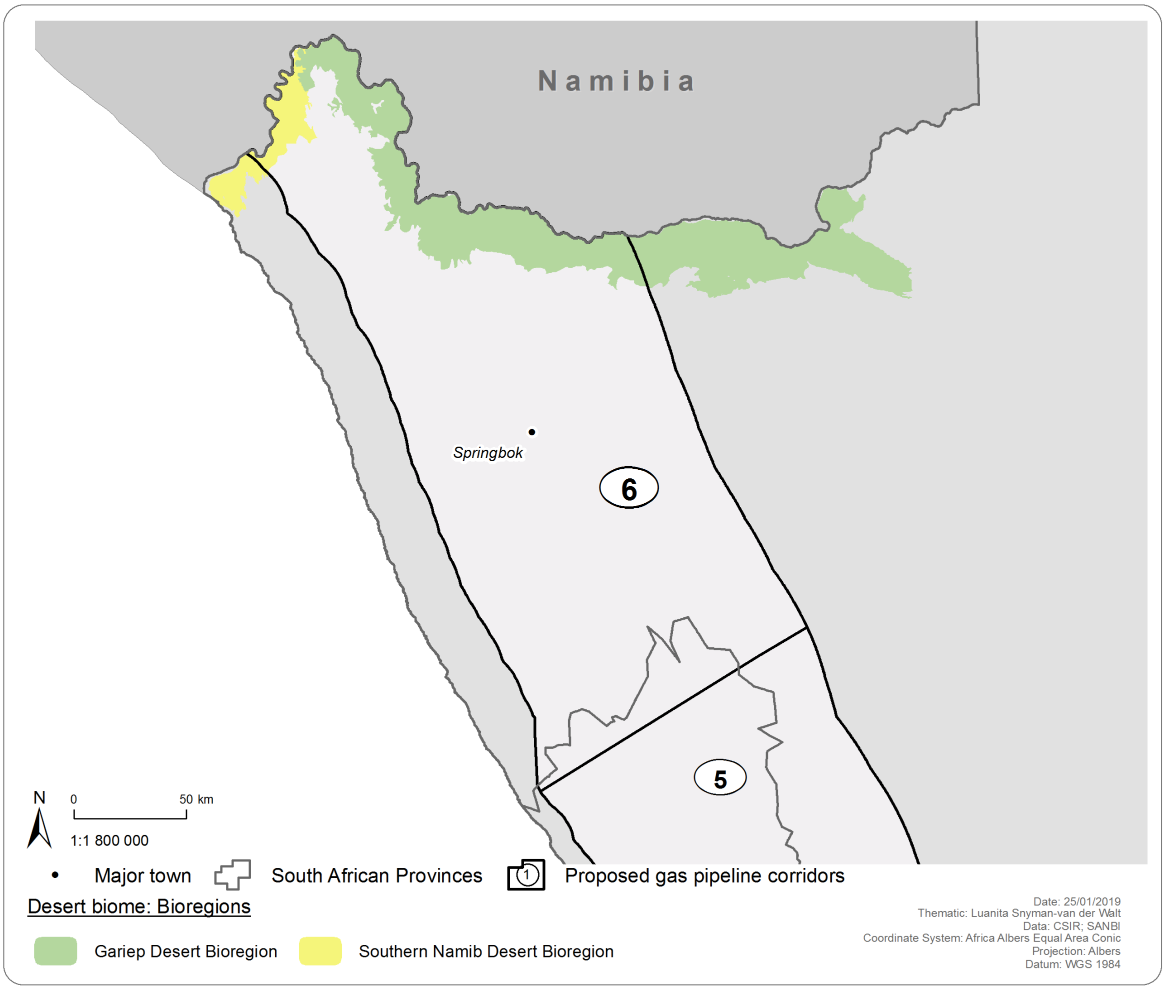

Figure 6. The Desert biome consists of two different bioregions.

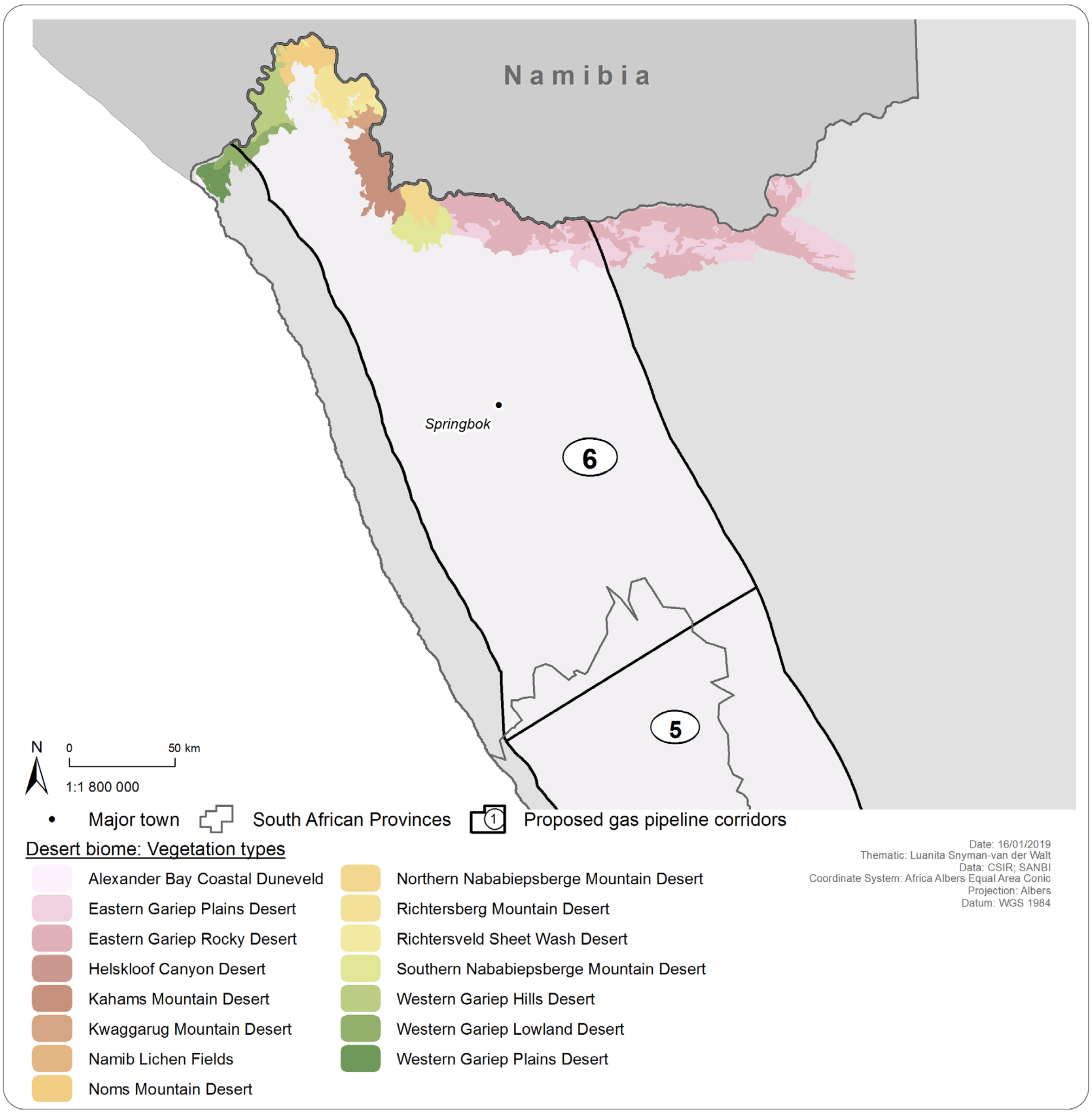

Figure 7. The Desert biome consists of 15 different types of desert habitat.

4.4.3 What is the state of the Desert biome?

The Desert biome, interfacing with the highly diverse and species-rich Succulent Karoo biome, is considered to be one of the most biologically diverse and environmentally sensitive deserts in the world. Although the region is sparsely populated with only few small villages, communal livestock farming (mainly sheep and goats) across large areas of the biome has had a significant impact on vegetation cover. Overgrazing due to overstocking, intensified by extended periods of drought, especially surrounding some permanent settlements in the Richtersveld, resulted in severe deterioration of veld condition, and in some places total desertification (Hoffmann *et al.*, 1999; Jürgens, 2006; Hoffmann *et al.,* 2014).

Commercial scale crop farming along the lower Orange River has also substantially increased during the past century now having extensive areas cultivated with inter alia vineyards, dates and subtropical fruit orchards. In addition to irrigation agriculture, open-cast diamond mining and exploration activities, mostly along the lower Orange River from Alexander Bay to Swartwater, have largely scarred the desert landscape adding to the human impact on this sensitive ecosystem. Although alien invasive plants such as *Prosopis* spp., *Nicotiana glauca, Ricinus communis* and *Atriplex lindleyi* are a common phenomenon of dry river beds, drainage lines and around human settlements, its distribution has been limited by the lack of subsurface water in the greater desert area (Milton *et al.*, 1999; Jürgens, 2006). Unfortunately, unique species richness and high levels of endemism associated with the Desert biome have also seen the illegal removal of succulents by collectors and traders (Van Wyk and Smith, 2001).

So far, only approximately 22% of the Desert biome is formally protected in statutory and non-statutory reserves of which the Richtersveld National Park, the Nababieps Provincial Nature Reserve and the Orange River Mouth Provincial Nature Reserve constitute the largest area of conservation (Jürgens, 2006; Taylor and Peacock, 2018). The average conservation target for vegetation types in the Desert biome is 32%. Other efforts to preserve this unique desert ecosystem include the Richtersveld Community Conservancy and two proclaimed National Heritage Sites, namely (i) the lichen field near Alexander Bay and (ii) the renowned population of *Aloidendron pillansii* on Cornellskop (Jürgens, 2006).

Transformation of the Desert biome has so far been relatively limited transformed despite the effect of the aforementioned impacts on desert ecosystems (Jürgens, 2006). However, rising temperatures and decreasing rainfall as a direct result of climate change could intensify desertification of the Desert biome over the next 50 years (Hoffmann *et al.*, 1999; Rutherford *et al.,* 1999).

4.4.4 Value of the Desert biome

4.4.4.1 Biodiversity value

a) Flora
Plant species richness of the vegetation types included in the Desert biome is exceptionally high when compared to other desert environments with similar aridity levels globally (Jürgens, 2006). The most profound feature of the Desert biome is the Gariep Centre of Endemism which covers the northern most part of the biome stretching inland along the Lower Orange River Valley. The Richtersveld forms the core of the centre boasting a total of approximately 2 700 vascular plant species of which more than 560 species are endemic and near-endemic to the Gariep Centre. More than 80% of species among these endemics are succulents (Van Wyk and Smith, 2001). Also, the Orange River Mouth is located at South Africa's coastal border with Namibia and contains two threatened vegetation types which are both highly disturbed, namely the Arid Estuarine Salt Marshes that is a National Freshwater Ecosystem Priority Area (NFEPA) and Endangered Wetland, as well as the Critically Endangered Alexander Bay Coastal Duneveld (SANBI, 2011; Driver *et al.,* 2012; Holness and Oosthuysen, 2016).

b) Fauna
More than 60 different mammal species are known to occur in the Desert biome (UCT, 2018a). Three species are considered Vulnerable, namely the Hartmann's zebra (*Equus zebra hartmannae*), the Black-footed cat (*Felis nigripes*) and the Cape leopard (*Panthera pardus*). A further three mammals have a Near-Threatened status including the Brown Hyena (*Hyaena brunnea*), the African Clawless Otter (*Aonyx capensis*) and Littledale's Whistling Rat (*Parotomys littledalei*). Antelope species common to the desert plains include Gemsbok (*Oryx gazella*), Springbok (*Antidorcas marsupialis*), Steenbok (*Raphicerus campestris*) and Kudu (*Tragelaphus strepsiceros*) (Williamson, 2010; Child *et al.*, 2016; Walker *et al.*, 2018).

The Desert biome has a relatively high bird diversity with a total of 133 species of which 12 are listed as threatened species. A tally of 212 species have been recorded in the Richtersveld National Park (UCT, 2007-present; Taylor and Peacock, 2018). An Important Bird Area (IBA) for avifauna diversity is the Orange River Mouth which is regarded as the second most important estuary in South Africa in terms of conservation importance (Taylor and Peacock, 2018). This coastal wetland near Alexander Bay received Ramsar status in June 1991 and supports more than 250 recorded bird species of which 102 are waterbirds (BirdLife SA, 2015; SARS, 2016).

The reptile diversity of the Desert biome is fairly high with about 84 species (UCT, 2018b), three of which are of conservation concern. These include the Near-Threatened Richtersveld Pygmy Gecko (*Goggia gemmula*), the Critically Endangered Namib Web-footed Gecko (*Pachydactylus rangei*) and the Vulnerable Speckled Padloper (*Chersobius signatus*) (Bates *et al.,* 2014).

A total of 13 frog species can potentially occur in the Desert biome (UCT, 2018d) of which two species are listed as being Vulnerable, namely the Desert Rain Frog (*Breviceps macrops*) and the Namaqua Stream Frog (*Strongylopus springbokensis*) (Minter, 2004).

The Desert Biome includes an abundant insect fauna which includes many Scarabaeidae and Tenebrionidae beetles. Its insect diversity further includes about 69 species of moths and butterflies, 20 species of dragonflies and 32 species of lacewings (Mecenero *et al.,* 2013). Up to 24 scorpion species could potentially be found in this desert environment (UCT, 2018c).

4.4.4.2 Socio-economic value

The Desert biome is not particularly rich in natural resources, hence providing employment to a relatively small number of people. The main economic drivers in this arid area are commercial scale crop cultivation and mining activities along the Lower Orange River Valley, whereas small stock farming is the main agricultural land use practised in most of the remaining biome. Ecotourism and conservation, as well as collection of plants for the horticultural trade, specifically succulents, add to the economic value of the Desert biome (Hoffmann *et al.*, 1999; Jonas, 2004; Jürgens, 2006).

Due to the ecologically sensitive nature of this biome, not all of the aforementioned land uses are sustainable. Clearance of vegetation and removal of topsoil for irrigated croplands as well as large scale surface mining along the Orange River have resulted in total biodiversity loss and increased soil erosion. In addition to overstocking of small livestock, which leads to overgrazing, unsustainable land use exacerbated by global climate change is causing desertification which could have a negative impact on the socio-economic value of the Desert biome (Hoffmann *et al.*, 1999; Jonas, 2004; Jürgens, 2006; Milton, 2009).

5 FEATURE SENSITIVITY MAPPING

5.1 Methodological approach to sensitivity mapping

The sensitivity mapping approach, takes as a starting point, the distribution of Protected Areas and CBAs as Very High sensitivity features. The whole study area has been subject to recent fine-scale conservation planning and this represents an important biodiversity input layer for the mapping. Such fine-scale conservation planning identifies CBAs which represent biodiversity priority areas which should be maintained in a natural to near natural state. The CBA maps indicate the most efficient selection and classification of land portions requiring safeguarding in order to meet national biodiversity objectives. As such, development in such areas is not considered desirable as this may compromise the ability to meet conservation targets or impact on biodiversity patterns or processes within the CBA. Furthermore, as these have been derived in an efficient manner and taking competing land uses into account, to compensate for habitat loss within CBAs even greater areas are required to meet the same targets. Both Protected Areas and CBAs are considered to represent Very High sensitivity areas.

Building on from the above features, another process-level feature used is the drainage features of the area. These are based on the NFEPA layer and buffered from 100 m to 1 000 m, depending on the stream order, with larger rivers being buffered by increasingly large amounts. As there can be extensive floodplains associated with some large drainage systems, this was also supplemented by the azonal vegetation types layer derived from the VegMap for the study area, which maps riparian vegetation types associated with wetlands and drainage systems. These areas are also considered Very High sensitivity.

Plant and faunal species-level biodiversity information was vetted and checked before being used to inform the sensitivity mapping as the data sets contained various errors as well as some species localities of poor accuracy. Rather than buffer the point localities by a set distance, a more ecologically sound approach was considered to be allocating sensitivity to a quinary sub-catchment, based on species occurrence within the sub-catchment. These represent relatively small and localised quinary catchments with similar climatic and environmental conditions likely to be more widely suitable for fauna species of concern present elsewhere within the basin.

A number of additional modifiers were also used to inform the sensitivity mapping, with the presence of threatened ecosystems and National Protected Area Expansion Strategy (NPAES) Focus Areas being used to increase sensitivity levels where appropriate. Custom sensitivity layers used include a custom specialist interpretation of the new 2018 VegMap beta layer, whereby each vegetation type in the study area was allocated a sensitivity category based on the inherent sensitivity of the vegetation type due to the diversity, ecological function, faunal value or abundance of species of conservation concern within the vegetation type. An additional layer of sensitive areas identified by the specialist, as well as from the Shale Gas Strategic Environmental Assessment (SEA) and the Renewable Energy Development Zones (REDZ) SEA, were also used to identify higher sensitivity areas.

In addition, the old fields' layer and croplands layer were used to drop the sensitivity of degraded areas to low. A number of layers were either selectively used or not used at all due to the issues with data quality. This includes the land cover layer which was not used as experience with this layer indicates that it is not sufficiently reliable in the arid parts of the country. This is largely because many bare areas which correspond in the field to pans or other low-vegetation habitats are often classified as degraded or transformed habitats. In addition, wetland features present in the Nama Karoo, Succulent Karoo and Desert biomes were captured using the 2018 wetlands layer.

5.2 Biodiversity features and classification of sensitivity criteria

The biodiversity sensitivity values are adapted from the CBA classifications, as based on the provincial systematic conservation plans for the Northern, Western and Eastern Cape provinces. This is summarised in Table 6.

The biodiversity feature data and critical biodiversity classification rules for Gas Pipeline Corridor Phases 7, Inland and part of 2; were adapted from the draft Eastern Cape Biodiversity Conservation Plan (2017); while the biodiversity feature data and critical biodiversity classification for Gas Pipeline Corridor Phases 1 and part of 2 falling into the Western Cape was obtained from the Western Cape Biodiversity Spatial Plan (2017). Biodiversity feature data and critical biodiversity classification for Gas Pipeline Corridor Phases 6 and part of 5 falling into the Northern Cape was obtained from the CBAs of the Northern Cape (2016).

Additional detail and data sources relevant to the biodiversity features used and the rules to derive the sensitivity classifications are also provided in Table 6.

Table 6. Biodiversity feature classes and sensitivity ratings derived from CBA classifications used in this assessment.

Feature Class, Data Source and Date of Publication	Sensitivity Feature Class	Sensitivity Rating & Buffer	Data Description, Preparation and Processing
2017 Western Cape Biodiversity Framework - CBAs	CBA 1	Very High	High value and irreplaceable areas.
	CBA 2	High	Degraded areas of high value.
	ESA	Low	Data generally taken as is.
2016 Northern Cape CBA Map	CBA 1	Very High	These areas also overlap with the Northern Cape Protected Area Expansion Strategy Focus Areas and as such, the latter is not used as this is already captured in the CBA mapping.
	CBA 2	High	Data generally taken as is.
	ESA	Low	Data generally taken as is.
2017 Eastern Cape CBAs	CBA 1	Very High	Data generally taken as is.
	CBA 2	High	CBA2 areas are over-mapped in the Eastern Cape and are used to capture broad corridors where there are currently no major threats. Possibly these areas should be dropped to Medium sensitivity.
	ESA	Low	Data generally taken as is.
Protected Areas from latest (2018 Q3) SAPAD Database	DEA Protected Areas	Very High	Formal protected areas all classified as Very High.
2016 NPAES	NPAES Focus Areas	**Medium**	This is considered a useful layer as it is aligned with the more recent provincial plans which are seen as the current benchmark in conservation planning for each province.
Old Fields Layer	Old Fields	Old fields = **Low**	The old fields' layer is used to downgrade the sensitivity of CBA areas from High and Very High to Medium.
		CBA 1 + Old Fields = **Medium**	
		CBA 2 + Old Fields = **Medium**	
Croplands Layer	Croplands	Low	All active croplands are listed as Low sensitivity regardless of CBA or other status
SANBI (2006-2018). The Vegetation Map of South Africa, Lesotho and Swaziland, Mucina, L., Rutherford, M.C. and Powrie, L.W. (Editors), Online, http://bgis.sanbi.org/Projects/Detail/186, Version 2018	All vegetation types within the study area were categorised into sensitivity classes based on their vulnerability to disturbance or ecological value.	Azonal Vegetation Types = Very High except for extensive non-wetland related types which are generally classified as **High**	This is a specialist interpretation of the VegMap types which is aimed at capturing sensitive features that have not been captured via other means.
		Other Veg types which have a high abundance of Species of Conservation Concern = **High**	
		Veg types which are considered vulnerable to disturbance (dunes) = **High**	

Feature Class, Data Source and Date of Publication	Sensitivity Feature Class	Sensitivity Rating & Buffer	Data Description, Preparation and Processing
Western Cape Threat Status from WCBSP2017	Threat Status	Critically Endangered – **Very High** Endangered- **High** Vulnerable - **Medium**	Data generally taken as is.
Wetlands Layer 2018 NBA Layer	Wetlands	High in Succulent Karoo **Low** in Nama Karoo	Data generally taken as is.
Rivers from the NFEPA – 1:250 000 layer (Note that these features are considered in the Freshwater Assessment and are included for information purposes here. Refer to the Freshwater Assessment Report (Appendix C.1.7 of the Gas Pipeline SEA Report) for feedback on sensitivity ratings in this regard).	Stream Order 1-3 4-5 6-7	Stream Order was buffered as follows: 1-3: 100 m 4-5: 500 m 6-7: 1000 m All classified as Very High	This is aimed at highlighting riparian areas. While the VegMap should capture riparian vegetation as an Azonal Veg type, this does not always occur as many riparian areas are poorly mapped.
Fauna Layers	Fauna of conservation concern (CR/EN/VU)	Quinary catchments where SCC were present were mapped as **High**	Not all data points could be used as the older data is not georeferenced well as the data is from 1:50 000 or 1:250 000 map centroids. In addition, it is not appropriate to buffer the localities as most of these species are also present between the observations. The best approach was seen to allocate sensitivity to quinary catchments based on the presence of SCC. Where species are known to occupy specific habitats, intervening quinaries between observations were also included. Widespread more generalist species were excluded.
SANBI Plant Habitats	Mapped areas of occurrence of Plant SCC	SANBI Plant habitats classified as Very **High** Occurrence classified as **High**	Data generally taken as is.
Specialist identified sensitive areas in Karoo and Desert ecosystems	Areas of high biodiversity significance based on the specialists own experience or gained from working on the REDZ and Shale Gas SEAs	Classified as **High**	Custom layer based on the specialists' own knowledge and experience.
Shale Gas SEA	Very High sensitivity areas	Classified as **High**	Sensitivities mapped in the Shale Gas SEA are specific to the SEA and Shale Gas development as such, these are not considered directly transferrable to the current study. But areas mapped as Very High are considered to represent biodiversity priority areas and are also used here within the area of overlap of these two assessments.

5.3 Four-Tier Sensitivity Mapping

5.3.1 Gas Pipeline Corridor - Phase 1

Within Phase 1, important features present include the Tanqua Karoo, which includes the Tanqua Karoo National Park as well as several areas where the Riverine Rabbit is known to occur (Figure 8). The Riverine Rabbit is also known to occur more widely within the corridor, from Touws River, through to the Robertson area and Sanbona Private Nature Reserve and northwards towards Anysberg Nature Reserve. The Worcester-Robertson Succulent Karoo region is also considered to be an area of high plant diversity and endemism and the vegetation in this area is considered fairly high sensitivity (Figure 9). In the east the corridor also includes the area around Calitzdorp as well as the open plains between Laingsburg and Prince Albert, where the major features are the larger drainage systems present including the Dwyka, Gamka, Groot and Touws Rivers. The mountains in this area are generally important areas for the Grey Rhebok, as well as potential habitat for the Cape Mountain Zebra, Cape Leopard and fauna more generally.

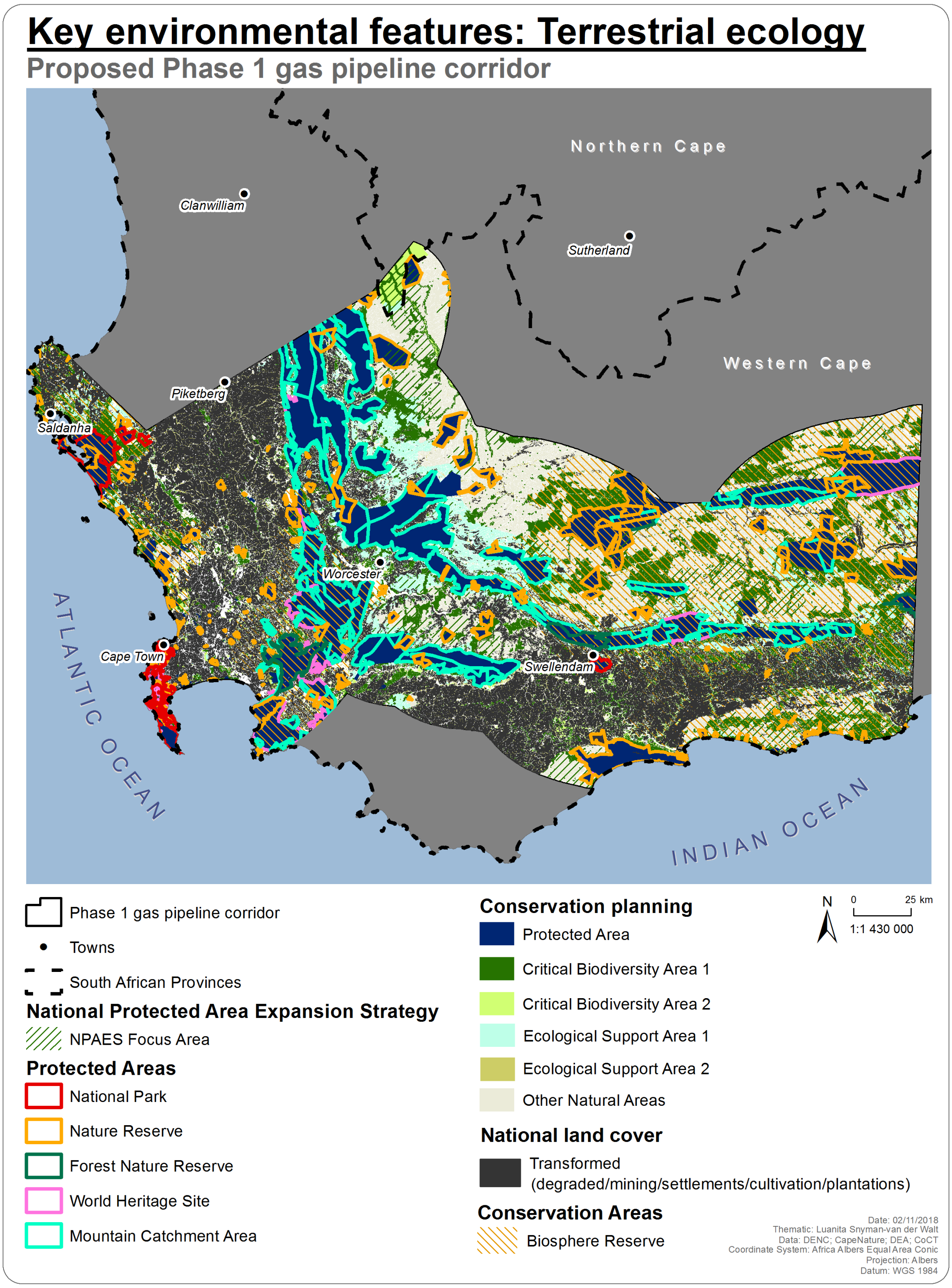

Figure 8. Key environmental features in the proposed Gas Pipeline Phase 1 corridor.

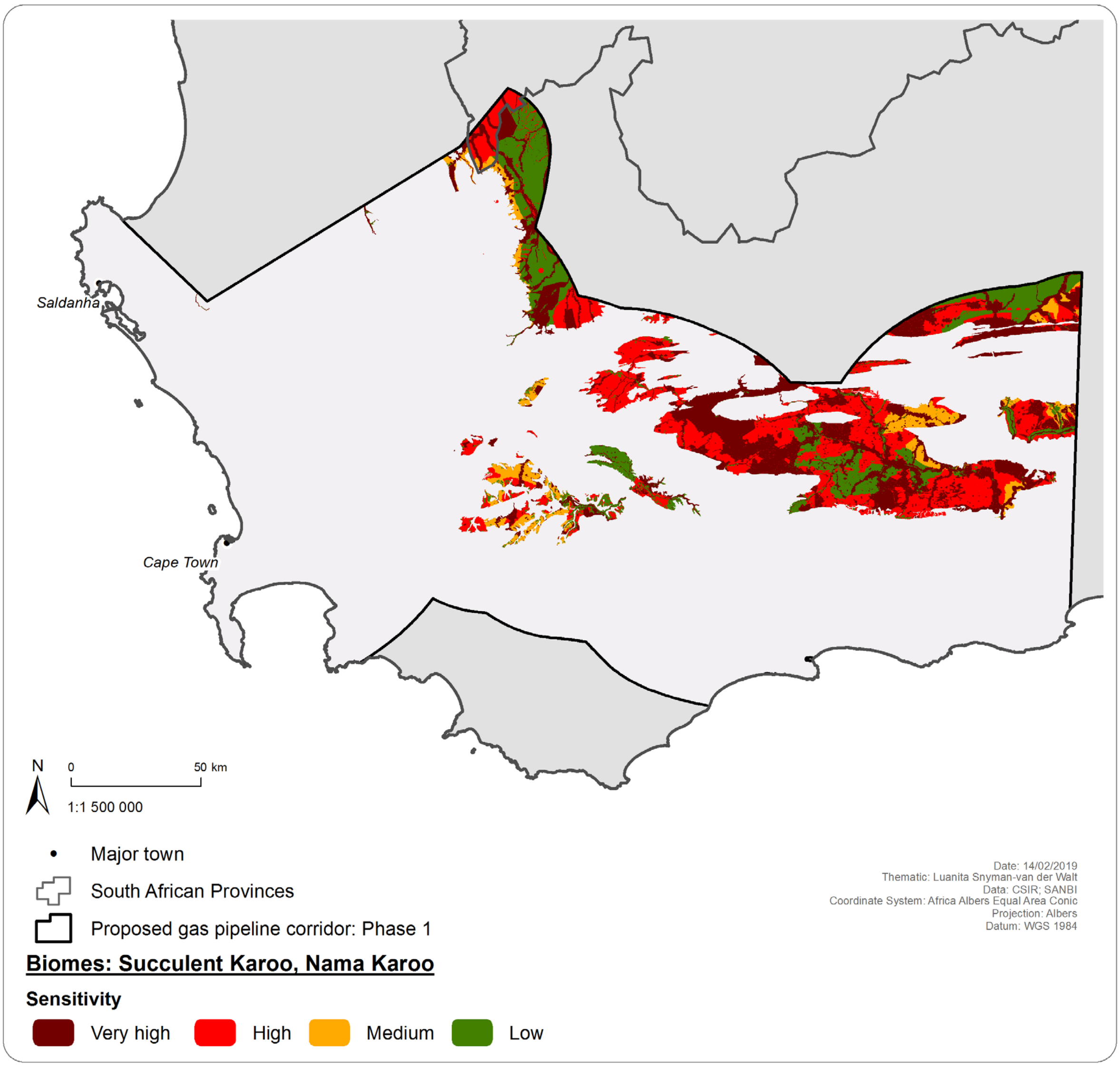

Figure 9. Sensitivity of Karoo ecosystems in the proposed Gas Pipeline Phase 1 corridor.

5.3.2 Gas Pipeline Corridor - Phase 2

The arid sections of Corridor Phase 2 are bounded by various mountain ranges in the south such as the Swartberg and Baviaanskloof (Figure 10). The arid Karoo plains from Prince Albert in the west to Steytlerville and Jansenville in the east are generally of moderate sensitivity, but there are occasional high to very high sensitivity areas present including the major features such as the Kariega, Sout and Groot Rivers, as well as the transition areas between the plains of the Nama Karoo and the thicket communities present on the slopes and hills of the area (Figure 11). In terms of fauna, this is generally a low sensitivity area with few fauna of conservation concern present across this area, apart from the Black-footed Cat which occurs at a low density across this area as well as the South African Hedgehog, which is known from the eastern margin of this corridor. The mountains are also home to the Near-Threatened Mountain Reedbuck and Grey Rhebok.

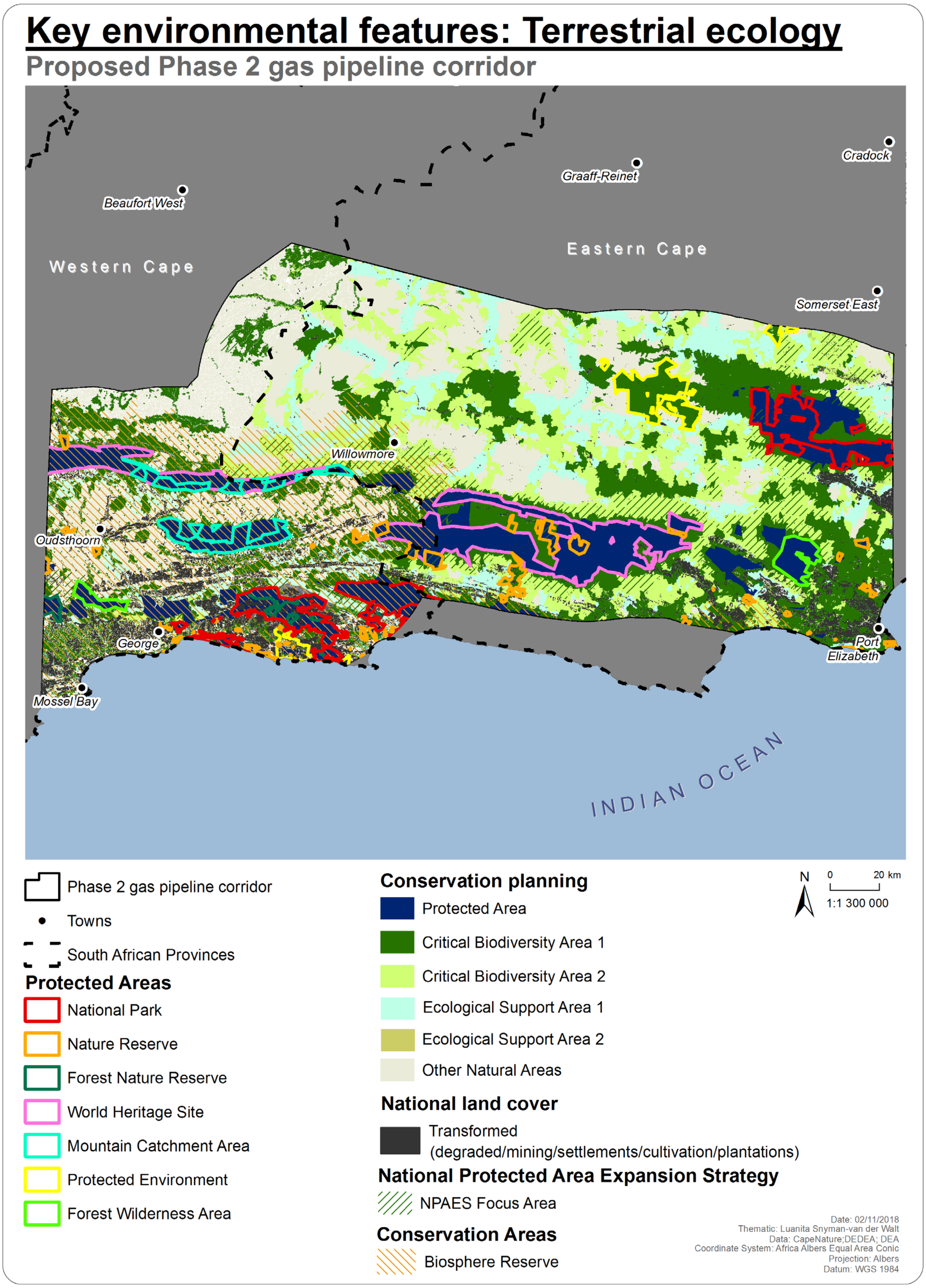

Figure 10. Key environmental features in the proposed Gas Pipeline Phase 2 corridor.

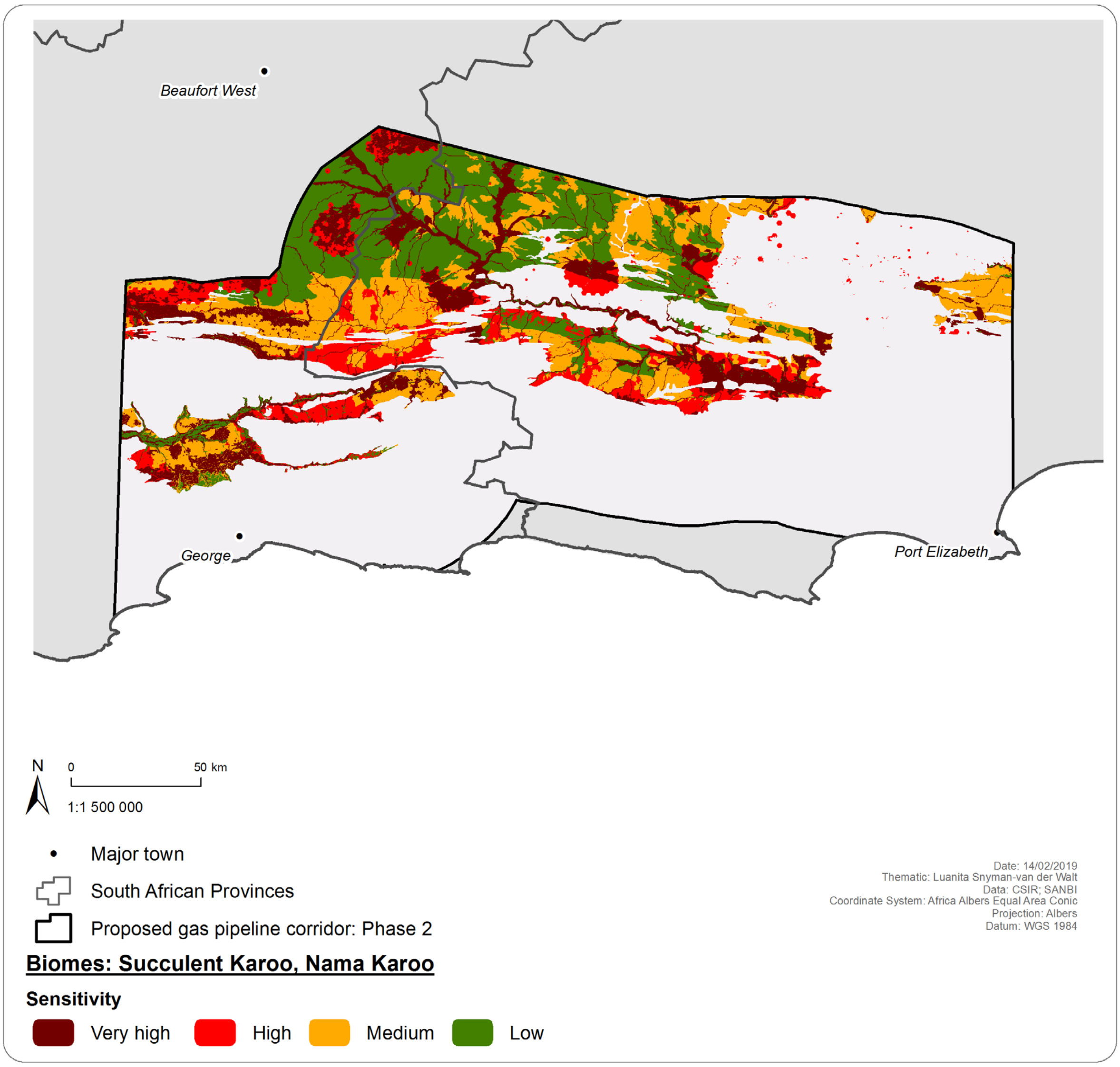

Figure 11. Sensitivity of Karoo ecosystems in the proposed Gas Pipeline Phase 2 corridor.

5.3.3 Gas Pipeline Corridor - Phase 5

Phase 5 of the Gas Pipeline Corridor includes the transition from the arid Knersvlakte in the north to the wetter Swartland and Cedarberg Mountains in the south (Figure 12). Within the Karoo study area, the most significant features of this phase include the various parts of the Knersvlakte Nature Reserve along the N7 as well as the Bokkeveld Escarpment in the east. The Knersvlakte is considered especially sensitive due to the exceptional levels of endemism which characterise this area as well as its arid nature and associated difficulty in effectively rehabilitating disturbed areas (Figure 13).

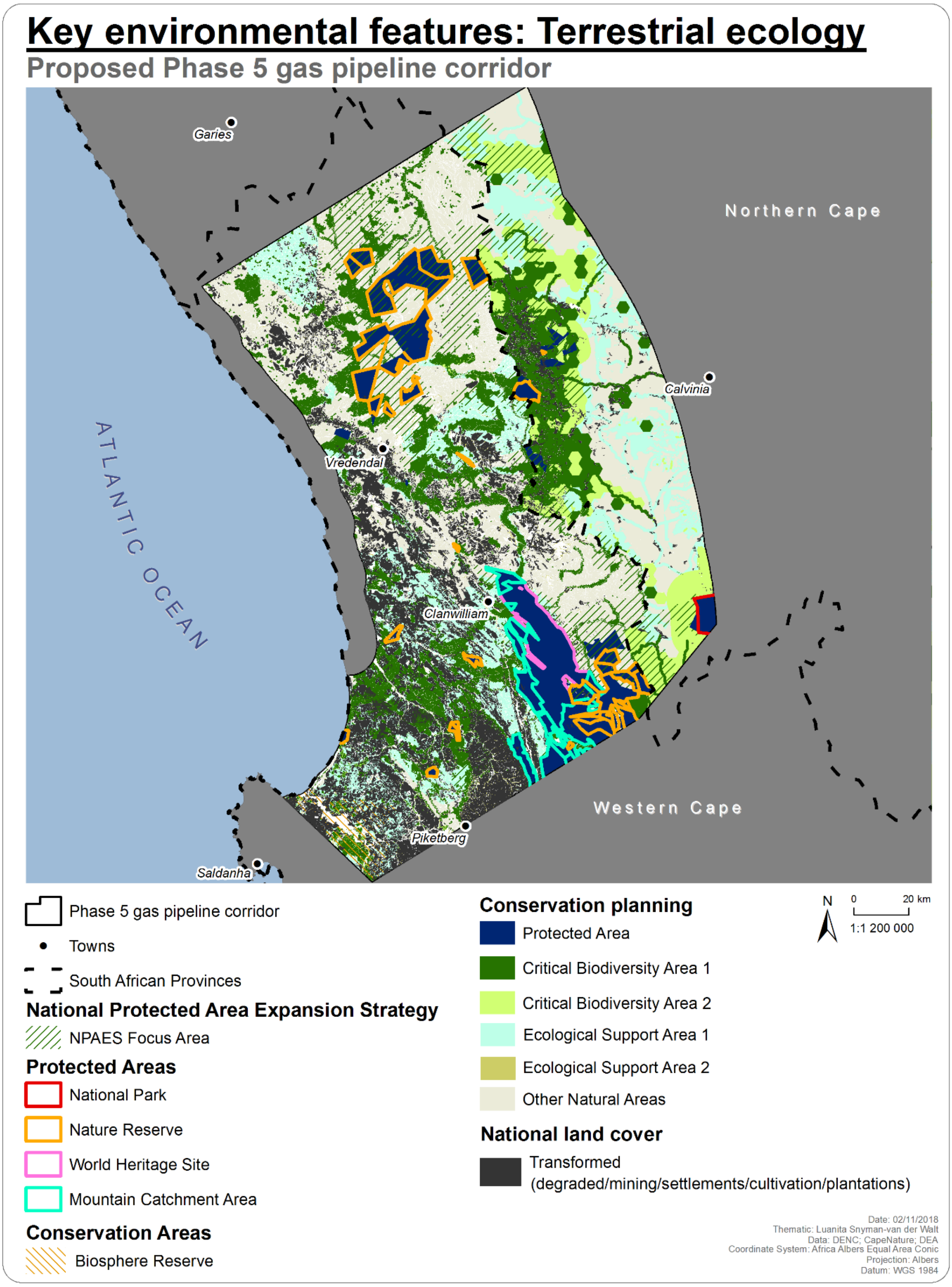

Figure 12. Key environmental features in the proposed Gas Pipeline Phase 5 corridor.

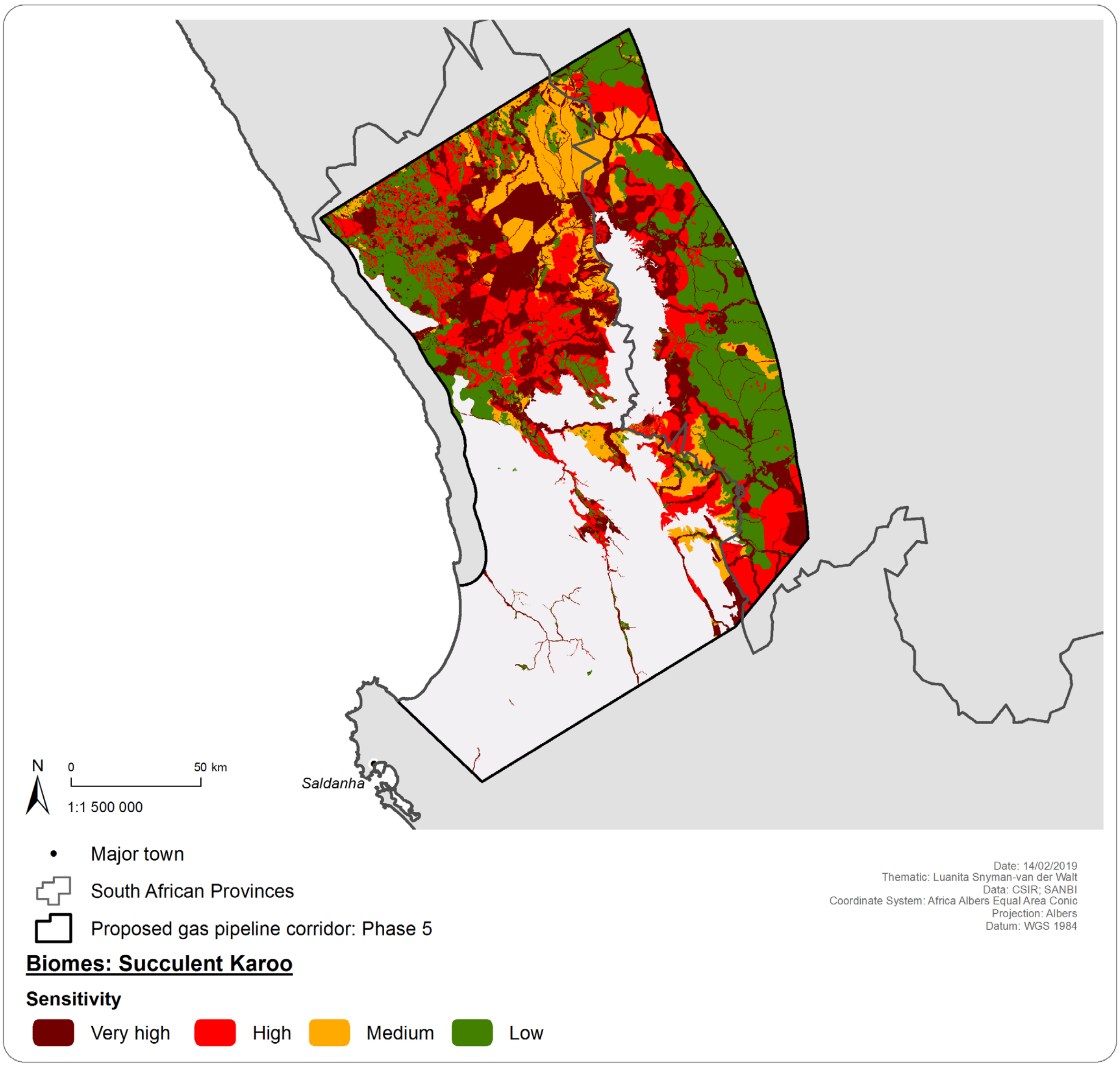

Figure 13. Sensitivity of Karoo ecosystems in the proposed Gas Pipeline Phase 5 corridor.

5.3.4 Gas Pipeline Corridor - Phase 6

The dominant features of the Phase 6 corridor are the large Protected Areas present in the northern section of the corridor, which includes the Richtersveld National Park and the Richtersveld World Heritage Site, as well as the Orange River Mouth and the Nababieps Provincial Nature Reserves (Figure 14). The Orange River Mouth Nature Reserve also includes a Ramsar wetland. This arid environment is typified by Desert and Karoo vegetation rich in succulents with a high level of species richness and endemism, many of which are of conservation concern such as the Endangered Giant Quiver tree (*Aloidendron pillansii*) and the 'halfmens' (*Pachypodium namaquanum*). The abundance of fauna of conservation concern in this corridor is also quite high, with numerous locally-endemic gecko species present along the mountains of the Orange River valley. Along the coast, there are also several fauna of concern including the Namib Web-footed Gecko and Grant's Golden Mole.

The central section of the corridor is characterised by several Protected Areas including the Goegap Provincial Nature Reserve and the Namakwa National Park. Other sensitive areas include the Kamiesberg Mountains which are considered largely unsuitable for pipeline construction due to the rugged terrain as well as diversity of this area. Also, elements of sensitive Fynbos ecosystems can be found in this corridor as isolated fragments located mostly on mountain tops in the Kamiesberg (central), Richtersveld (north) and Bokkeveld (south), or on the coastal plain (west). The Knersvlakte Nature Reserve is an important Protected Area located in the southern section of the corridor.

In general, this Phase of the pipeline corridor is considered generally fairly high sensitivity due to the diversity of the underlying Succulent Karoo and Desert vegetation, and the high abundance of features and fauna of conservation concern within this area (Figure 15). In the north, along the Orange River, as well as in the west, along the coast, there is little scope for avoidance of very high and high sensitivity areas. Also, both the Namaqualand Hardeveld and the Namaqualand Sandveld, as well the Knersvlakte in the south are considered areas of conservation concern. However, some areas in a southerly direction along the centre of the corridor have a medium sensitivity due to the presence of extensive degraded rangeland. The far eastern section of the corridor located within Bushmanland is typified by Nama Karoo vegetation with very few species of conservation concern and are thus generally considered to be of low sensitivity.

Although there are these low sensitivity areas situated in the far eastern parts of the corridor, within Bushmanland, it is not likely that this area can be easily accessed by the pipeline route given that the Bushmanland plains are situated on the inland plateau, which are separated from the western section of the corridor by the escarpment. Also, it is recommended that this Gas Corridor is extended westwards towards the coast as there are some less sensitive as well as transformed areas located in the Sandveld along the coast where the topography and soils are also far more conducive for pipeline construction than through the rugged mountains within the current corridor alignment.

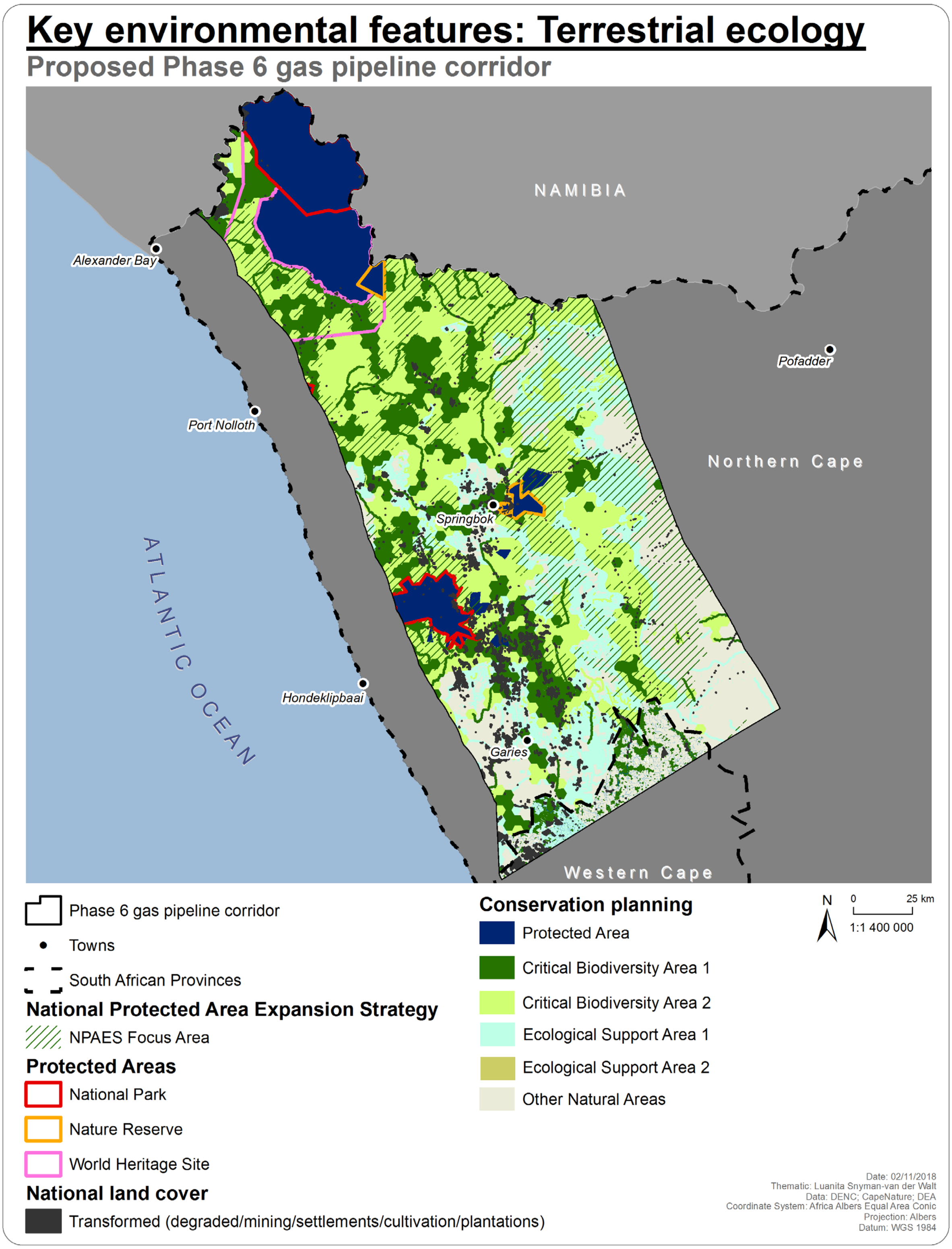

Figure 14. Key environmental features in the proposed Gas Pipeline Phase 6 corridor.

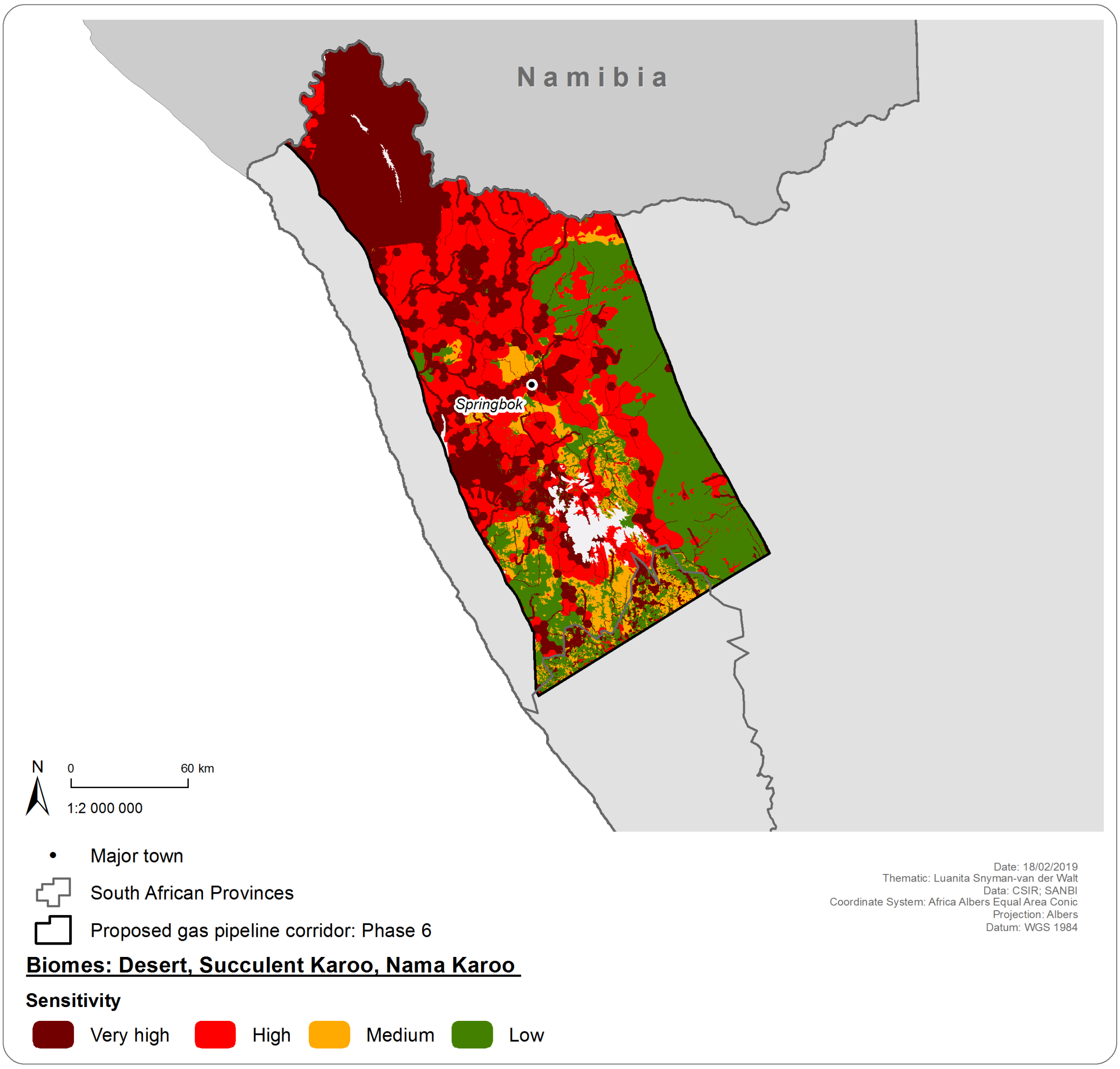

Figure 15. Sensitivity of Desert and Karoo ecosystems in the proposed Gas Pipeline Phase 6 corridor.

5.3.5 Gas Pipeline Corridor - Phase 7

There is very little Karoo habitat within the Phase 7 corridor, with a small extent of Albany Broken Veld in the western section of the corridor (Figure 16). The vegetation type is transitional between the low grassy shrublands of the open plains and the thickets on the slopes of the hills of the area. The majority of species and features of conservation concern within this area are associated with the adjacent areas of thicket, grassland or small pockets of Afromontane forest that occur in moist positions along the mountains of the area (Figure 17). There are numerous private as well as public nature reserves in this area.

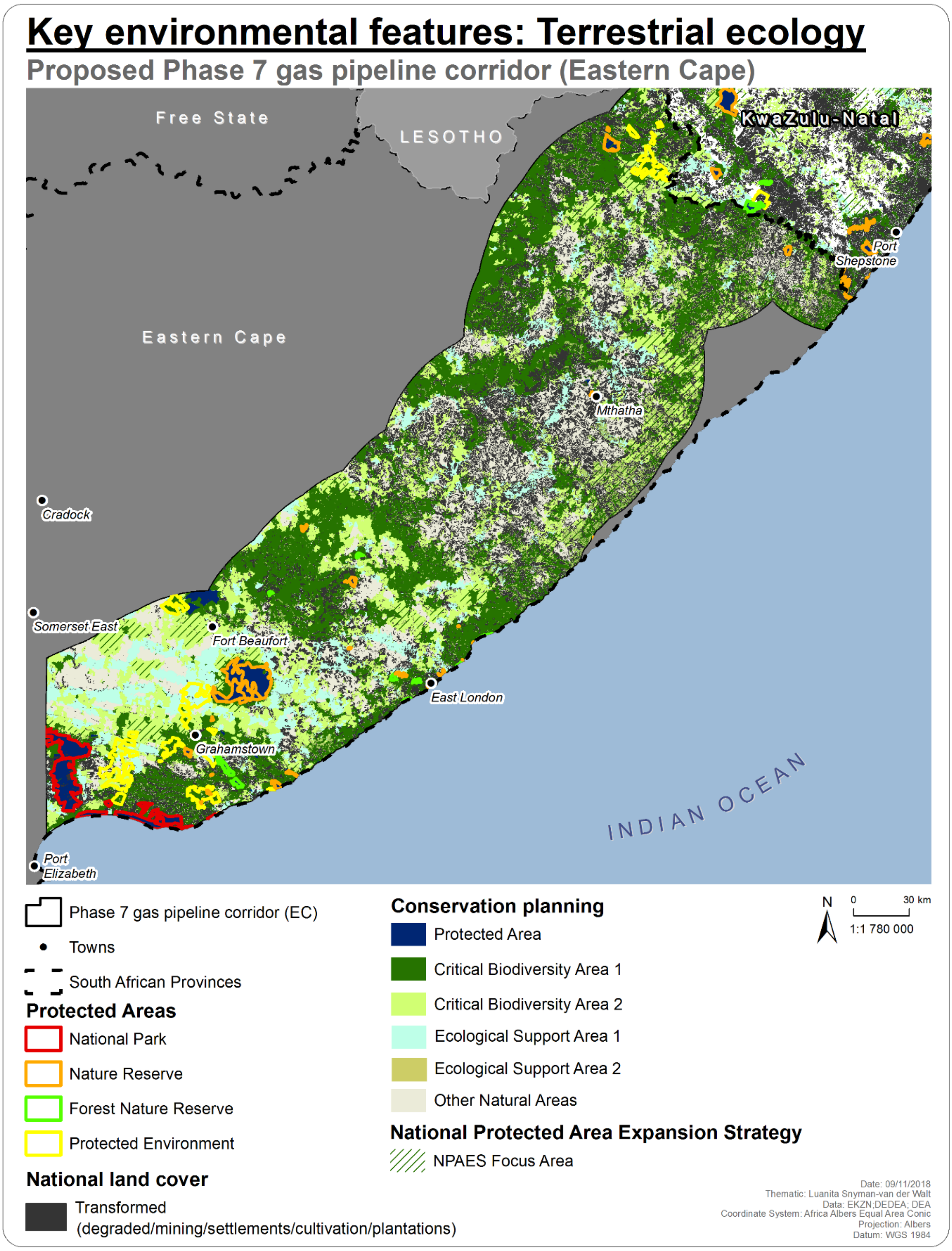

Figure 16. Key environmental features of the Nama Karoo ecosystem in the proposed Gas Pipeline Phase 7 corridor.

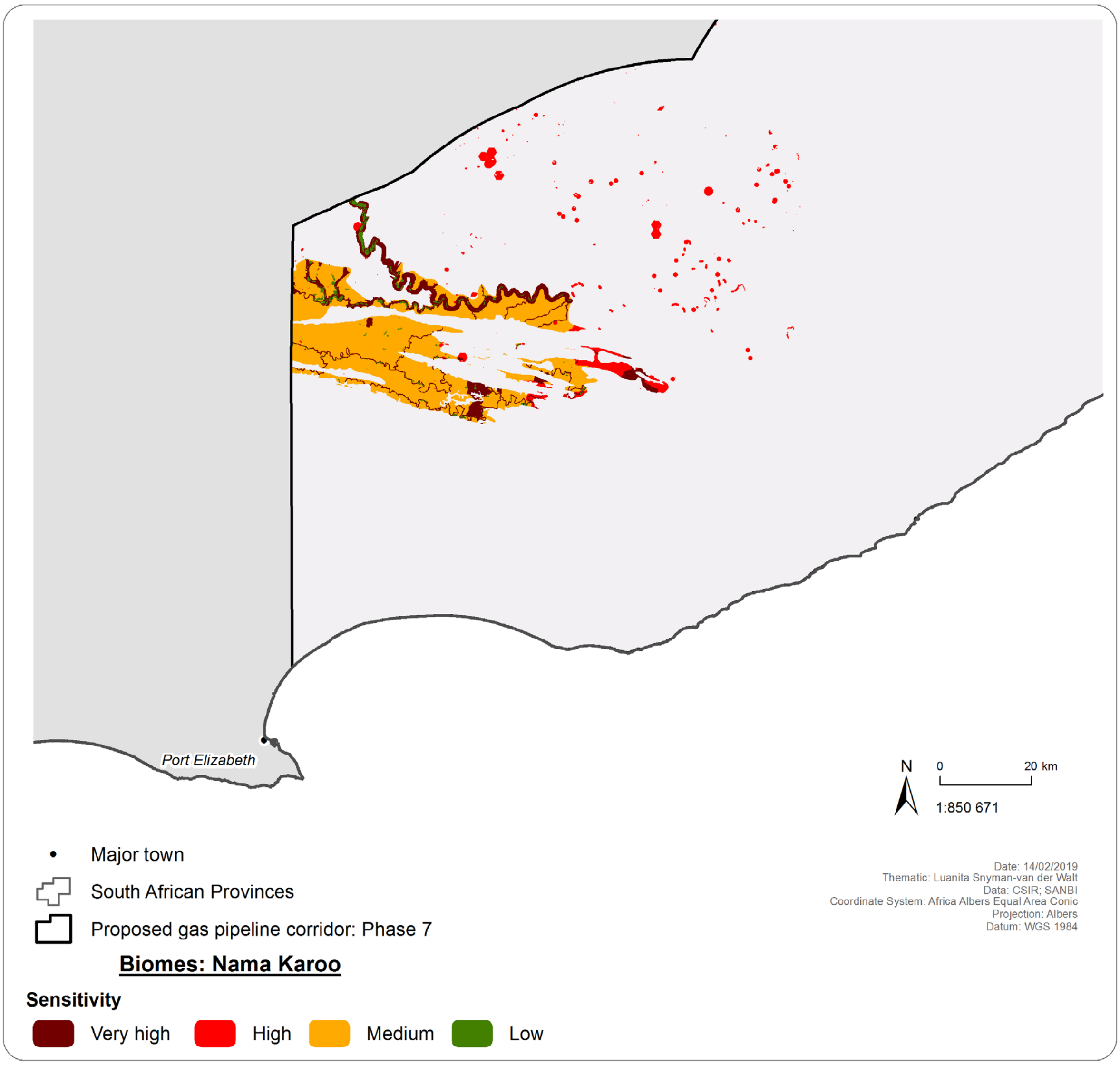

Figure 17. Sensitivity of the Nama Karoo ecosystem in the proposed Gas Pipeline Phase 7 corridor.

5.3.6 Gas Pipeline Corridor - Inland

The inland corridor consists of the plains of the Lower Karoo in the south, which gives way to the Roggeveld and Nuweveld mountain ranges in the north (Figure 18). In general, at a broad level the areas of Lower Karoo are considered less sensitive than the mountains and Upper Karoo in the north. Important features of the Inland Corridor include the Tanqua Karoo National Park in the west, the Roggeveld Mountains which lie within the Roggeveld-Hantam centre of endemism, as well as the Karoo National Park near Beaufort West and the Camdeboo National Park near Graaff-Reinet in the east (Figure 19). Diversity of the rugged northern sections of the inland Corridor is considered high and these areas are considered generally unsuitable for a pipeline. The area from Sutherland across Beaufort West and up towards Loxton and Victoria West is also home to the Critically Endangered Riverine Rabbit. The open plains to the south of the mountains are however generally of lower diversity with the key biodiversity feature present being the major drainage features such as the Gamka, Buffels, Dwyka, Kariega and Sundays Rivers.

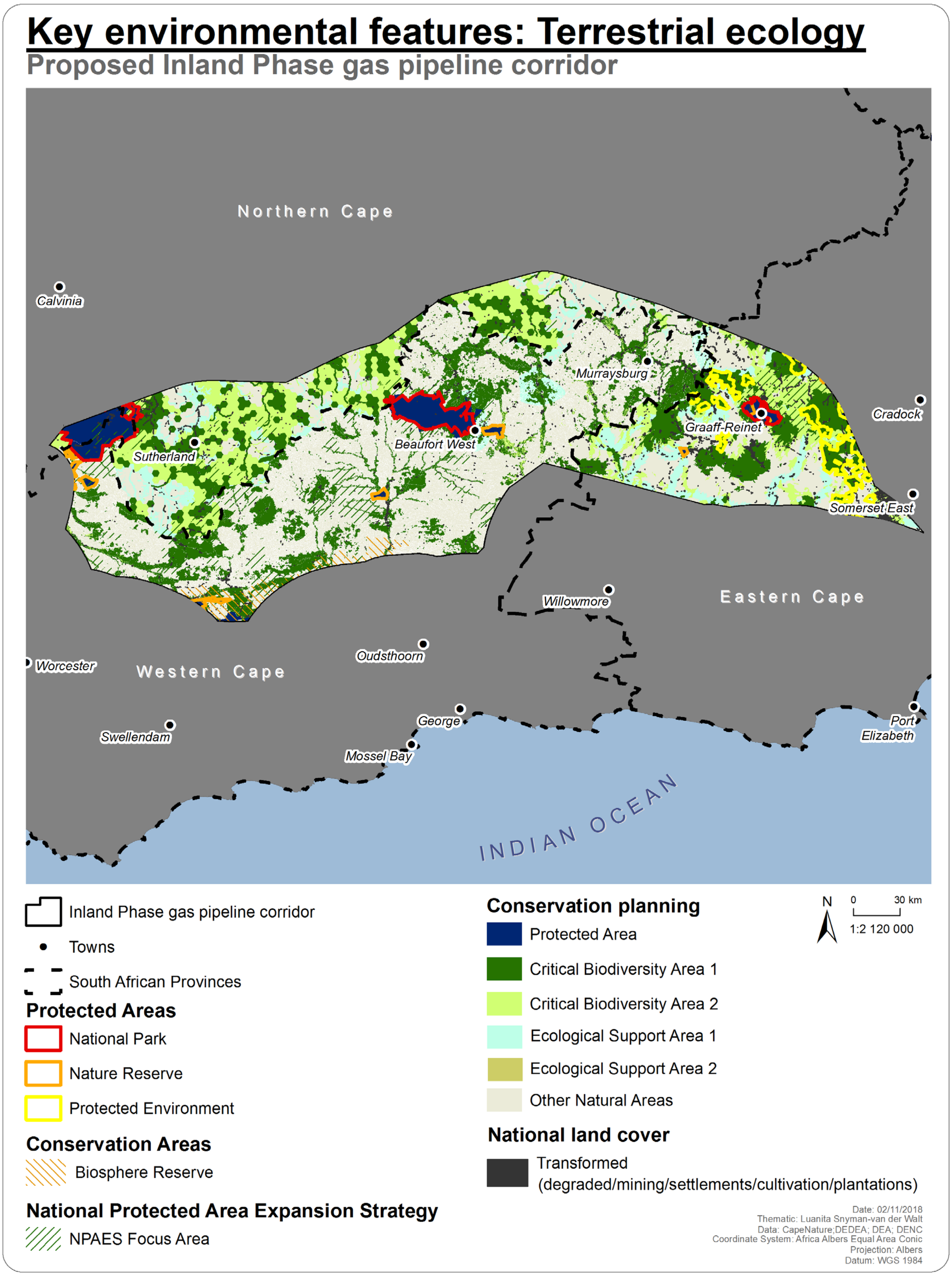

Figure 18. Key environmental features in the proposed Gas Pipeline Inland Phase corridor.

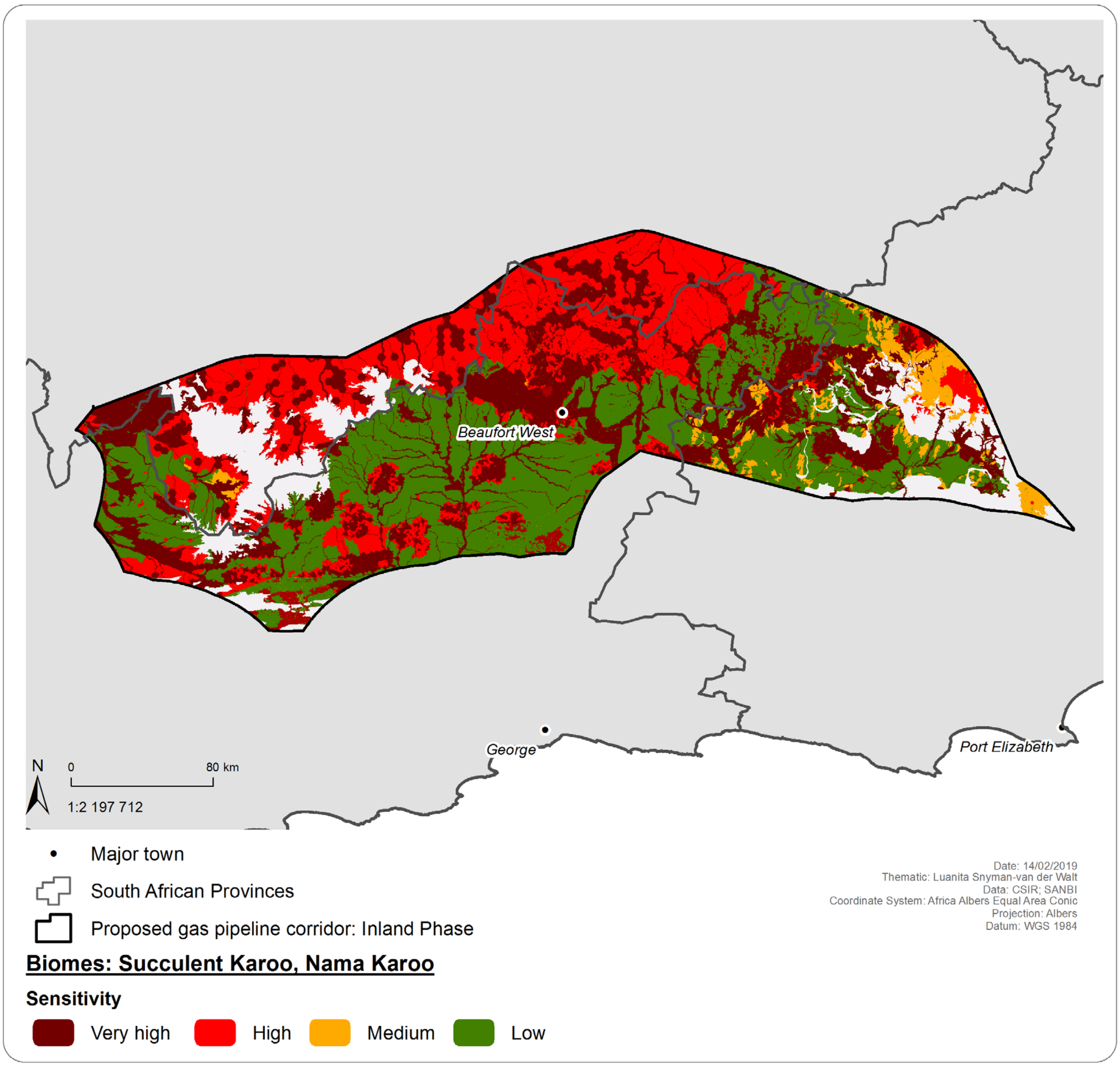

Figure 19. Sensitivity of Karoo ecosystems in the proposed Gas Pipeline Inland Phase corridor.

5.4 Environmental suitability of gas pipeline corridors

The largest constraints on the construction of the gas pipeline appear to be operating within the Desert region along the Orange River Valley and the broader Succulent Karoo, in particular the Richtersveld, the Knersvlakte and the Namaqualand sections of the corridor. This stems from the higher general sensitivity of these areas as well as the particular ecological features and high diversity of locally endemic species that are present within the Phase 6 Gas Corridor. These numerous high and very high sensitivity areas that are dominating across the corridor are generally associated with areas of conservation concern including formal Protected Areas, CBAs, ESAs and areas earmarked for protected area expansion. These areas, in addition to the mountainous upland terrain of the Kamiesberge and the Richtersveld, which could pose serious engineering constraints, can all be considered ‘no-go’ areas that should largely be avoided.

However, despite the high and very high sensitivity of the coastal plains along the western extremities of the corridor, in addition to the numerous mining rights that are active in this region, there are much improved opportunities for the gas pipeline routing to follow based on more detailed mapping and corridor refinement as the overall undulating to flat topography, soils and poor ecological state of this area are more conducive to gas pipeline construction. Also, it is further recommended that the lower sensitive areas located to the far eastern and south-eastern sections of the corridor be considered for gas pipeline construction.

6 KEY POTENTIAL IMPACTS AND PROPOSED MANAGEMENT ACTIONS

Impacts associated with gas transmission pipelines may occur during the construction, operation or maintenance of the pipeline (Table 7). Typical impacts during construction are related to the removal of vegetation and the disturbance of soils within the pipeline servitude, constructing access roads and installing the pipeline. Gas pipeline servitudes and other linear developments like transmission lines, roads, seismic lines and trails can increase human access into new, undisturbed areas; damage sensitive ecosystems and destroy plant SCC; displace fauna from their natural habitat; act as barriers to wildlife movement and also affect faunal migration routes. Such servitudes may cross different ecosystems and can fragment habitats, lead to the clearance of sensitive vegetation and create pathways for the spread of invasive species. Servitude stream crossings can result in significant bio-physical as well as engineering problems. The scope and magnitude of any gas pipeline project requires proper mitigation and management actions to protect natural biological diversity, especially in areas of high and very-high ecological sensitivity.

Maintenance of gas pipeline servitudes often involves the chemical or mechanical control of vegetative growth (specifically of deep-rooted species and alien invasive plants) within the servitude contributing to the loss of natural plant species diversity. Cleared servitudes may also be a continued source of sedimentation, due to possible soil erosion, into nearby watercourses. Frequent maintenance could further result in soil compaction, alteration of natural landscape topography and drainage patterns, and the disruption of normal groundwater flows. Repair and maintenance activities can also disturb wildlife, result in spills and contribute to continued habitat loss.

Table 7. Key potential impacts on terrestrial Karoo and Desert Biome ecosystems associated with gas pipeline construction and operation with proposed management actions.

Key Impact/impact driver	Description and possible effect	Proposed management actions
Vegetation destruction, habitat loss and impact on plant species of conservation concern as a result of servitude clearance	Removal of vegetation cover will result in: • Increased risk of threatened, protected and endemic species loss; • Decline in ecosystem resilience; • Disruption of ecosystem services; • Increased habitat fragmentation; • Change in terrain morphology; • Change in water surface runoff; • Loss of topsoil; • Increased noise levels and dust deposition; • Increased risk of illegal collection of indigenous medicinal plants and other valuable plants by collectors e.g. cycads, rare succulents and orchids, etc. and • Increased risk of illegal harvesting of timber and/or firewood.	**Avoid** *Planning:* • Use of environmental sensitivity maps and least cost in routing design; • Design and layout of infrastructure to avoid highly sensitivity areas; • Ground assessments and pre-construction walk-through by specialist to further refine the layout and further reduce impacts on sensitive habitats and protected species through micro-siting of the development footprint; • Placement of infrastructure should be done in such a way that no threatened SCCs are affected; • Design to use as much common/shared infrastructure as possible with development in nodes, rather than spread out; • Avoid any construction on steep slopes (>25 degrees). *Construction:* • Avoid any unnecessary vegetation clearance; and • No collection of 'fuelwood' should be allowed on site. **Minimise** *Construction:* • Minimise construction footprint with careful planning; • Construction footprint should be clearly demarcated; • Use existing roads as far as possible for access; • Construction outside of peak rain season as much as possible; • Soil compaction should be kept to a minimum by restricting driving to designated roads; • Use plant rescue to remove rare plants in construction footprint; • If roads or structures are fenced, use plain strands and not jackal proof fencing to ensure animals can still move through fences; and

Key Impact/impact driver	Description and possible effect	Proposed management actions
		• Excessive dust can be reduced by spraying water onto the soil to control dust generation. Other suitable dust control mitigation measures can also be considered. **<u>Rehabilitate</u>** *<u>Construction</u>:* • During construction maintain topsoil for later rehabilitation; • Revegetate all cleared areas as soon as possible following construction; • Rehabilitate using locally indigenous plant species. Where feasible translocate savage plants. Where not feasible use a seed mix that includes both annuals and perennials. • Stabilise all slopes and embankments of water courses; and • Where fragmentation of key habitats has occurred use landscape design methods to re-establish ecological connectivity such as green bridges or wildlife crossings, establishment of conservation corridors, underpasses for migrating animals, use of indigenous seeds and plants for landscaping, creation of riparian strips and revitalisation of flowing waterbodies.
Impact on faunal SCC	• Loss of faunal habitat and consequently loss of SCC; • Open deep trenches can trap certain ground-dwelling animals with no shelter, water or food. Also, if the trenches fill with water, animals that cannot escape, drown; • Possible ensnarement of animals or ingestion waste due to materials such as cables and plastic left lying around on site; • Increases in noise, vibrations, dust and light levels could potentially cause changes in behavioural patterns of animals and cause them to flee the area; • Increase in road traffic and associated road kills; • Faunal mortalities as a result of soil compaction and construction activities; • Soil compaction and open trenches may hamper overland and subsoil movement (e.g. mole rats) of some	**<u>Avoid</u>** *<u>Planning</u>:* • Avoid identified areas of high fauna importance, including SCC. *<u>Construction</u>:* • Avoid poaching of animals, or illegal collection of rare species. All instances of illegal collection should be reported to the applicable provincial Nature Conservation Authorities; • No dogs or other pets should be allowed on site; • Proper waste management procedures should be in place to avoid waste lying around and where possible to remove all waste material from the site. • Avoid road kills as far as possible; and • No construction should be done at night, as far as

Key Impact/impact driver	Description and possible effect	Proposed management actions
	animals • Increased human activities may cause animals to migrate away from their natural habitat; and • Increased risk of poaching due to an increase in human activities and road access to formerly remote and inaccessible areas. • Electrocution on ground as tortoises and other small fauna that get stuck underneath or against electrical fences, should such electrified fencing be installed.	possible. **Minimise** *Planning:* • Appropriate design of roads and other infrastructure where appropriate to minimise faunal impacts and allow fauna to pass through or underneath these features. *Construction:* • Search and rescue for reptiles and other vulnerable species during construction, before areas are cleared, as well as fauna that become trapped in trenches; • Access to the construction site should be strictly regulated and limited, and ensure that construction staff and machinery remain within the demarcated construction areas during the construction phase; • Environmental training for all staff and contractors on-site to increase their awareness of environmental concerns; • Night driving should be limited on site; • Appropriate lighting should be installed to minimize negative effects on nocturnal animals; • Speed limits should be set on all roads on site; and • Electrical fences, if installed, should be erected at least 30 cm from the ground or according to relevant the norms and standards of the Nature Conservation Authorities in the Western, Northern and Eastern Cape provinces. **Rehabilitate** *Operation:* • An Open Space Management Plan is required for the development, which makes provision for favourable management of the infrastructure and the surrounding area for fauna.
Alien plant invasion	• Removal of vegetation cover and topsoil can create pathways for the spread of invasive species; and • Altered soil structure and moisture promotes the establishment of alien invasive plants and animals.	**Avoid** *Construction:* • Avoid unnecessary disturbance of plant cover and topsoil;

Key Impact/impact driver	Description and possible effect	Proposed management actions
		• Use existing roads as far as possible; and • Do not use soil sources contaminated with alien invasive plant seeds for bedding of the pipe or for construction work. **Minimise** *Construction:* • Remove alien invasive plants occurring on or in vicinity of the construction site, preferably before they set seed. Dispose of all the cut plant material from site immediately using carefully considered and suitable methods that are in compliance with relevant legislation and based on consultation with experts, as required **Rehabilitate** *Construction:* • Remove all alien vegetation and re-vegetate disturbed areas as soon as possible after construction with perennial local fast-growing vegetation. Dispose of all the cut plant material from site immediately using carefully considered and suitable methods that are in compliance with relevant legislation and based on consultation with experts, as required. *Operation:* • Keep all livestock out of rehabilitated areas; • Avoid off road driving in rehabilitated areas; • An Alien Invasive Species (AIS) Management Plan to be implemented during the operational phase of the development, which makes provision for regular alien clearing and monitoring.
Soil disturbance and increased erosion	• Increased soil erosion and water run-off due to vegetation loss; • Potential siltation of drainage lines and watercourses.	**Avoid** *Construction:* • Avoid areas of high erosion vulnerability as much as possible; and • Clearing of vegetation, compaction and levelling should be restricted to the footprint of the proposed development.

Key Impact/impact driver	Description and possible effect	Proposed management actions
		Minimise and Rehabilitate *Construction:* • Revegetation of cleared areas with monitoring and follow-up to ensure that rehabilitation is successful; • Use barriers, geotextiles, active rehabilitation and other measures during and after construction to minimise soil movement at the site; • Roads should be provided with run-off structures; and • Roads should not be built on steep inclines.
Impact on CBAs and broad-scale ecological processes	• Changes in local habitat features and ecological processes; • Transformation of intact habitat within a CBA. Such CBAs are areas required to meet biodiversity targets for ecosystems, species or ecological processes and as such development in these areas is discouraged; • Transformation of habitat within an ESA. ESAs are areas that are not essential for meeting biodiversity targets, but play an important role in supporting the ecological functioning in a CBA; and • May affect the suitability of certain areas for inclusion in NPAES.	**Avoid** *Planning and Construction:* • Avoid CBAs as far as possible; and • Avoid impact to restricted and specialised habitats such as cliffs, large rocky outcrops, quartz, pebble patches and rock sheets. **Minimise** *Planning and Construction:* • Minimise construction in ESAs as far as possible. • Minimise the development footprint as much as possible and rehabilitate cleared areas after construction; and • Locate temporary-use areas such as construction camps and lay-down areas in previously disturbed areas as far as possible. **Rehabilitate** *Operation:* • Ensure that management of the pipeline development occurs in a biodiversity-conscious manner in accordance with an Open Space Management Plan for the development.
Cumulative impacts on habitat loss and broad-scale ecological processes	• Cumulative habitat loss; • Impact on broad-scale ecological processes; • Biodiversity loss; • Risk of explosions and/or gas leaks to aquatic and terrestrial ecosystems, including soil-dwelling fauna; and • Loss of wilderness character; ecotourism opportunities and the potential of unspoilt conservation areas.	**Avoid** *Planning and Construction:* • Avoid CBAs as far as possible. **Minimise** *Planning and Construction:* • Minimise construction in ESAs as far as possible.

Key Impact/impact driver	Description and possible effect	Proposed management actions
		• Ensure proper design and planning for demolition activities, with an emphasis on using delayed explosion methods, if blasting is required; • Minimise blasting operations to mid-day, where required; and • Minimise the development footprint as much as possible and rehabilitate cleared areas after construction is completed. **<u>Rehabilitate</u>** *<u>Operation</u>:* • Ensure that management of the pipeline development occurs in a biodiversity-conscious manner in accordance with an Open Space Management Plan for the development; • Ensure that gas pipeline infrastructure is regularly inspected for signs of corrosion or any potential perforation of the pipeline walls that could result in gas leaks and subsequent explosions

7 RISK ASSESSMENT

7.1 Consequence levels

Consequence levels used in the risk assessment, with thresholds for species, ecosystems and ecological processes are presented in Table 8 below. Thresholds for species are linked to thresholds used in IUCN Red List assessments, and those for ecosystems and ecological processes are linked to thresholds used in national assessments of ecosystem threat status and in biodiversity planning in South Africa.

Table 8. Consequence levels used in the risk assessment, with thresholds for species, ecosystems and ecological processes.

	Consequence level → / Impact ↓	Slight	Moderate	Substantial	Severe	Extreme
Species of special concern	Reduction in population or occupied area*	<20% (Least Concern LC)	20-30% (Near Threatened NT)	30-50% (Vulnerable VU)	50-80% (Endangered EN)	80-100% (Critically Endangered CR)
Ecosystems (habitat types)	Reduction in intact area**	<20% (Least Threatened LT)	20-40% (Least Threatened LT)	40-60% (Vulnerable VU)	60-80% (Endangered EN)	80-100% (Critically Endangered CR)
Ecological processes	Disruption of ecological functioning***	<20%	20-40%	40-60%	60-80%	80-100%

** In relation to national distribution (except for keystone species – in relation to study area)*
*** In relation to national distribution*
**** In relation to their functioning within the study area*

7.2 Risk assessment results

Biodiversity features do not necessarily share the same potential for mitigation after impact. This may depend on the extent, duration and severity of each impact, but also on the sensitivity of the receiving environment. Areas of very high and high ecological sensitivity, comprising both plant and animal SCC will be more vulnerable. The success of management actions may be variable.

Table 9. Impacts and risk assessment with and without mitigation applicable to all six gas pipeline corridor phases in this assessment.

Impact	Location	Without mitigation			With mitigation		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Vegetation removal and habitat loss due to clearance and infrastructure development, including impact on plant SCC	Very High	Extreme	Very Likely	Very High	Severe	Very Likely	High
	High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
	Medium	Substantial	Very Likely	Moderate	Moderate	Likely	Low
	Low	Moderate	Very Likely	Low	Slight	Likely	Very Low
Impact on fauna due to habitat loss, including impact on fauna SCC	Very High	Extreme	Very Likely	Very High	Severe	Very Likely	High
	High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
	Medium	Substantial	Very Likely	Moderate	Moderate	Very Likely	Low
	Low	Moderate	Likely	Low	Slight	Likely	Very Low
Increased risk of alien plant invasion	Very High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
	High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
	Medium	Substantial	Very Likely	Moderate	Moderate	Likely	Low
	Low	Moderate	Likely	Low	Slight	Likely	Very Low
Impact of wind and water erosion	Very High	Severe	Very Likely	High	Substantial	Likely	Moderate
	High	Substantial	Very Likely	Moderate	Moderate	Likely	Low
	Medium	Moderate	Likely	Low	Slight	Not Likely	Very Low
	Low	Moderate	Likely	Low	Slight	Not Likely	Very Low
Impact on CBAs and broad-scale	Very High	Extreme	Very Likely	Very High	Severe	Very Likely	High

Impact	Location	Without mitigation			With mitigation		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
ecological processes	High	Severe	Very Likely	High	Substantial	Likely	Moderate
	Medium	Substantial	Likely	Moderate	Moderate	Likely	Low
	Low	Moderate	Likely	Low	Slight	Not Likely	Very Low
Cumulative ecological impacts	Very High	Severe	Very Likely	High	Substantial	Very Likely	Moderate
	High	Substantial	Likely	Moderate	Moderate	Likely	Low
	Medium	Moderate	Not likely	Low	Slight	Not Likely	Very Low
	Low	Slight	Not likely	Very Low	Slight	Very Unlikely	Very Low

7.3 Limits of Acceptable Change

Limits of acceptable change are defined as the variation that is considered acceptable by experts in the field (Stankey *et al*., 1985) of a particular environmental indictor of a component or process of the ecological system in question. Potential limits of acceptable change for the Nama Karoo, Succulent Karoo and Desert biomes have been suggested by this author and are presented in Table 10.

Table 10. Suggested limits of acceptable change

Variable	Threat Status	Acceptable Change
Vegetation/Ecosystem Types	Critically Endangered	No Nett Loss of Vegetation/Ecosystem Type
	Endangered	No Nett Loss of Vegetation/Ecosystem Type
	Vulnerable	No more than 1% of the remaining extent of the vegetation type. No loss resulting in the vegetation type being elevated to a higher threat status
	Near-Threatened	No more than 5% of the remaining extent of the vegetation type No loss resulting in the vegetation type being elevated to a higher threat status
Plant SCC	Critically Endangered	No Nett Loss of plant SCC
	Endangered	No Nett Loss of plant SCC
	Vulnerable	No more than 1% of the remaining local population No loss resulting in a species being elevated to a higher threat status
	Near-Threatened	No more than 5% of the remaining local population No loss resulting in a species being elevated to a higher threat status
Fauna SCC	Critically Endangered	No nett loss of fauna SCC or resulting in a SCC being elevated to a higher threat status. Should sections of the planned Gas Pipeline routes transect the known Extent of Occurrence / distribution of a fauna SCC, a taxon-specific specialist should be appointed to confirm the sensitivity and assess the significance of potential impacts on that SCC. The impact assessment process must prove to the relevant competent authority that the proposed development will not have an unacceptable negative impact on SCC populations, both locally and regionally. Any identified impacts should be avoided or mitigated. All mitigation measures from the specialist study are to be incorporated into the EMPr. A South African Council for Natural Scientific Professions (SACNASP) accredited zoologist must conduct the impact assessment in accordance with the NEMA regulations.
	Endangered	
	Vulnerable	
	Data Deficient	
Alien plant invasion	All sensitivity categories	No invasion of adjacent natural habitats
Wind and water erosion activity	All sensitivity categories	No long-term soil erosion
Loss of CBAs	CBA1	No loss of irreplaceable CBAs No loss resulting in it no longer being possible to meet biodiversity targets

8 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

8.1 Planning phase

- Planning stage avoidance of high-threat status ecosystems, as well as fauna and flora species populations of conservation concern is required. In many areas, the known extent of occurrence (EoO) / distribution range of SCC are not well known and as such, the planning phase should make provision for flexibility in determining the final pipeline alignment to avoid locally sensitive features and populations of SCC. Should sections of the planned gas pipeline route transect the known EoO / distribution of an SCC, a taxon-specific specialist should be appointed to confirm the sensitivity and assess the significance of potential impacts on that SCC. The impact assessment process must prove to the relevant competent authority that the proposed development will not have an unacceptable negative impact on SCC populations, both locally and regionally. Any identified impacts should be avoided or mitigated. All mitigation measures from the specialist study to be incorporated into the EMPr. A SACNASP accredited botanist and zoologist must conduct the impact assessment in accordance with the NEMA regulations.
- Pre-construction walk-through and on-site assessment by a SACNASP accredited botanist and zoologist of the final pipeline route is mandatory to identify any features that should be avoided or buffered from impact, and to identify and locate any plant and animal SCC that should be subject to search and rescue prior to construction.
- The final gas pipeline route should be checked in the field by the appropriate accredited specialists and at the appropriate time of year. In the winter rainfall areas, all fieldwork for flora should take place from late July through to mid-September depending on the exact timing of rainfall. In the summer rainfall areas, fieldwork should take place following good rainfall and growth of the vegetation. In most areas this is usually late summer to early autumn (February to April).
- Where high sensitivity areas cannot be avoided and there is significant habitat loss in these areas, an offset study should be conducted to ascertain whether an offset is an appropriate mechanism to offset the impact on the high sensitivity area. This should include an identification of offset receiving areas as well as an estimate of the required extent of the offset and the degree to which the offset would be able to compensate for the assessed impacts.

8.2 Construction phase

- The construction operating corridor should be clearly delimited and demarcated with construction tape or similar markers to limit construction activity and disturbance to the pipeline corridor.
- Temporary lay-down areas should be located within previously transformed areas or areas that have been identified as being of low sensitivity. These areas should be rehabilitated after use.
- All construction vehicles should adhere to a low speed limit (30km/h for trucks and 40km/h for light vehicles) to avoid collisions with susceptible species such as snakes and tortoises.
- All hazardous materials should be stored in the appropriate manner to prevent contamination of the site. Any accidental chemical, fuel and oil spills that occur at the site should be cleaned up in the appropriate manner as related to the nature of the spill.
- Any trenches or holes that need to be dug should not be left open for extended periods of time as fauna may fall in and become trapped. Trenches which are standing open should have places where there are soil ramps allowing fauna to escape the trench.
- Measures should be taken to prevent and limit poaching of fauna and harvesting of flora by construction crews or other people accessing the pipeline route.

8.3 Operations phase

- If parts of the pipeline such as compressor stations (which is not part of the scope of the assessment) need to be lit at night for security purposes, this should be done with low-UV type lights (such as most LEDs), which do not attract insects.

- If any parts of the pipeline, or any work area in the vicinity of the pipeline need to be fenced, then no electrified strands should be placed within 30 cm of the ground as some species such as tortoises are susceptible to electrocution from electric fences as they do not move away when electrocuted but rather adopt defensive behaviour and are killed by repeated shocks.
- All vehicles accessing the pipeline should adhere to a low speed limit (30 km/h max) to avoid collisions with susceptible species such as snakes and tortoises.
- Oils, fuels and other hazardous materials required for machine and vehicle maintenance and repair are to be securely stored to prevent spill and contamination during operation and maintenance of the gas pipeline infrastructure.
- Regular alien clearing along the pipeline route is required. An annual check and clearing should be sufficient in most arid and semi-arid areas.
- Regular erosion monitoring and remediation. An annual check with follow-up rehabilitation and remediation should be sufficient in most areas. It is important to note that erosion can be severe in semi-arid environments due to the occasional occurrence of heavy showers and the lack of sufficient vegetation cover to protect the soil or slow runoff, with the result that occasional high-risk erosion events can cause large amounts of damage.
- Access to the pipeline servitude should be restricted to service and maintenance staff and affected landowners.

8.4 Rehabilitation and post closure

Arid areas are very difficult to rehabilitate with a variety of constraints limiting success. In most cases topsoil management is a key factor as the soils deeper down may have a very high pH, be salt- or metal-laden, be very nutrient poor or otherwise inhospitable to plant establishment. Furthermore, in most instances, the restoration of pre-construction levels of diversity is not a realistic goal and the rehabilitation should focus on the establishment of an ecologically functional cover of locally-occurring species to protect the soil and provide some cover for fauna. The following recommendations are provided for the rehabilitation and post closure phase:

- Clear rehabilitation targets should be set for each area based on the background perennial vegetation cover. A reasonable target would be 60% of the vegetation cover of adjacent indigenous vegetation achieved after five years.
- All species used in rehabilitation should be locally occurring perennial species. A mixture of different functional type species is recommended.
- No fertilizers or irrigation should be applied during rehabilitation as this is likely to lead to a green flush after rain and failure of perennial species to establish in competition with annuals and ephemerals.
- There should be annual monitoring and follow-up action on alien species occurrence and erosion.

8.5 Monitoring requirements

- Populations of key fauna and flora SCC, of which the known extent of occurrence or distribution range was identified and confirmed by a SACNASP accredited botanist and zoologist during the planning (pre-construction) phase and which are being transected by the planned gas pipeline route, should be monitored throughout construction and operation to ensure that these SCC are not being poached or otherwise negatively impacted by the presence and operation of the gas pipeline. Monitoring frequency depends to some extent on the longevity of a specific species, but should also be informed by its threat status and the consequences of not identifying unacceptable negative impacts beforehand. Any identified impacts should be avoided or mitigated. As such, the following basic monitoring schedule is proposed – Pre-construction, Post-construction and every 3-5 years during operation depending on the species.
- The successful establishment and persistence of plant species of high conservation concern translocated during the search and rescue should be monitored for at least five years after construction is completed. An appropriate frequency would be a year after translocation and every second year thereafter.

9 GAPS IN KNOWLEDGE

- A major gap in knowledge for the Karoo study area is that there is a paucity of baseline information as the area is generally poorly sampled and sparsely distributed with the result that extensive areas will have no records for fauna or flora in the existing biodiversity databases.
- Areas with generally good records include the national parks, along the main access roads and near to towns and other popular tourist destinations.
- As a result, all areas should receive detailed baseline data collection in the appropriate season to inform the final pipeline alignment.

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APPENDIX A – PEER REVIEW AND SPECIALIST RESPONSE SHEET

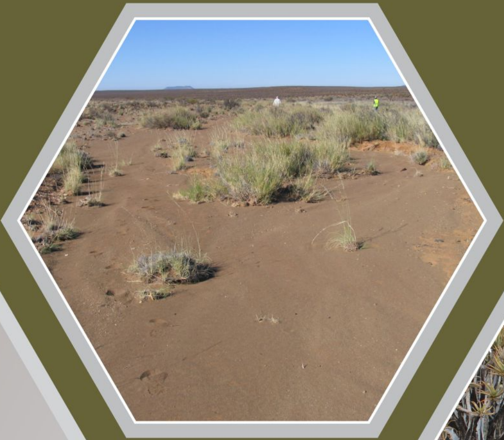
Peer Reviewer: Professor Sue J. Milton-Dean; Renu-Karoo Veld Restoration

EXPERT REVIEW AND SPECIALIST RESPONSES: Karoo and Desert Biomes - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/Figure**	**Expert Reviewer Comments**	**Response from Specialist**
Sue Milton	1-82			The report, including methods, mapping, coverages used, conclusions and recommendations are all clear, logical and easy to follow. I have made a few suggestions for corrections to grammar and additions to the text and references. These are listed by page and line number below.	Noted
Sue Milton	1-82		Additional Refs	Cherryl Walker, Suzanne J Milton, Tim G O'Connor, Judy M Maguire & W Richard J Dean (2018) Drivers and trajectories of social and ecological change in the Karoo, South Africa, African Journal of Range & Forage Science, 35:3-4, 157-177	Reference added
Sue Milton	1-82		Additional Refs	M Timm Hoffman, Andrew Skowno, Wesley Bell & Samukele Mashele (2018) Long-term changes in land use, land cover and vegetation in the Karoo drylands of South Africa: implications for degradation monitoring, African Journal of Range & Forage Science, 35:3-4, 209-221	Reference added
Sue Milton	1-82		Additional Refs	W Richard J Dean, Colleen L Seymour & Grant S Joseph (2018) Linear structures in the Karoo, South Africa, and their impacts on biota, African Journal of Range & Forage Science, 35:3-4, 223-232	Reference added
Sue Milton	19	4		"Although mostly still intact, heavy grazing has left certain parts" add a noun such as "Although the habitat is mostly intact"	Noted and updated
Sue Milton	19	6		"increased stocking rates that in turn exacerbates" should read "exacerbate"	Noted and updated
Sue Milton	19	13		"well as the construction of dams also threaten the Nama Karoo's" could add "construction and failure of dams"	Noted and updated
Sue Milton	19	17		"invasive plants currently common to the Nama Karoo region" should read "common in"	Noted and updated
Sue Milton	19	18		Suggest adding Opuntia spp and various other Cactaceae - (bearing in mind the widespread distribution of Tephrocactus and Echinopsis in the Nama Karoo)	Noted and updated
Sue Milton	19	19		Suggest adding Pennisetum setaceum - especially as this is very successful on disturbed rocky ground such as cutting on the escarpment, borrow pits etc.	Noted and updated

EXPERT REVIEW AND SPECIALIST RESPONSES: Karoo and Desert Biomes - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	Page Range	Line/s	Table/Figure	Expert Reviewer Comments	Response from Specialist
Sue Milton	19	31		"with the highest concentrations particularly within the avifauna, specifically raptors " Suggest inserting "highest concentration of pesticides…"	Noted and updated
Sue Milton	20	17		"Euphorbiaceae adds to the species diversity of Nama Karoo" "richness" may be a more appropriate adjective	Noted and updated
Sue Milton	21	33		Should probably also mention scorpions	Noted and updated
Sue Milton	22			4.2.4.2 Socio-economic value. This paragraph could also cite Walker et al 2018	Noted and reference added
Sue Milton	22	12		"commercial exploitation of medicinal bioprospecting (such as Hoodia gordonii)" Suggest changing "medicinal bioprospecting" to "medicinal plants"	Noted and updated
Sue Milton	22	26		"extreme summer aridity with daily temperatures in excess of 40°C the norm" Suggest changing to read " daily temperature maxima in summer in excess of 40°C the norm"	Noted and updated
Sue Milton	23	3		See also see Joseph R. McAuliffe,⁎, M. Timm Hoffman, Leslie D. McFadden, Wesley Bell, Sam Jack, Matthew P. King, Veronica Nixon, 2018 ,Landscape patterning created by the southern harvester termite, Microhodotermes viator: Spatial dispersion of colonies and alteration of soils. Journal of Arid Environments, 157: 97–102 OR Joseph R. McAuliffe,⁎, M. Timm Hoffman, Leslie D. McFadden, Sam Jack, Wesley Bell, Matthew P. King 2019 Whether or not heuweltjies: Context-dependent ecosystem engineering by the southern harvester termite, Microhodotermes viator. Journal of Arid Environments. in press	Noted and references added
Sue Milton	25 or 26	4.3.3		To match the other sections you need a statement about invasive alien plants in the Succulent Karoo. I would think that Arundo, Nerium, Tamarix ramossissima, Atriplex lindleyi, Cactaceae, Pennisetum setaceum and Prosopis should be mentioned especially as alien problems are exacerbated by cropping, mining and eutrophication of water	Noted and updated
Sue Milton	29	15-19		Perhaps add hippo. Also this section needs a citation to support the statement.	Noted, updated and references added
Sue Milton	30	7		"the Karoo chat (Cercomela schlegelii)" Why single out this widespread species probably more common in the Nama than	Noted. Species removed.

EXPERT REVIEW AND SPECIALIST RESPONSES: Karoo and Desert Biomes - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/Figure**	**Expert Reviewer Comments**	**Response from Specialist**
				Succulent Karoo?	
Sue Milton	30	17-18		Scorpions: Move this sentence to the paragraph dealing with invertebrates	Noted and updated
Sue Milton	31	16-20		Should probably also cite Walker et al 2018	Noted and reference added
Sue Milton	32	7		Brownanthus now Mesembryanthemum	Noted and updated
Sue Milton	32	12		"and Pachypodium namaquanum ('halfmens'), is typical of non-succulent 11 woody perennials such as Boscia albitrunca (Shepherds tree)," Perhaps write "is typified by non-succulent woody perennials.."	Noted and updated
Sue Milton	66			"Avoid impact to restricted and specialised habitats such as..." Suggest adding quartz or pebble patches	Noted and updated
Sue Milton	67			Do explosions and leaks pose any particular risk to terrestrial or aquatic systems or to soil-dwelling animals?	Yes, noted and section updated
Sue Milton	73	27		Should not this section also cover best practice guidelines for fuel storage and vehicle and machine repair on site	Yes, noted and section updated
Sue Milton	74	8.5		Possibly add to the guidelines "No fertilizers or irrigation should be applied during rehabilitation as this is likely to lead to a green flush after rain and failure of perennial species to establish in competition with annuals and ephemerals"	Yes, noted and section updated
Sue Milton	74	25-31		"A key gap in knowledge for the Karoo study area is that baseline information is generally poorly sampled" would read better as "there is a paucity of baseline information as the area is generally poorly sampled etc."	Noted and updated
Sue Milton	75	4		Allsopp with 2 ps	Noted and updated

Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa



Appendix C.1.5

Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Albany Thicket Biome

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

ALBANY THICKET BIOME

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[7] WWF, ECPTA

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ABBREVIATIONS AND ACRONYMS

AIP	Alien Invasive Plants
CBA	Critical Biodiversity Area
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
EC	Eastern Cape Province
ECBCP	Eastern Cape Biodiversity Conservation Plan
EN	Endangered
ESA	Ecological Support Area
ESI	Environmental sensitivity index
EWT	Endangered Wildlife Trust
GIS	Geographic Information System
H	High (sensitivity)
L	Low (sensitivity)
LCP	Least Cost Path
M	Medium (sensitivity)
NEMBA	National Environmental Management: Biodiversity Act
PU	Planning Unit
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
STEP	Subtropical Thicket Ecosystem Project
VH	Very high (sensitivity)
WC	Western Cape Province
WCBCP	Western Cape Biodiversity Conservation Plan

1 SUMMARY

This assessment aims to identify the potential impacts of constructing and maintaining gas pipeline infrastructure in the Albany Thicket biome of South Africa.

Key environmental attributes of the Albany Thicket biome in the proposed Phased Gas Pipeline study areas include:

- High diversity and endemism for succulents;
- Highly fragmented biome nested in a mosaic of other biomes;
- Extensively degraded due to overgrazing (e.g. goats); and
- Invasion of non-thicket species (e.g. Grassland and Nama-Karoo elements).

The activities associated with gas pipeline construction and maintenance may pose a risk of habitat destruction and degradation, establishment and spread of invasive vegetation, and increased poaching of rare and endangered fauna and flora.

2 INTRODUCTION

The purpose of this assessment is to identify the potential impacts of gas pipeline construction and maintenance to the Albany Thicket biome of South Africa. Furthermore, it recommends management actions and best practice mechanisms to avoid and minimise any potential impacts to sensitive Albany Thicket ecosystems.

This assessment forms part of an overarching Strategic Environmental Assessment (SEA) which ultimately aims to guide sustainable development and environmental decision-making on proposed phased gas pipeline construction and maintenance in South Africa.

The Albany Thicket biome, one of South Africa's nine recognised biomes, and covers an area of nearly 42 000 km^2 in the Eastern Cape and Western Cape provinces (Vlok et al., 2003).

Approximately 60 % of this biome has been severely degraded and the mesic thicket, which has the highest levels of endemism and species richness within the biome, is under the greatest pressure, especially due to overgrazing (Vlok et al., 2003).

The Subtropical Thicket biome provides the resource base for a wide range of economic activities that provide employment for many thousands of people, including commercial and subsistence pastoralism, and growing wildlife-based industries (ecotourism, game breeding, meat and sport hunting).

3 SCOPE OF THIS STRATEGIC ISSUE

3.1 Data Sources

This analysis has made extensive use of data resources arising from the updated, revised Eastern Cape Biodiversity Conservation Plan (ECBCP, 2017) and the Subtropical Thicket Ecosystem Project (STEP) (Pierce & Mader, 2006). Primary data sources used in these projects come from a wide range of organizations and databases compiled by these organizations, including those listed in Table 1.

Table 1: Organizations who provided data used in the Eastern Cape Biodiversity Conservation Plan and used in this study (workshop held in Grahamstown, June 2017).

Organization	Data
South African National Biodiversity Institute (SANBI)	Red listed species data (plants, reptiles, butterflies, bats)
BirdLife South Africa	Important bird areas, and red listed distribution maps
Endangered Wildlife Trust (EWT)	Red listed mammals distribution maps
Geoterraimage	Land cover map 2013/14*. ** This data was further augmented with data from the Agricultural Research Commission and the South African National Biodiversity Institute for the ECBCP.*

In addition to the data sources indicated above, experts for specific taxa were consulted to verify the distribution of and threats to species of special conservation concern within the Eastern Cape (Table 2).

Table 2: Corresponding authors for specific taxa to verify distribution of and threats to species.

Taxa	Experts	Position
Bats	Dr. Werner Marais	Independent consultant
Birds	Jon Smallie	Birdlife Africa
Butterflies	Dr. John Midgely	Academic/Researcher
Frogs	Dr. William Branch	Academic/Researcher
Reptiles	Werner Conradie/ Dr. William Branch	Academic/Researcher
Mammals	Dr Dean Pienke/WWF	Eastern Cape Parks and Tourism Agency
Plants	SANBI data base	SANBI

3.2 Assumptions and Limitations

The scale of input data used in the 2017 ECBCP is variable, however data was integrated at the level of one-hectare pixels, making fine scale analysis possible.

There are a number of assumptions relating to the assignment of subjective sensitivity classes to the various conservation planning categories (Critical Biodiversity Areas (CBAs), and Ecological Support Areas (ESAs)). The main underlying assumption is that biodiversity value, equates to biodiversity sensitivity. In essence, this is implying that for any given activity (like vegetation clearing) the associated impacts will be higher on areas of 'high biodiversity' value than on areas with 'medium' or 'low' value biodiversity. While this is a reasonable assumption, for any one specific area, for this to hold across all gas pipeline phases, it requires that the same sensitivity designation will respond to impacts in a similar way. This assumption may not always hold, because there may be different reasons (biodiversity features) for any sensitivity classification, and these biodiversity features may not respond the same to any particular stress (see example in Table 3).

Table 3: Example showing why a biodiversity sensitivity class may not always provide a good indication of a response to an impact.

Biodiversity planning category	Biodiversity sensitivity	Reasons for classification	Response to impact of clearing vegetation for pipes
CBA1	Very high	Red data plants	Very high (direct displacement)
CBA1	Very high	Within home range of Cape vulture	Medium (indirect, noise and dust etc.)

3.3 Relevant Regulations and Legislation

Table 4 lists key legislation, policies and plans pertaining to conservation planning in the Eastern Cape.

Table 4: Key legislation, policies and plans relevant to biodiversity conservation planning in the Eastern Cape.

Year	Document/Act
Legislation	
1934	Townships Ordinance 33 of 1934 (governing urban areas in the former Transkei)
1970	Mountain Catchment Areas Act (No. 63 of 1970)
1970	Subdivision of Agricultural Land Act (No. 70 of 1970)
1974	Cape Nature and Environmental Conservation (Ordinance 19 of 1974)
1987	Ciskei Nature Conservation Act 1987
1987	Land Use Regulation Act (No. 15 of 1987) (governing former Ciskei)
1983	Conservation of Agricultural Resources Act (No. 43 of 1983)
1998	National Forest Act (No. 84 of 1998)
1985	Land Use Planning Ordinance (Ordinance 15 of 1985) (governing former old Cape Province)
1992	Transkei Environmental Conservation Decree (No. 9 of 1992)
1998	National Water Act (No. 36 of 1998)
1999	National Heritage Resources Act (No. 25 of 1999)
2000	Municipal Systems Act (No. 32 of 2000)
2002	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
2003	National Environmental Management: Protected Areas Act (No. 57 of 2003, as amended)
2004	National Environmental Management: Biodiversity Act (No. 10 of 2004)
2004	National Environmental Management: Air Quality Act (No. 39 of 2004)
2008	National Environmental Management: Waste Act (No. 59 of 2008, as amended)
2010	Eastern Cape Parks and Tourism Agency Act (No. 2 of 2010)
2013	Spatial Planning and Land Use Management Act (No. 16 of 2013)
Conventions, Policies and Plans	
1971	Convention on Wetlands (Ramsar Convention)
1973	Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES)
1994	United Nations Framework Convention on Climate Change (UNFCC)
2011	National Freshwater Ecosystem Priority Areas (Nel et al., 2011)
2015	National Biodiversity Strategy and Action Plan (Version 2)
Under revision	Eastern Cape and National Protected Area Expansion Strategy

Note that this Specialist Assessment Report was peer reviewed prior to release to stakeholders for review. The report was updated, as required, following the peer review findings. A copy of the peer review report and responses from the Specialist Team is included in Appendix C of this report.

4 BASELINE DESCRIPTION

4.1 Demarcation of study area

The four Gas Pipeline Phases (study areas) falling within the Albany Thicket biome are shown in Table 5 and Figure 1 below.

Table 5: Gas Pipeline Phases coinciding with the Albany Thicket biome and intersecting municipalities and STEP map book tile (Pierce & Mader, 2006)

Gas Pipeline Corridor Phase and Province	Local Municipalities	STEP map book tiles
Phase 1 (WC)	Kannaland, Hessequa, Mosselbay	14
Phase 2 (WC/EC)	Oudsoorn,Baviaans,Ikwesa, Sundays river valley, Kou-kamma, Kouga, Nelson Mandela Bay	18, 17, 16, 10, 9, 15
Phase 7 (EC)	Blue crane Route, Sundays River valley, Nelson Mandela Bay, Makana, Ndlamabe, Nkonkobe,Ngushwa, Buffalo City, Great Kei	6, 13, 12, 19
Gas Phase inland (EC)	Camdaboo, Inkwezi, Bluecrane route	2,3
WC = Western Cape; EC = Eastern Cape		

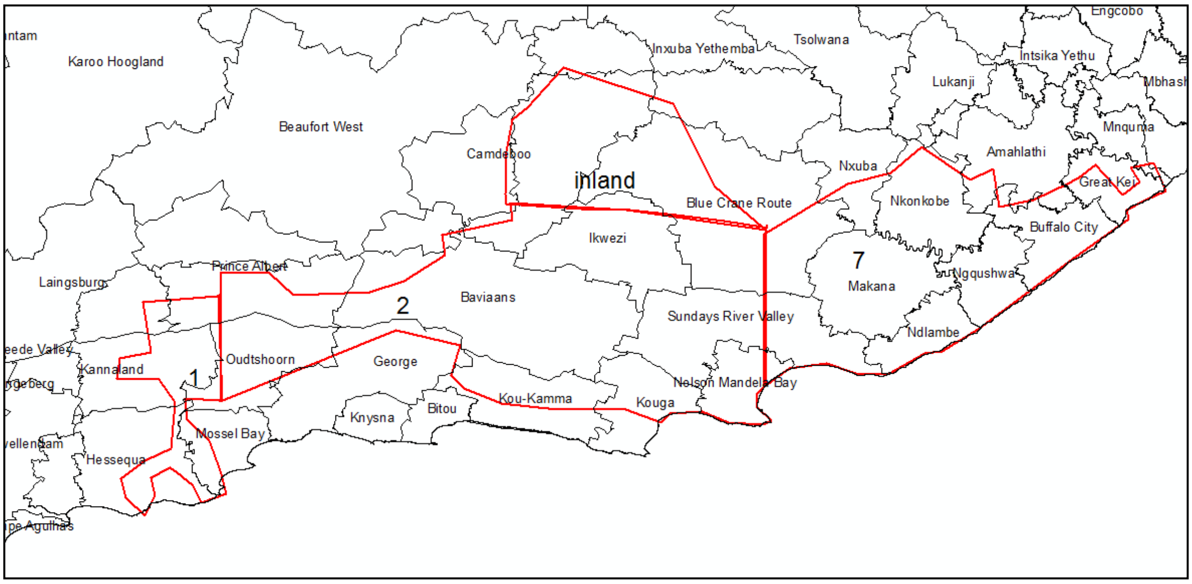

Figure 1: Image of the proposed phased gas pipeline study areas, clipped to a notional buffered extent (25 km) of Albany Thicket biome, showing overlap with local municipalities.

The Albany Thicket biome is a highly fragmented biome, consisting mostly of valleys, embedded within a mosaic of other biomes. For this study, the gas pipeline corridor phases occurring within the Albany Thicket biome have been buffered (25 km) as large blocks that include other biomes that surround the Albany Thicket (Figure 2).

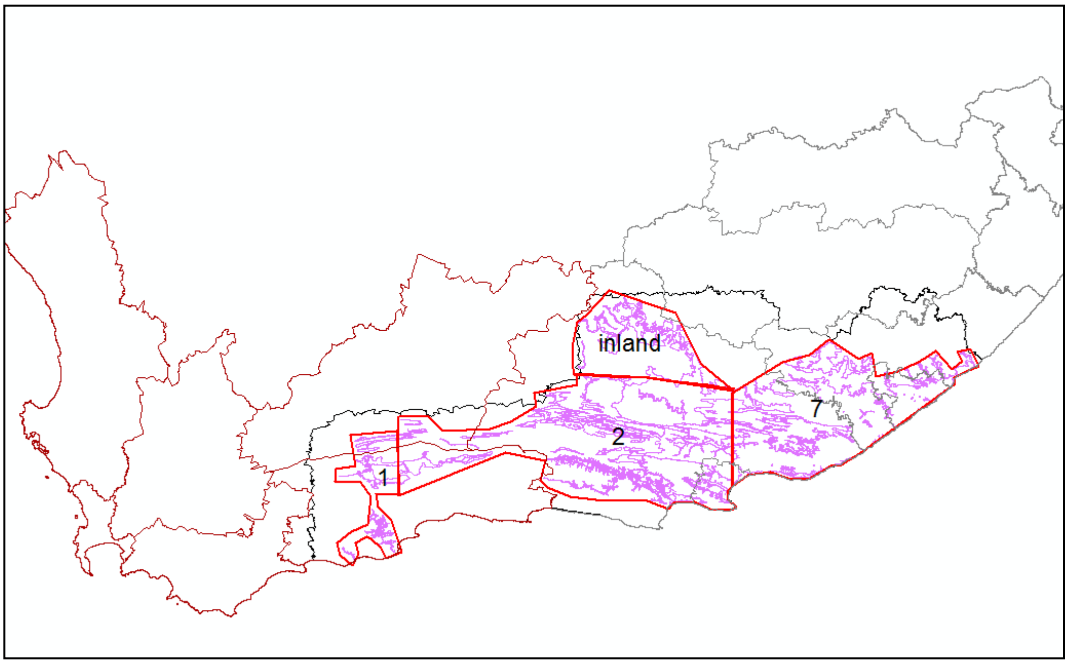

Figure 2: Image of the study areas for Gas Pipeline Corridor Phases 1, 2, 7 and Inland, within a notional buffer around the Albany Thicket biome (Albany Thicket biome extent shown in purple outline, and STEP planning domain in black).

4.2 Baseline Environmental Description of the Albany Thicket Biome

4.2.1 What and where is the Albany Thicket biome in South Africa?

The Albany Thicket biome (also referred to as the 'Thicket biome') is concentrated mainly in the Eastern Cape but also extends into the Western Cape and up the east coast, to a limited degree, as far as the Tugela River basin (Figure 3). It is one of South Africa's nine biomes, covering an area of nearly 42 000 km^2 (Vlok et al., 2003).

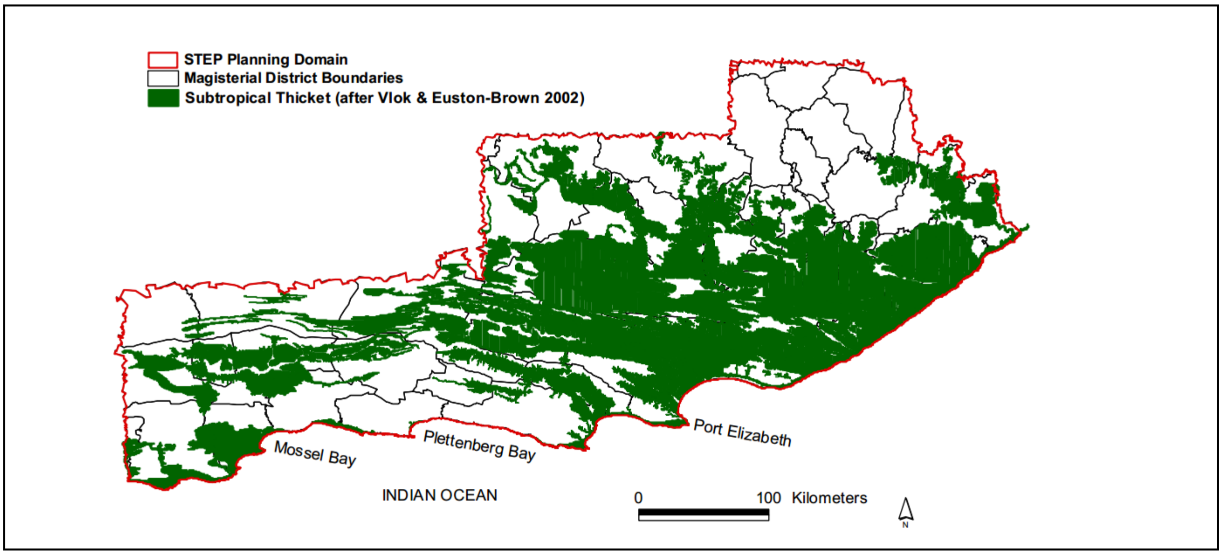

Figure 3: Subtropical Thicket Ecosystem Project (STEP) planning area (Vlok et al., 2003).

Subtropical thicket is a closed shrubland to low forest dominated by evergreen, sclerophyllous or succulent trees, shrubs and vines, many of which have stem spines. It is often almost impenetrable, is generally not divided into strata, and has little herbaceous cover. According to certain definitions subtropical thickets can be considered as a low forest, however this definition is problematic, for several reasons, in that it often occurs in many areas with a rainfall too low to support forests (<800 mm/yr.), does not have the horizontal stratification of forests, and does not have the signature species typical of Southern African afrotemperate forests, (Vlok et al., 2003).

The vegetation of the Albany Thicket can be divided into three eco-regions: the dry, inland areas of the Fish, Sundays, and Gamtoos river valleys; the mesic coastal areas of these river valleys; and the intermontane valleys to the north and west. The vegetation contains a high proportion of both leaf and stem-succulent shrubs such as Spekboom (*Portulacaria afra), Euphorbia bothae* (dominant along the Fish River Valley), *Euphorbia ledienii* and Noorsdoring (*Euphorbia coerulescens*), (Vlok et al., 2003).

The distribution of Albany Thicket communities is determined by a complexity of interrelated factors. The most important of these appears to be soil type. Albany Thicket is restricted to deep, well-drained, fertile sandy loams with the densest thickets occurring on the deepest soils (Cowling, 1983). Soil moisture is another important limiting factor. The vegetation is adapted to grow in hot, dry river valleys where soil moisture is limited for extended periods. Soil moisture increases towards the east, resulting in thickets that are more open, less succulent and less thorny.

The findings of a brief field work exercise are captured in Appendix B of this chapter.

4.2.2 Vegetation types of subtropical thicket

This biome was originally described as 'Valley Bushveld' (Acocks, 1953), for good reasons, it typically occurs within the steep slopes of river valleys. This has been a particularly problematic veld type in terms of its delimitation, origins, affinities and dynamics. Tinley (1975) was the first to recognise Valley Bushveld and allied types (Spekboomveld and Noorsveld) as part of a ‘thicket biome’, characterised by a closed-canopy vegetation consisting of an impenetrable tangle of shrubs and low tree. However, Cowling (1984) was the first to formalise the thicket concept in the South African phyto-sociological literature, and Low & Rebelo (1996) recognized the thicket biome in a revised map of Southern Africa vegetation types. The first comprehensive study of the vegetation patterns of diversity was done by Vlok et al., (2003). This yielded 112 unique thicket vegetation types, 78 of which comprised thicket clumps in a matrix of non-thicket vegetation (mosaics) (Figure 4).

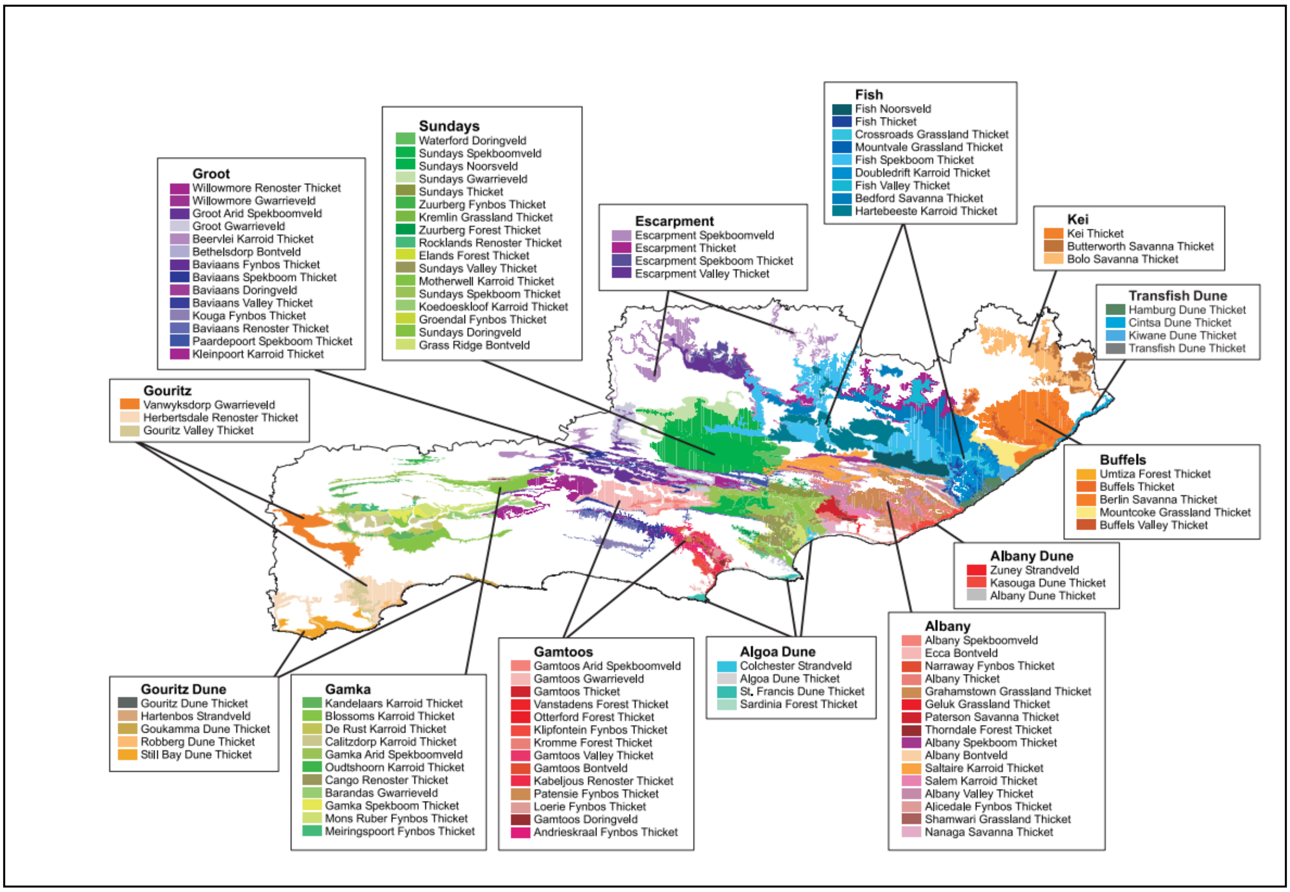

Figure 4: The 112 unique thicket vegetation types for the STEP area (after Vlok *et al.*, 2003).

4.2.3 What is the state of subtropical thicket?

According to Mucina and Rutherford (2006), overall 60 % of this biome has been severely degraded, with only 11 % still in pristine condition, and around 7.3 % totally lost. The mesic thicket, which has the highest levels of endemism and species richness within the Thicket biome, is under the greatest pressure.

A more detailed analysis by Lloyd et al. (2002) and Vlok & Euston-Brown (2002b) provides figures on levels of severely degraded and moderately degraded thicket for each vegetation sub-class. This analysis shows that except for the Mainland Montane Solid (Thicket) and Coastal Dune Solid Thicket, all the vegetation units described show high levels of severe and moderate degradation. Refer to Table 6 below.

Table 6: Proportions (%) of three thicket condition classes (i.e. Pristine Thicket, Moderately Degraded Thicket and Severely Degraded Thicket), and transformed land in the solid thicket types, as a function of the total area of solid thicket (20 730.32 km²) as described by Vlok & Euston-Brown (2002b).

Thicket Type	Other land cover			Thicket condition classes			Total
	Transformed	Water/Sand	Non-Thicket	Pristine Thicket	Moderately degraded Thicket	Severely Degraded Thicket	
Dune thicket	0,13	0.17	0.14	0.3	0.56	0.07	1.40
Valley Thicket	1,85	0.11	0.62	9.97	17.72	14.01	44.28
Arid thicket	0,22	0.11	0.44	3.02	11.58	23.35	38.73
Thicket mainland-montane	0,64	0.11	0.11	5.78	5.87	1.84	14.34
Thicket mainland-basin	0	0.0	0.02	0.53	0.48	0.22	1.25
Totals	2,84	0.51	1.32	19.60	36.21	39.49	100

Forms of thicket vegetation that have been especially ravaged by overgrazing in the past century, are those rich in spekboom or igwanishe, *Portulacaria afra*. There is evidence that even in the short space of a decade, heavy browsing, especially by mohair-producing angora goats, can convert dense shrubland into a desert-like state (Vlok & Euston-Brown, 2002a). Of some 16,000 square km formerly covered in spekboom-rich thicket, some 46 % has undergone severe degradation and 34 % moderate disturbance. This is predominantly from overgrazing, although clearing for crop cultivation is another major threat to the Thicket vegetation. Land has been cleared along the rivers, and lucerne and other crops are grown under irrigation. Land has also been cleared for orange orchards in the Addo region (Vlok & Euston-Brown, 2002b).

The role that indigenous herbivores may have played in determining vegetation boundaries, as do domestic livestock today under certain management regimes has been the subject of much speculation (Hoffman & Cowling, 1990). Several studies have shown that African elephant (*Loxodonta Africana*) has a substantial impact on subtropical thicket composition (Stuart-Hill, 1992), however, these animals as well as black rhinoceros (*Diceros bicornis*), even under exceptionally high population density (unlike goats) do not convert solid thicket into a mosaic savannah, as Thicket types are probably much more resilient to the impacts of indigenous herbivores. Overgrazing by domestic livestock, in particular goats, has caused dramatic changes in thicket vegetation, with Nama-Karoo shrub like elements invading Arid Thicket types, and subtropical grasses massively increasing in cover in some Valley Thickets, creating savanna-like vegetation that burns at regular intervals, further eliminating succulents and fire-sensitive shrubs (Hoffman & Cowling, 1990).

Unfortunately, removing livestock and resting the veld does not lead to natural recovery of the vegetation, as seedling establishment is constrained by the exposed soil's temperature extremes and reduced water-holding capacity. Essentially, to restore this thicket type requires active interventions (Vlok & Euston-Brown, 2002a).

4.2.4 Value of subtropical thicket

4.2.4.1 Biodiversity Value

- *Flora*

The Albany Centre is a major centre of botanical diversity and endemism for succulents of karroid affinity, especially in the Mesembryanthemeceae, Euphorbiaceae and Crassulaceae, as well as a centre for certain bulb groups.

Subtropical thicket is renowned for its high plants species richness and levels of endemism (i.e. species that grow nowhere else). Vlok & Euston-Brown (2002a) provide a tally of 1 588 subtropical thicket species for the planning domain, 322 (20 %) of which are endemic. Most of these endemics are succulents associated with the vygie, euphorbia, crassula, aloe and stapeliad plant groups (Vlok & Euston-Brown, 2002a).

The subtropical thicket is associated with two globally recognised centres of succulent plant endemism, namely the Little Karoo Centre of the Succulent Karoo in the west and the Albany Centre in the east (van Wyk & Smith, 2001). The Albany Centre encompasses elements of the Cape, Succulent Karoo and Maputaland-Pondoland regions. The Subtropical Thicket biome comprises the south-western sector of the Maputaland-Pondoland hotspot (Figure 5).

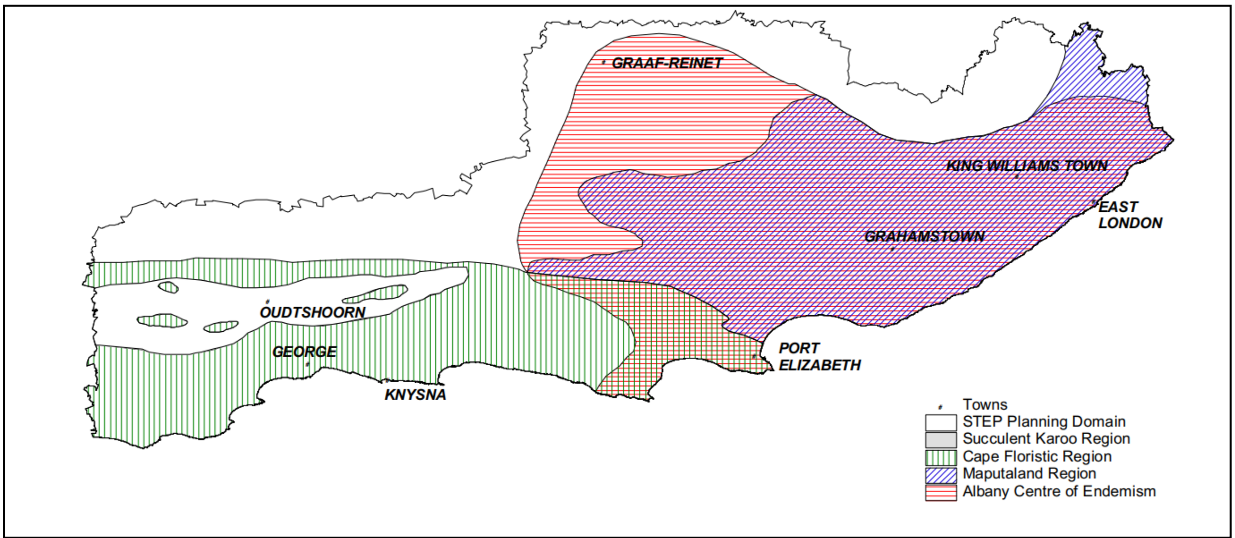

Figure 5: Centres of plant diversity within the STEP planning domain. Boundaries according to van Wyk & Smith (2001).

Subtropical thicket forms mosaics with other South African biomes, namely Fynbos, Forest, Grassland, Nama-Karoo, Savanna and Succulent Karoo. The result is outstanding ecosystem level diversity. Albany Thicket contains at least 125 threatened species, with the mesic thicket vegetation types having the highest number of threatened species (Vlok & Euston-Brown, 2002a).

- *Fauna*

The fauna of the Albany Thicket biome, although diverse, does not demonstrate the level of endemism shown by the flora (Vlok et al., 2002a).

Mammal diversity is relatively high, with 48 species of large and medium-sized mammals, a consequence of the diversity of biomes within the STEP planning domain. Unfortunately, many of these species have been extirpated and all have undergone extensive reductions in their distribution. The smaller mammals include at least two endemic species (long tailed forest shrew and Duthie's golden mole), none of which is restricted to subtropical thicket.

The avifauna is diverse, with 421 species of birds recorded within the planning domain (with no endemics), of which 307 species utilise thicket (Dean, 2002). Birds appear to play an important role in seed dispersal of thicket plants (Dean, 2002). A total of 10 “Important Bird Areas” occur within the planning domain, although only three of these include subtropical thicket (Dean, 2002).

The reptile fauna includes five tortoise species – an exceptional tally - as well as relatively high endemism (six species) among the lizards and snakes (Branch, 1998). The amphibian fauna includes at least three endemic species (Passmore & Carruthers, 1995). Although the invertebrate diversity and endemism is probably high, little is known about this group, other than charismatic species such as the flightless dung beetle (*Circellium bacchus*), which is restricted to subtropical thicket.

4.2.4.2 Socio-economic value

The Subtropical Thicket biome provides the resource base for a wide range of economic activities that provide employment for many thousands of people. It provides resources to support extensive commercial and subsistence pastoralism, and growing wildlife-based industries (ecotourism, game breeding, meat and sport hunting (Sims-Castley, 2002; Brownlie et al., 2019). A detailed analysis of the economic value of this biome was done by Sims-Castley (2002), in which the following economic activities were listed:

Direct consumptive use value:

- Agriculture – Small stock farming (e.g. Angora goats & boer goats);
- Game farming (e.g. trophy hunting, live game sales, venison sales, etc.);
- Horticulture;
- Aloe sap industry;
- Medicinal plants; and
- Fuel wood.

Direct non-consumptive use value:

- Eco-tourism & conservation.

Indirect use value:

- Ecosystem services (e.g. clean air, clean water, soil retention, carbon storage, etc.).

Not all of these forms of land use are sustainable. It is documented that overstocking of small stock, in particular goats, in Thicket areas is ecologically unsustainable (see for example, Hoffman and Cowling, 1990). It leads to loss of phytomass and biodiversity, and an increase in soil erosion and unpalatable plant species – ultimately leading to desertification and loss of natural resources. Game ranching, on the other hand, has been shown to be more ecologically sustainable (Sims-Castley, 2002). Since 1995 there has been a large growth in the game farming industry, with at least 27 additional game farms having been established in the subtropical thicket biome.

Degradation of thicket has negative socio-economic repercussions. Reductions in diversity, soil carbon, soil quality, and plant productivity all lead to lower livestock productivity (Mills & Cowling, 2006).

5 ENVIRONMENTAL SENSITIVITY OF THE ALBANY THICKET BIOME

5.1 Methodological approach to sensitivity mapping

5.1.1 Defining Environmental sensitivity

Environmental Sensitivity Index (ESI) maps are spatial representations of a compilation of information about biodiversity features and their sensitivity to certain specified impacts. In this case the construction of a gas pipeline, where the dominant impacting activity (during construction phase) is clearance of vegetation and the impacts associated with this (erosion, disruption of water flow regimes, fragmentation).

Figure 6 shows how the ESI should be calculated. In a sense it is equivalent to the biodiversity value, but has taken into consideration the vulnerability of the receiving environment to the impact (i.e. the risk of loss). This is in turn determined by the nature of the impact (magnitude, frequency, and likelihood), as well as the ability to mitigate against these impacts, and the inherent fragility of the receiving environment.

The inherent fragility of the receiving environment will vary depending on the specific type of biodiversity feature being considered; however, for any given feature a number of contingent factors will influence fragility, typically these will include the slope and rainfall of the site being impacted. For any given impact, receiving environments on steep slopes (>30 %), and with very high or very low rainfall will be more fragile, and susceptible to cumulative and secondary impacts, such as erosion or poor recovery after rehabilitation. It is believed that this criterion should be considered at finer scales of planning, where for example adjustments to routing paths may be considered based on topography.

Because we are considering a linear structure (gas pipeline), where the associated magnitude, frequency, and likelihood of impacts will be the same throughout the whole study site, we need not include this in the ESI calculations. This is because we are looking at relative and not absolute values.

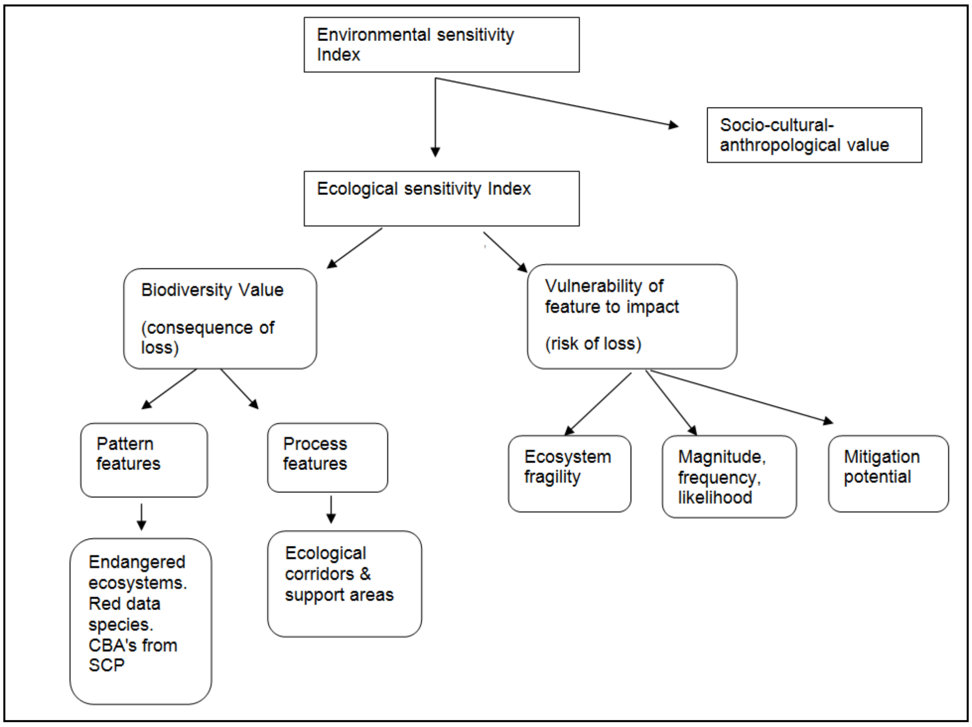

Figure 6: Conceptual outline of the components an Environmental Sensitivity Index

5.1.2 Biodiversity features and sensitivity classification

The biodiversity feature data and critical biodiversity classification rules for Gas Pipeline Phases 7, Inland and part of 2; were adapted from the ECBCP (2017); while the biodiversity feature data and critical biodiversity classification for Gas Pipeline Phases 1 and part of 2 falling into the Western Cape was obtained from the Western Cape Biodiversity Conservation Plan (WCBCP) (2017).

The biodiversity sensitivity values are adapted from the CBA classifications, as based on the provincial systematic conservation plans for the Western and Eastern Cape. This is summarised in Table 7.

Table 7: The biodiversity sensitivity values as derived from the Critical Biodiversity Area classifications.

Conservation Planning Category	Biodiversity sensitivity value
Terrestrial	
PA	Very high
CA	High
CBA1	Very high
CBA2	High
ESA1	Medium
ESA 2	Medium
Protected Area buffers	High
Other Natural Areas	Medium
Non Natural Areas	Low
Aquatic*	
River main stems	Very high
Wetlands	Very high
Estuaries	Very high
*Note: Aquatic ecosystems are considered in detail as a separate topic as part of the SEA (Appendix C.1.7 of the Gas Pipeline SEA Report).	

Additional detail and data sources, regarding the biodiversity features used and the rules to derive the CBA and ESA classifications are provided in Table 8.

Table 8: Summary table of biodiversity feature data used in this study, to derive biodiversity sensitivity classes based on the Critical Biodiversity and Ecological support areas classification as used in the ECBCP (2017).

Biodiversity feature	Sensitivity class	VH	VH	H	M	M	Data source
	CBA category	PA	CBA 1	CBA 2	ESA 1	ESA 2	
Protected Areas							DEA National Protected and conservation areas data base
Protected Areas (state)	Biosphere Reserves	x					
	World Heritage Sites	x					
	State Owned - SANParks and ECPTA	x					
	Protected Environments	x					
Conservation Areas	Private Nature Reserves			x			
	De Facto Private Nature Reserves			x			
	DAFF forest reserves		x				
Terrestrial							
SA Vegetation Types	Threatened Ecosystems SA vegmap CR and EN Plus with patches >3ha in size		x				From SANBI 2011 data and updated with the ECBCP 2017 analysis. Selected Planning Units (PUs) that are natural and which intersect vegetation type units listed as threatened.
	VU vegetation types needed to meet targets			x			
STEP Vegetation Types	Threatened Ecosystems STEP vegetation CR and EN PUs with remnants						Calculated from STEP vegetation map 2003 against the EC integrated Land Cover 2014
NFI Forests	NFI critically endangered/high priority forest patches (DB)		x				As defined by DAFF, 2006 Report (Derek Berliner)
	Priority clusters (DB)		x				
Other Forests	All other forests (DB)		x				
	CBA1 forest patch 500m buffer				x		
MARXAN analysis	Irreplaceable Sites (selection frequency>80%) - PUs selected to meet targets for: (1) vegetation types, (2) species points, (3) expert areas		x				ECBCP (2017)
	Best Design Sites (selection frequency<80%) - PUs selected to meet targets for: (1) vegetation types, (2) species points, (3) expert areas			x			
	Other sites required to complete the ecological corridor network				x	x	

Biodiversity feature	Sensitivity class	VH	VH	H	M	M	Data source
	CBA category	PA	CBA 1	CBA 2	ESA 1	ESA 2	
Special habitats	Selected cliffs buffered by 100m				x		
	Cliff buffers 500m				x		
	Bat roost sites and 500m radius*		x				
	Vulture breeding sites 5km buffer*		x				
Eastern Cape corridors	Best Design Corridor Sites - PUs selected to meet 60% targets for vegetation types,				x	x	
Ecological infrastructure	Climate change refugia (SANBI 2016 Model)				x		
	Coastal functional zone				x		
	Climate change resilience (SH)				x		
Aquatic*							
	River main stems		x				
	Wetlands		x				
	Estuaries		x				

**Note: Aquatic ecosystems, avifauna and bats are considered in detail as a separate topic as part of the SEA (Appendix C.1.7, C.1.8, C.1.9 of the Gas Pipeline SEA Report, respectively).*

The biodiversity sensitivity designations used in maps are derived from the conservation planning categories as used in ECBCP (2017) (Table 9).

Table 9: Summary of biodiversity features of the Albany Thicket biome assigned a sensitivity to gas pipeline development.

Sensitivity	Reasons
Very High	Protected Areas, CBA1, STEP remnant Endangered and Critically Endangered vegetation types
High	CBA2
Medium	ESA1 and ESA 2
Low	Remaining areas

5.1.3 Threatened ecosystems and vegetation types within study area

The National Environmental Management: Biodiversity Act (NEMBA) provides for the listing of threatened or protected ecosystems in South Africa. A list of Threatened Ecosystems for South Africa has been drawn up (SANBI, 2011). These are threatened ecosystems which require protection and conservation, under NEMBA. Of these only the Albany Alluvial Vegetation (listed as EN) falls within the Albany Thicket biome.

The Threatened Vegetation types for the Eastern Cape province were recalculated for the ECBCP (2017) using the prescribed method of SANBI, but with a revised land cover map that takes into account changes in vegetation cover since the last assessment (i.e. based on the integrated 2014 land cover developed for the Province for this project). In Table 10 and Figure 7 below, the vegetation types occurring within the Albany Thicket biome that were classified as critically Endangered or Endangered are shown.

Table 10: Vegetation types occurring within the Albany Thicket biome that were classified as Critically Endangered or Endangered, with the assigned sensitivity classes used in this study.

Vegetation Type	Status (SANBI, 2011)	Sensitivity (this study)
Buffels Valley Thicket	Critically Endangered	Very high
Escarpment Valley Thicket	Critically Endangered	Very high
Gamtoos Bontveld	Critically Endangered	Very high
Gamtood Doringveld	Critically Endangered	Very high
Paterson Savanna Thicket	Critically Endangered	Very high
Sundays Noorsveld	Critically Endangered	Very high
Sundays Spekboomveld	Critically Endangered	Very high
Zuney Strandveld	Critically Endangered	Very high
Motherwell Karroid Thicket	Endangered	High
Shamwari Grassland Thicket	Endangered	High
Sundays Doringveld	Endangered	High

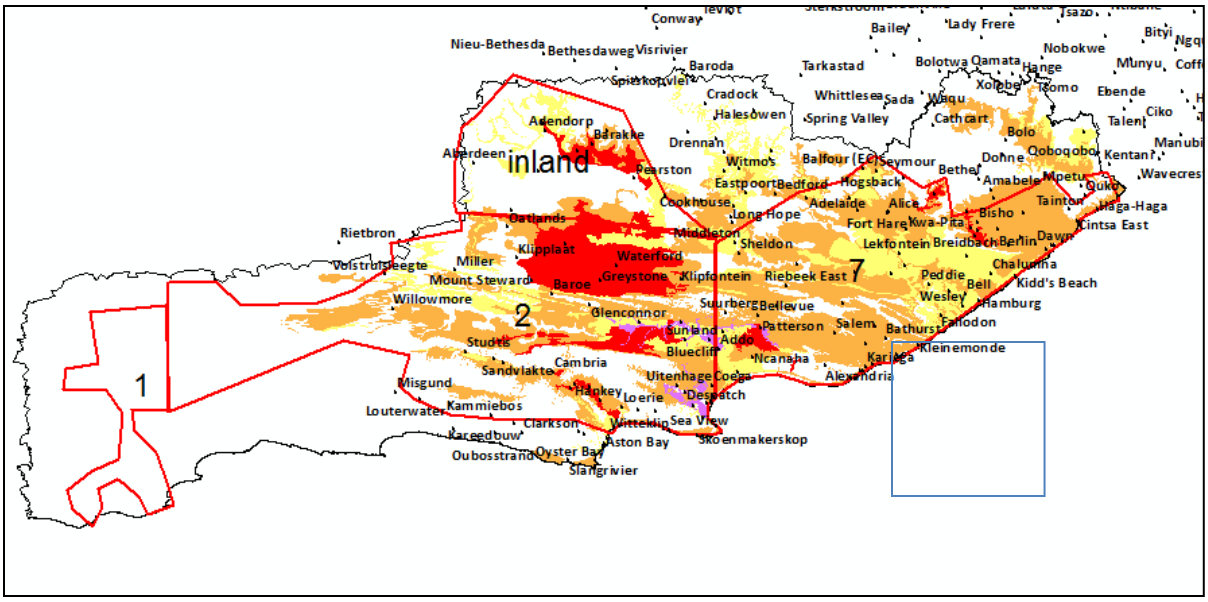

Figure 7: Threatened vegetation types occurring within the Thicket biome.

5.2 Four-tier sensitivity maps

5.2.1 Gas Pipeline Phase 1

This gas pipeline phase falls within the Western Cape and covers the local municipalities of Kannaland, Hessequa, and Mossel Bay. It includes a number of important Protected Areas and a section of the Cape Floral World Heritage site (Figure 8). Vegetation is highly diverse with at least four distinct vegetation biomes forming a mosaic with Albany Thicket mostly in river valleys.

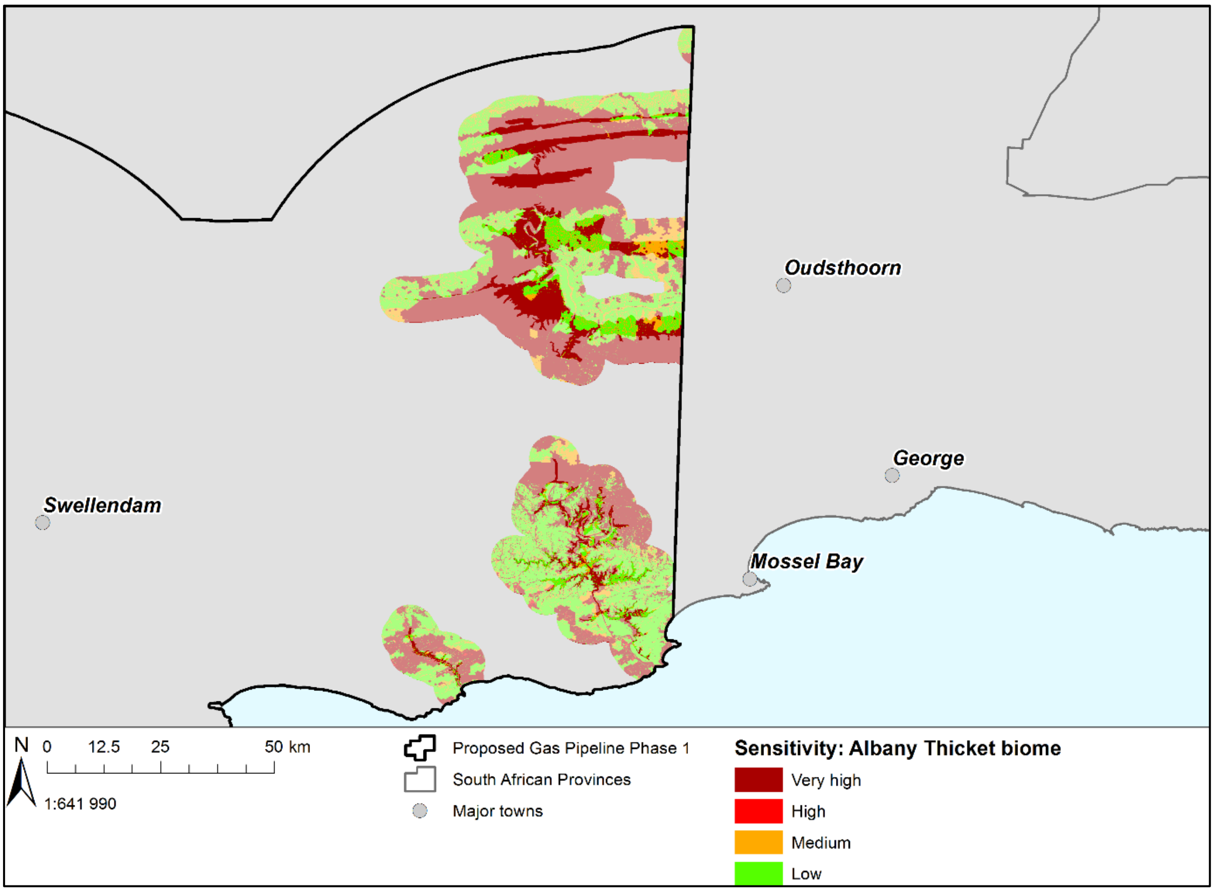

Figure 8: Sensitivity of the Albany Thicket biome in the proposed Gas Pipeline Phase 1 study area. Due to the patchy mosaic nature of the Albany Ticket Biome directly adjacent sensitivities have been masked with a semi-transparent pale buffer for the purposes of this map.

5.2.2 Gas Pipeline Phase 2

This area is rich in high value biodiversity areas as can be seen from the large number of Protected Areas and CBAs. It contains the Baviaanskloof Protected Area, part of the Cape Floral regions World Heritage serial sites, as well as a number of critically endangered vegetation types including, Sundays Spekboomveld and Sundays Noorsveld (Figure 9).

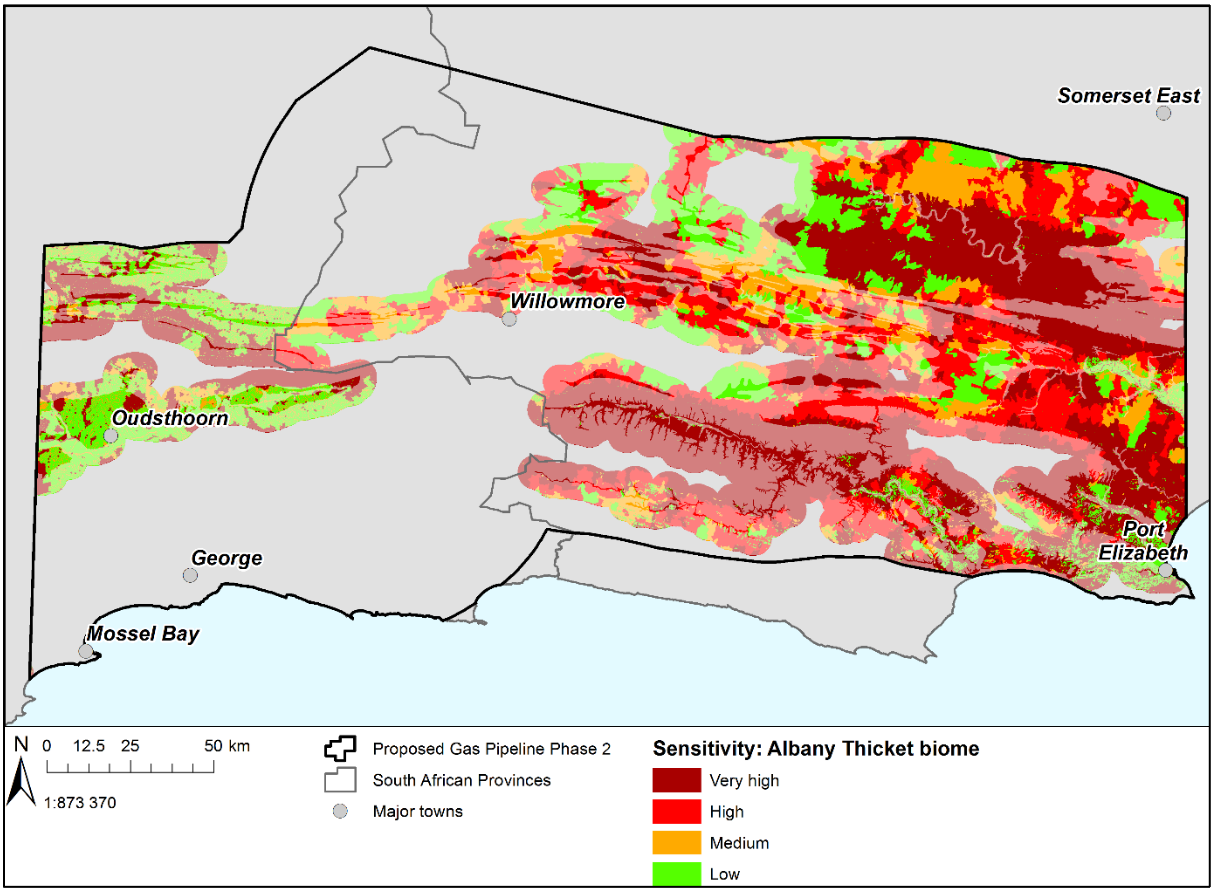

Figure 9: Sensitivity of the Albany Thicket biome in the proposed Gas Pipeline Phase 2 study area. Due to the patchy mosaic nature of the Albany Ticket Biome directly adjacent sensitivities have been masked with a semi-transparent pale buffer for the purposes of this map.

5.2.3 Gas Pipeline Phase 7

This is a large block stretching roughly from Kei Mouth to Coega. It contains a large number of highly sensitive areas mostly due to many state-owned Protected Areas, and private nature reserves and game farms. The coastal areas are incised by deep river valleys often with sensitive and endangered vegetation types. There are numerous sensitive estuaries and wetland areas within the coastal zone, and it is recommended that gas pipelines stay at least 50 km from the coast. It includes important Protected Areas such as Great Fish River and part of Addo Elephant National Park, as well as a number of critically endangered vegetation types including Buffels Valley Thicket, Albany Dune, and Albany Thicket, and one endangered vegetation type, Sundays Valley Thicket (Figure 10).

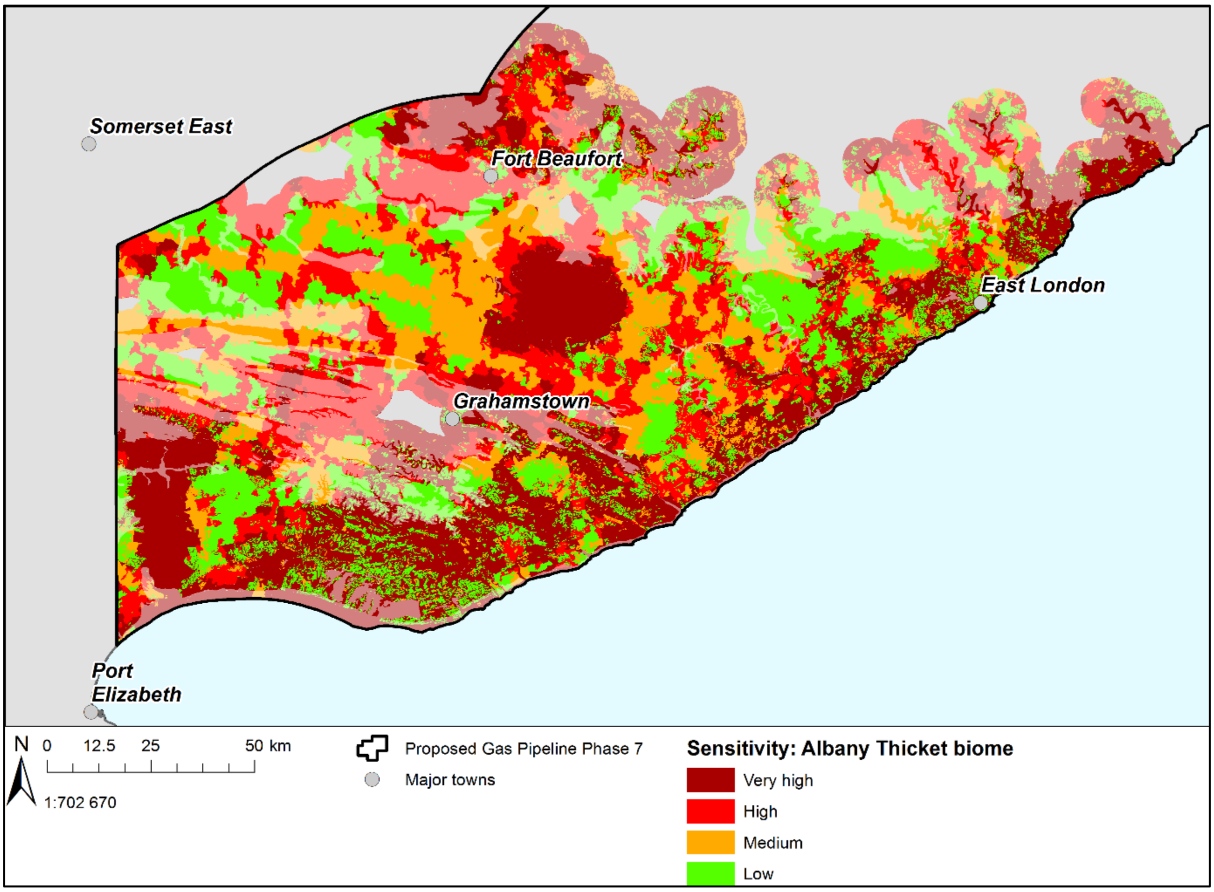

Figure 10: Sensitivity of the Albany Thicket biome in the proposed Gas Pipeline Phase 7 study area. Due to the patchy mosaic nature of the Albany Ticket Biome directly adjacent sensitivities have been masked with a semi-transparent pale buffer for the purposes of this map.

5.2.4 Gas Pipeline Phase Inland

This area contains many highly sensitive areas due to a number of state Protected Areas (Figure 11) including the Camdeboo National Park and part of Mountain Zebra National park. It also contains one Critically Endangered vegetation type, Escarpment Valley Thicket, and part of the Sundays Arid Thicket.

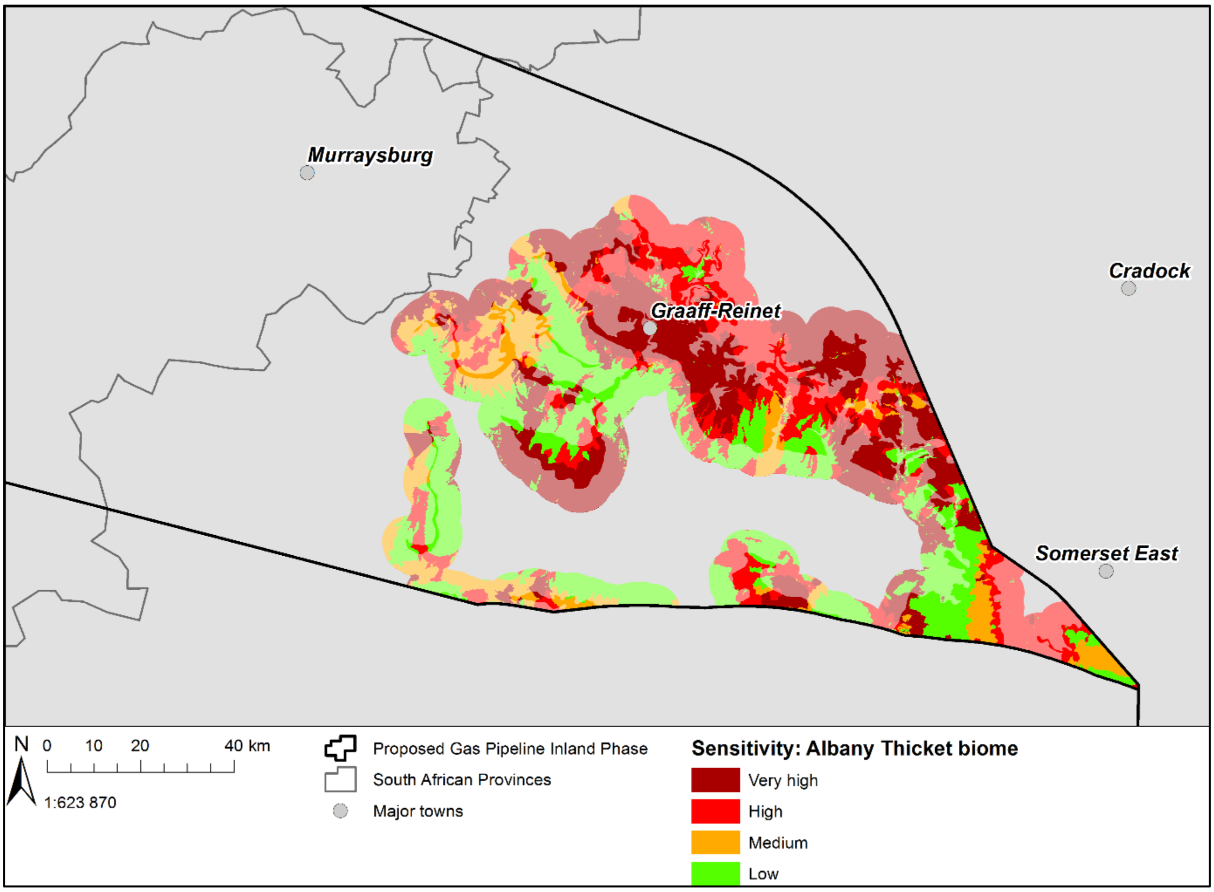

Figure 11: Sensitivity of the Albany Thicket biome in the proposed Gas Pipeline Inland Phase study area. Due to the patchy mosaic nature of the Albany Ticket Biome directly adjacent sensitivities have been masked with a semi-transparent pale buffer for the purposes of this map.

5.3 Environmental suitability of gas pipeline corridors

All of the gas pipeline corridor phase study areas within the Albany Thicket biome have relatively high proportions of land falling in either, Protected Areas (22 - 10 %), or Critical Biodiversity Areas category 1 (29 - 24 %) (Table 11).

Table 11: Area percentages of biodiversity planning categories for each Gas Pipeline Phase within the Albany Thicket biome

CBA category	% Of Total Area			
	Phase 1	Phase 2	Phase 7	Inland
Protected Areas	22.5	16.8	12.0	10.6
CBA1	29.0	25.8	23.9	26.5
CBA2	1.0	27.6	24.2	20.2
ESA1	9.0	11.7	14.5	12.1
ESA2	2.3	0.5	2.3	0.2
Other	36.22	17.6	23.0	30.3

The biodiversity planning categories can be translated into the four sensitivity classes and expressed as a Percentage of total land area for each gas pipeline phase within the Albany Thicket biome. This is visually displayed in Figure 12.

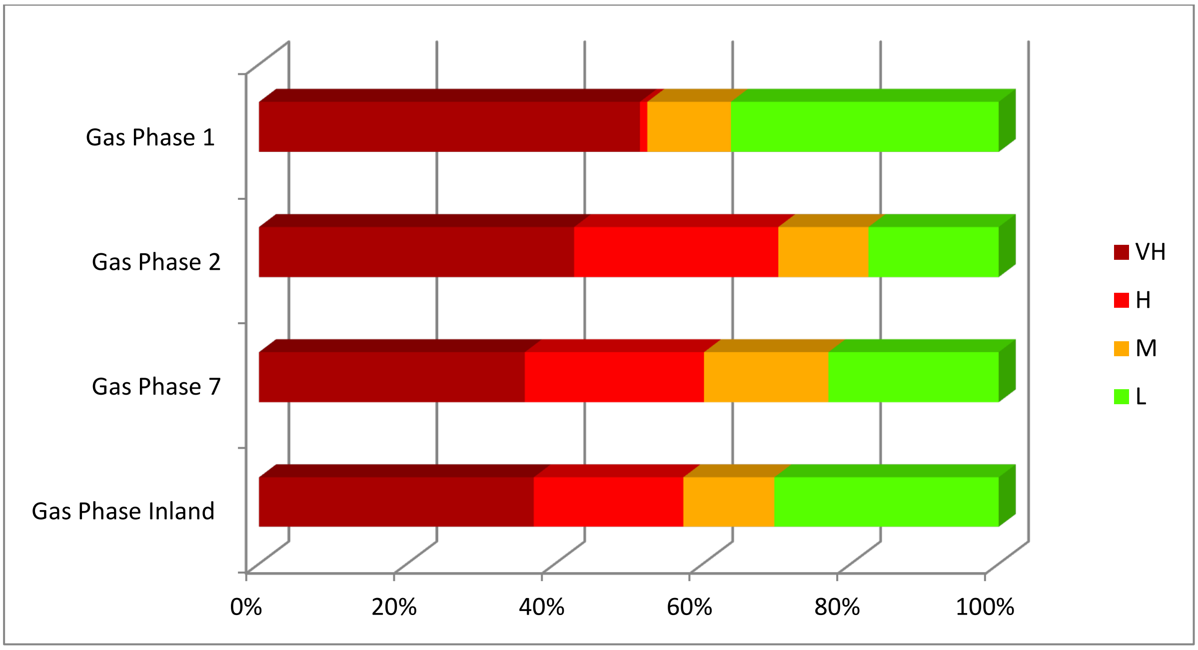

Figure 12: Percentages of each sensitivity class for each gas pipeline corridor phase considered within the Thicket biome

To calculate an overall suitability to development score for each of the study areas, each sensitivity class has been weighted, and multiplied by the percentage area of each class. This was then scaled as a score out of ten (Table 12). Refer to Appendix A of this report which provides a description of the methodology used for the calculation of the sensitivity scores.

Table 12: Weighted suitability score for each class for each gas pipeline corridor phase (weighting x % area). The higher the score the higher the overall suitability of the gas pipeline corridor phase (The following ratings for suitability have been subjectively assigned by the author: 1 – 4 = Poor; 4 – 4.5 = Medium, 4.5 – 5.5 = Fair, >5.5 = Good)

	% Area of Land					Comment
Sensitivity class	VH	H	M	L	Suitability Score (1-10)	
Suitability Weighting	1	3	6	10		
Phase 1	51.5	1	11.3	36.22	4.8 (fair)	Most H and VH areas can be avoided, Cumulative impact on aquatic systems*.
Phase 2	42.6	27.6	12.2	17.6	3.7 (poor)	Some impact on H and VH sensitive areas.
Phase 7	35.9	24.2	16.8	23	4.4 (medium)	Difficult to avoid the many VH and H sensitive areas.
Inland	37.1	20.2	12.3	30.3	4.7 (fair)	Most H and VH areas can be avoided.

**Note: Aquatic ecosystems are considered in detail as a separate topic as part of the SEA (Appendix C.1.7 of the Gas Pipeline SEA Report).*

All the gas pipeline phases that fall within the Albany Thicket biome have relatively low suitability ratings, but the Gas Pipeline Corridor Phase 1 pipeline corridor has the highest suitability (most suitable) and Gas Pipeline Corridor Phase 2 has the lowest suitability (least suitable) from an environmental perspective compared to the other gas pipeline phases in the Albany Thicket biome.

6 DESCRIPTION OF IMPACTS AND MANAGEMENT ACTIONS

Table 13: Key potential impacts associated with the proposed gas pipeline and recommended management actions. The mitigation hierarchy must be applied for all stages and scales of the project.

Key Impact	Description	Proposed Management Actions
Habitat destruction and degradation	Removal of vegetative cover will result in: • Increased risk of rare species loss • Decline in ecosystem resilience • Decline in ecosystem services • Increased habitat fragmentation • Change in water surface runoff • Increased soil loss • Noise, dust	Avoid • Use of environmental sensitivity maps and least cost in routing design • Design and layout of infrastructure to avoid highly sensitivity areas • Ground assessments and verification before construction • Design to use as much common/shared infrastructure as possible with development in nodes, rather than spread out. • Avoid any construction on steep slopes (> 25 degrees) Minimise • Minimise construction footprint with good planning • Use existing roads as far as possible for access • Construction outside of peak rain season as much as possible • Use dust reduction methods during construction • Use plant rescue to remove rare plants in construction footprint • If roads or structures are fenced, use plain strands and not jackal proof fencing to ensure animals can still move through fences Rehabilitate • During construction maintain top soil for later rehabilitation • Re-vegetate all cleared areas as soon as possible • Stabilise all slopes and embankments, water courses • Where fragmentation of key habitats has occurred use landscape design methods (over and under pass wildlife bridges) to re-establish ecological connectivity
Invasive plant spread	Removal of plant cover and top soil promotes the establishment of pioneers, in particular invasive plants. In addition altered soil structure, moisture availability and light availability can lead to invasion by weeds and invasive alien plants and animals.	Avoid • Unnecessary disturbance of plant cover and top soil. Use existing roads • Do not use sand sources contaminated with invasive alien plant seed for bedding of the pipe or for construction work.

Key Impact	Description	Proposed Management Actions
		Minimise • Where invasive plants occur on or in vicinity of construction site, remove before they set seed. Rehabilitate • Remove all alien vegetation and re-vegetate as soon as possible with perennial fast-growing vegetation • Keep out all livestock • Avoid off road driving
Increased poaching	The pipeline construction activities include opening up remote areas, and developing access roads for construction and maintenance in areas that may have been mostly inaccessible by road or footpaths. Increased road access may promote poaching, in particular if close to communities with a tradition of hunting, medicinal plant collection or illegal harvesting of timber and other valuable plants by collectors (cycads, rare succulents, reptiles etc.). There may also potentially be secondary poaching impacts during construction (and/or maintenance) conducted by the labour teams used in construction.	Avoid • Building access roads into sensitive areas with valuable resources Minimise • Use of surveillance and monitoring of snares, debarking, hunting etc. • Develop community education programs near vulnerable sites

7 RISK ASSESSMENT

7.1 Consequence levels

Table 14: Consequence levels used in risk assessment with thresholds

Impact	Consequence				
	Slight	Moderate	Substantial	Severe	Extreme
Habitat destruction/disturbance (Loss of ecosystem integrity, fragmentation and loss of ecosystem services)	No natural habitat is crossed	Natural habitat impacted is 'LOW' sensitivity	Any impact of 'MEDIUM' sensitive habitat caused by project activities	Any loss of ' 'HIGH' sensitive area caused by project activities	Any loss of 'VERY HIGH' sensitive caused by project activities
Risk of endemic/ rare species loss	No known red data species in footprint and no H or VH sensitive areas	Disturbance of any natural habitat with known red data species: where less than 1 % of this habitat is disturbed	Disturbance of any natural habitat, with known red data species, where up to 5 % of this habitat is disturbed	Disturbance of any natural habitat with known red data species, where more than 5 %, but less than 10 % of habitat is disturbed	Disturbance of any natural habitat with known red data species, where 10 % or more of habitat has been disturbed
Increased risk of spread of alien invasive plants (AIP)	Degree of AIP infestation in catchment of footprint = < 0.5 %	Degree of AIP infestation in catchment of footprint 0.5 to 2% of footprint	Degree of AIP infestation in catchment of footprint = 2-5%	Degree of AIP infestation in catchment of footprint = 5-10 %	Degree of AIP infestation in catchment footprint > 10%
Increased access to sensitive areas (poaching)	Distance to nearest settlement: > 50km	Distance to nearest settlement: 50-30km	Distance to nearest settlement: 30-20km	Distance to nearest settlement: 20-10 km	Distance to nearest settlement: Less than 10 km

7.2 Risk assessment results

Not all biodiversity features share the same potential for mitigation. This may depend on the extent, duration and severity of impact, but also on the sensitivity of the receiving environment. Areas of high biodiversity value, comprising local non-mobile species will be more vulnerable. The success of management actions may be variable (Table 15).

Table 15: Impacts and risk assessment with and without mitigation for gas pipeline development for all Phases within the Albany Thicket Biome for each sensitive class category.

Impact	Sensitivity class	Without mitigation			With mitigation		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Habitat destruction/disturbance	VH	Extreme	Very Likely	Very High	Severe	Likely	High
	H	Severe	Very Likely	High	Severe	Likely	High
	M	Severe	Likely	High	Substantial	Likely	Moderate
	L	Moderate	Likely	Low	Moderate	Likely	Low
Risk of endemic/ rare species loss	VH	Severe	Likely	High	Substantial	Not likely	Moderate
	H	Severe	Likely	High	Substantial	Not likely	Moderate
	M	Moderate	Not Likely	Low	Slight	Very unlikely	Very Low
	L	Moderate	Not Likely	Low	Slight	Very unlikely	Very Low
Increased risk of spread of alien invasive plants	VH	Extreme	Very Likely	Very High	Severe	Likely	High
	H	Severe	Very Likely	High	Substantial	Likely	Moderate
	M	Severe	Very Likely	High	Substantial	Likely	Moderate
	L	Substantial	Very Likely	Moderate	Moderate	Very unlikely	Low
Increased access to sensitive areas (poaching)	VH	Severe	Likely	High	Substantial	Likely	Moderate
	H	Severe	Likely	High	Moderate	Not likely	Low
	M	Moderate	Likely	Low	Slight	Very unlikely	Very Low
	L	Slight	Likely	Very Low	Slight	Very unlikely	Very Low

7.3 Limits of Acceptable Change

Limits of acceptable change are defined as the variation that is considered acceptable by experts in the field (Stankey et. al. 1985) of a particular environmental indictor of a component or process of the ecological system in question. Potential limits of acceptable change for the Albany Thicket biome have been suggested by this author and are presented in Table 16.

Table 16: Limits of acceptable change

Impact	Limits of acceptable change
Habitat destruction/disturbance	No more than 2 % loss of VH sensitive habitat polygon
Habitat destruction/disturbance	No more than 5 % loss of any H sensitive habitat polygon
Risk of endemic/ rare species loss	No more than 5% loss of any known population of any known Red data species
Increased risk of spread of alien invasive plants	Any increase over base line conditions
Increased access to sensitive areas (poaching)	No more than 20 % increase in poaching over base line levels

8 BEST PRACTICE GUIDELINES AND MONITORING

Apart from the management actions recommended in Section 6, succulent thicket vegetation has some unique characteristics that need to be considered in a biodiversity vegetation monitoring programme as well as in the restoration of natural habitat following pipeline construction. These include the following:

- High vulnerability to overgrazing by livestock, in particular *Portulacaria* dominated vegetation types. This is particularly relevant when rehabilitating sensitive habitat where livestock may be present.
- High vulnerability of some thicket types to fire damage;
- Invasive alien vegetation, especially rooikrans, (*Acacia cyclops*) poses a real threat to Thicket by increasing the fuel load. This renders it prone to hot fires that will severely damage if not destroy the succulent and tree component; and
- Slow re-growth and recovery after vegetation removal. This is particularly true for arid and some mesic thicket vegetation types.
- Disturbance in arid areas of succulent thickets are prone to invasion of karroid species and arid adapted alien vegetation (Milton, & Dean, 2010). This needs to be considered in restoration plans.

A biodiversity monitoring programme needs to be part of an effective project Environmental Management Programme (EMPr). Objectives of this need to include:

- Speed and progress of vegetation rehabilitation;
- Monitoring of health of rare plant communities/endangered vegetation types within or close to construction;
- Impact of construction activities on changes in water quality and flow, run-off and sedimentation, in particular near watercourses and on steep slopes where erosion is more likely to occur;
- A monitoring programme needs to identify key indicator species that are likely to be impacted within the Thicket biome. These must include both fauna and flora. Species that are relatively abundant as well as easy to monitor. Adaptive management approach must be used to feedback results of monitoring into improving management;
- Fossorial fauna require special attention as these are most likely to be impacted by construction activities; and
- Post construction re-vegetation projects can be combined with carbon sequestration programmes aimed to restore degraded subtropical thicket. This would achieve the combined aims of improving rural livelihoods, restoring biodiversity, and replenishing natural capital/ecosystem services (Mills et al., 2003).

Some best practise guidelines for monitoring of thicket vegetation, and associated fauna, will include:

- Development of a good baseline data by mapping the location of rare and threatened plant species near or within development footprint before any development occurs;
- Make provision for seasonal monitoring, during spring and autumn months, of rare and threatened flora on site;
- Identification of local extinctions caused by construction activities. A plant rescue plan must be developed before construction, and a reintroduction plan must be prepared, once construction has been completed; and
- Management of access into key sensitive areas along construction footprint.

9 GAPS IN KNOWLEDGE

Key gaps in knowledge include:

- Changes in land cover at fine scale;
- Techniques of rehabilitation for degraded thicket types;
- Limit to acceptable change of sensitive ecosystems within succulent thickets
- Extent, stability and distribution of rare and endangered thicket fauna and flora species;
- Differential responses of sensitive biodiversity features to pre- and post-construction activities, and how best to mitigate;
- Impact of climate change on the drivers of changes impacting on rare vegetation types, particularly in transformed and degraded landscapes of the Thicket biome; and
- Uncertainty around long-term fragmentation impacts of long linear structures on terrestrial fauna.

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APPENDIX A: CALCULATION OF SUITABILITY SCORES

Step 1: Calculate Area Percentage of Biodiversity Planning Categories Per Sensitivity

The area percentages of the biodiversity planning categories within the Albany Thicket biome (Table 11) were grouped to determine the percentage of total land area per sensitivity class ranking from Very High to Low, as shown below:

- Very High Sensitivity Class per phase = "% of Total Area of Protected Areas" + "% of Total Area of CBA 1"
- High Sensitivity Class per phase = "% of Total Area of CBA 2"
- Moderate Sensitivity Class per phase = "% of Total Area of ESA 1 + "% of Total Area of ESA 2"
- Low Sensitivity Class per phase = "% of Total Area of Other"

Example for Gas Pipeline Corridor Phase 1:

Very High Sensitivity Class = 22.50 % + 29.00 % = 51.50 %

High Sensitivity Class = 1.00 %

Moderate Sensitivity Class = 9.00 % + 2.30% = 11.30%

Low Sensitivity Class per phase = 36.22%

The percentage of the total area of each sensitivity rating per gas pipeline corridor phase is shown below and illustrated in Figure 12:

Sensitivity Class	% Of Total Area			
	Phase 1	Phase 2	Phase 7	Inland
VH	51.50	42.60	35.90	37.10
H	1.00	27.60	24.20	20.20
M	11.30	12.20	16.80	12.30
L	36.22	17.60	23.00	30.30

Step 2: Weight the Sensitivity Class

The following weighting has been assigned to each sensitivity class:

Sensitivity Class	Weighting
VH	1
H	3
M	6
L	10

Step 3: Calculate Overall Suitability Score for each Gas Pipeline Corridor Phase

The following formula has been applied to calculate the overall suitability to development score for **each gas pipeline corridor phase**:

Overall Suitability = [(% of Total Area for VH * 1) + (% of Total Area for H * 3) + (% of Total Area for M * 6) + (% of Total Area for L * 10)] / 100

Example for Gas Pipeline Corridor Phase 1:

Overall Suitability = [(51.50 % * 1) + (1 % * 3) + (11.30 % * 6) + (36.22 % * 10)] / 100
= [(51.50 %) + (1 %) + (67.80 %) + (362.20 %)] / 100
= [(484.50 %)] / 100
= <u>**4.8**</u>

Results of the Suitability Scores are shown in Table 12.

APPENDIX B: FIELD TRIP SUMMARY REPORT

Verification of the South Western extent of the Succulent Thicket biome fragments within the Swartberg and Baviaanskloof complex

Objectives

A short field trip was conducted to verify the extent and nature of the mosaic distribution of the Thicket Biome within two highly fragmented regions of the biome, i.e. the Baviaanskloof Wilderness and World Heritage Site, and the Grootswartberg area (specifically Goukamma nature reserve between Calitsdorp and Oudtshoorn).

Approach

Verification of the extent of the Thicket Biome within the complex mosaic of other vegetation types was approximated by comparing KML files of the Thicket Biome extent with Google Earth satellite imagery, as well as taking photographs with a GPS camera. Photographs were taken during a road trip and a four day hike within the Baviaanskloof nature reserve during the month of April 2018. *Portulacaria afra* (Spekboom) was used as an idicator species to astertain the presence of the Thicket Biome.

Study Areas

The map below (Figure B.1) gives the full extent of the Succulent Thicket Biome, as well as the gas pipeline corridor phases for this region.

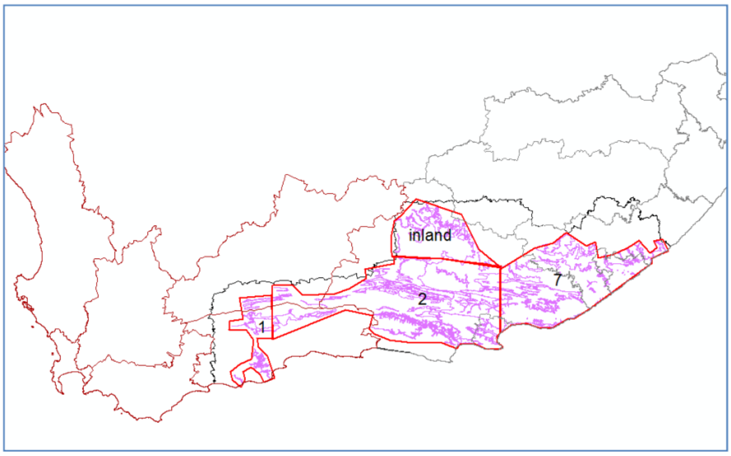

Figure B.1: Extent of the Succulent Thicket Biome. Both study sites fell within the Gas Pipeline Corridor Phase 2

Two areas were visited i.e. Baviaanskloof wilderness area and Gamkaberg nature reserve, which are shown in the maps below (i.e. Figures B.2 and B.3).

Figure B.2: Baviaanskloof Wilderness Area

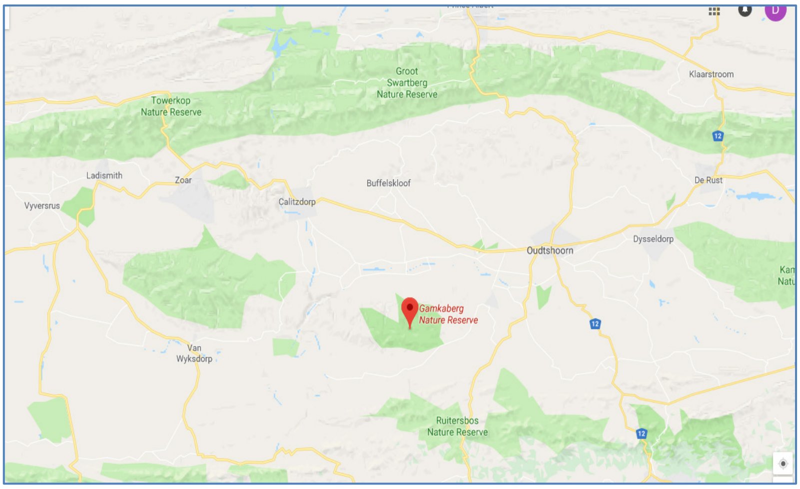

Figure B.3: Gamkaberg Nature Reserve

<u>Findings: Baviaanskloof</u>

Baviaanskloof vegetation is a mix of five diffferent vegetation biomes. Thicket vegetation occurs within the many valleys as mosaics within Fynbos, Succulent Karoo, Forest and Savanna. Typically this is represented as *Portulacaria afra* (Spekboom) clusters on the steep valley slopes. One can recognise it easily on north and east facing mountain slopes where bright green patches occur, usually intermixed with other shrubs. P. afra has an extensive root system which occupies a significant amount of space, and thus keeps loose soil from washing down the steep slopes when it rains. In many areas these Spekboom represents both natural and aided recovery from the overgrazed lands in the early 1900's from the Angora goat wool industry in the Baviaans area.

The Thicket vegetation of the Baviaans is recognised in the National Vegetation map as Gamtoos Thicket. Typical trees include: *Aloe ferox*, *Euphorbia tetragona*, *Boscia albitrunca*, *Cussonia spicata*, *Encephalartos lehmannii*, *Ozoroa mucronata*, *Pappea capensis*, *Schotia afra var. afra*, *Sideroxylon inerme*.

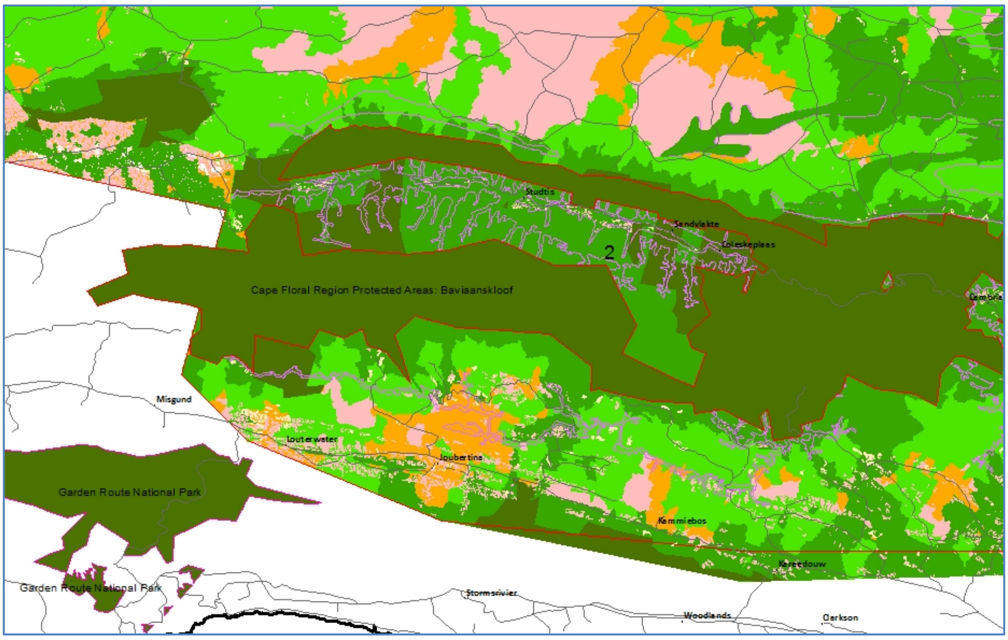

Figure B.4: Thicket vegetation occurs within the deep valley bottoms and north slopes of the Baviaanskloof Wilderness Area (shown by the pink lines)

Figure B.5: Succulent Thicket occurs in the deep valleys and slopes of the Baviaanskloof

Figure B.6: Dry river beds, with *Portulacaria* dominated mountain vegetation on the steep slopes of Baviaanskloof.

Diagnostic plant species seen include a high proportion of both leaf and stem-succulent shrubs such as Spekboom (*Portulacaria afra*), *Aloe africanai*, *Aloe ferox*, *Euphorbia spp. Maytenus procumbens*, and *Polygala myrtifolia*

<u>Conclusion</u>

The national vegetation mapping of Succulent Thicket within the Baviaanskloof complex is relatively accurate. This is mostly because it follows predictable topographic patterns. This region of the biome is characterised by many ecotones with other vegetation types, particularly mountain fynbos and Afromontane forests.

The thicket vegetation of the Baviaanskloof is heavily dominated by *Portulacaria.* It is not clear if this is a natural recovery to its former state, after a long history of overstocking with goats, or represents an intermediate stage of recovery that is a depauperate (species poor) version of mature Succulent Thicket.

Although not a characteristic Thicket species, the Willmore (Baviaans) Cedar occurs in the kloofs of this area. Unfortunately, a fire in 2016 destroyed most trees including many fine old specimens (perhaps as much as 85 % of the population was lost). Very few of the trees seen while on the four-day hike of this region were still alive. This tree occurs within a very limited distribution, known from only 12 locations. It is extremely vulnerable to fire. It is listed as 'Near Threatened' by the IUCN, but in the view of the specialist author, it should receive a higher conservation status of 'Endangered' (Refer to the pictures below i.e. Figures B.7).

Figure B.7: Willomore Cedar Forest destroyed by a fire in the Baviaans

Gamkaberg Nature Reserve

The Gamkaberg Nature Reserve is situated in the Little Karoo region of the Western Cape. Four of the Cape biomes occur in the Gamkaberg i.e. Fynbos, Succulent Karoo, Subtropical Thicket, and Evergreen Forest. On top of the mountain, where the last rain falls, there is plenty of fynbos – proteas, restios, ericas and geophytes. In the kloofs there are thick forests, nourished by the natural springs. The Gamkaberg Conservation Area forms part of the even larger UNESCO Gouritz Cluster Biosphere Reserve.

The steep slopes of the valleys are dominated by Thicket vegetation, *Portulacaria afra*. This has been classified in National vegetation maps as Gamka-*Portulacaria*-Thicket. Dense stands of spekboom (*Portulacaria afra*) occur, often with *Euclea undulata*, *Gloveria integrifolia*, *Pappea capensis* and *Rhus glauca*.

Figure B.8: *Portulacaria* dominated slopes.

Figure B.9: The valley bottoms are a mixture of vegetation types.

Figure B.10: It is uncertain if these slopes have been rehabilitated with Spekboom truncheons or represent a natural recovery succession after years of overgrazing from goat farming.

<u>Conclusion</u>

The national vegetation map's depiction of the extent and occurrence of the Thicket Biome for this region are supported by the direct observations made in this field trip.

APPENDIX C: PEER REVIEW AND SPECIALIST RESPONSE SHEET

Peer Reviewer: Professor Sue J. Milton-Dean; Renu-Karoo Veld Restoration

EXPERT REVIEW AND SPECIALIST RESPONSES: Albany Thicket Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	**Page Range**	**Line/s**	**Table/Figure**	**Expert Reviewer Comments**	**Response from Derek Berliner**
SJ Milton	**General**			The Albany Thicket assessment report adequately covers the requirements of the SEA. The sensitivity classification is based on adequate evidence at a broad scale, and the recommendations are sound if somewhat limited and non-specific because of the coarse scale of the project. The comments that follow include suggestions for additional impacts that could be evaluated, lack of clarity in certain areas, and minor grammatical corrections.	Noted
SJ Milton	9	16	Text	shrublands (one word)	Done
SJ Milton	10	10	Text	Albany Thicket (both words with caps)	Done
SJ Milton	11	14	Text	"degradation between 31-88%" difficult to relate these figures to tables 6 and 7	This refers to total degradation for both 'moderate' and 'severe classes' (i.e. sum of both), I have removed this in the text.
SJ Milton	12	2	Table 7	I have problems understanding how total pristine thicket is 406,316 sq km whereas the caption says the total thicket area is 20,730 sq km. Are the areas of thicket types in the table in hectares?	Well spotted, I have taken out the misleading tables and replaced with a single table in % 's of each class
SJ Milton	12	9	Text	"the short space of a decade, heavy browsing, especially by mohair-producing angora 9 goats, can convert dense shrub land into a desert-like state" Citation needed	I have included a reference
SJ Milton	14	38	Text	"pastorists" should be pastoralism	Done
SJ Milton	16	13	Table 8	What is "SCP" in the table column heading?	(Systematic) Conservation Planning Category
SJ Milton	24	8	Table 13	Not clear how the scaling out of 10 for suitability was calculated	See appendix
SJ Milton	24	14-16	Text & Table 13	According to the suitability score in Table 13, phase 1 is the most suitable (4.8) and Phase 2 least suitable at 3.7	The higher the score the higher the overall suitability of the gas phase
SJ Milton	25	3	Text	Should this read "gas phase 2" give the scoring in table 13?	Yes, thanks made the correction
SJ Milton	26	2	Figure 13	Do the pink parts of these maps represent "other biomes" or less-sensitive areas?	The Pink are other areas, i.e. lowest sensitivity, but applies only within the gas phase study area
SJ Milton	28		Table 15	Under Invasive alien plant spread: mitigation, you could add "do not use sand sources contaminated with invasive alien plant seed for bedding of the	Yes thanks

EXPERT REVIEW AND SPECIALIST RESPONSES: Albany Thicket Biome - Gas Pipeline Development					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	Page Range	Line/s	Table/Figure	Expert Reviewer Comments	Response from Derek Berliner
				pipe or for construction work"	
SJ Milton	28		Table 15	Invasive alien plants: mitigation perhaps alter to read "where invasive alien plants occur on or in the vicinity of the construction site"	Added
SJ Milton	28		Table 15	Other impacts probably include	See note below
SJ Milton	28		Table 15	1. development of access roads and impacts on fauna, soils and flora	Point 1 & 2 is covered under:' Habitat destruction and degradation' (includes fragmentation), point 3 was raised in the specialist workshop but felt to be low.
SJ Milton	28		Table 15	2. fencing off of pipeline infrastructure (implications for plant and animal dispersal, tortoise and bird mortality)	See note above
SJ Milton	28		Table 15	3. Risks of leakage and explosion?	Response from the SEA Project Team: No edit needed. It should be noted that block valves will be positioned every 30 km along the pipeline route, which will consist of a concrete slab on the surface that will lead to an inspection chamber. The valves can be automated remotely i.e. to stop a specific section of the line in the event of a leak (i.e. close two valves). If the line needs to be repaired, the remaining gas within the line will be vented off. Therefore, it is understood that the impact of leaks are expected to be low.
SJ Milton	29	8	Text	"comprising of local non mobile species" Delete "of"	Done
SJ Milton	31	3	Text	"variation that is considered acceptable by experts" Give names of experts	Changed to 'this author'
SJ Milton	31	7	Table 18	Is 10% loss acceptable where 80% has already been lost or damaged?	The degree of loss of a feature is implicitly built into its sensitivity class. How much loss has occurred in remnant vegetation types should be reflected in its endangered status/CBA status/sensitivity status.
SJ Milton	31	23	Text	"Disturbance in arid areas of succulent thickets are prone to invasion karroid species (Milton, & Dean, 2010)" Should this be "invasion OF karroid species? Millton & Dean 2010 dealt with invasive alien species rather than range extensions.	Fixed

Strategic Environmental Assessment for the Development of a Phased Gas Pipeline Network in South Africa

Appendix C.1.6

Biodiversity and Ecological Impacts (Aquatic Ecosystems and Species) - Estuaries

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

ESTUARIES

Integrating Author/s	Lara van Niekerk [1]
Contributing Authors	Carla-Louise Ramjukadh [1] Steven Weerts [1] Susan Taljaard [1]

[1] Coastal Systems Research Group, Natural Resources and the Environment (now operating within Smart Places), CSIR, South Africa

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FIGURES

ABBREVIATIONS AND ACRONYMS

DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
EFZ	Estuary Functional Zone
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
HDD	Horizontal Directional Drilling
IAP	Invasive Alien Plant
ICM	Integrated Coastal Management Act
KZN	KwaZulu-Natal
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MPA	Marine Protected Area
NEMA	National Environmental Management Act (Act 107 of 1998)
NPAES	National Protected Areas Expansion Strategy
NWA	National Water Act (Act 36 of 1998)
PIGS	Pipeline Intelligence Gauge Station
ROW	Right-of-way
Sp.	Species
TDS	Total Dissolved Solids
ToPs	Threatened or Protected species
TSS	Total Suspended Solids

1 SUMMARY

This assessment aims, at a strategic level, to identify the potential impacts of constructing and maintaining gas pipeline infrastructure to estuaries along the South African coast.

Estuaries are highly productive, but also highly dynamic environments that require undisturbed “accommodation space” so that sedimentary processes can reset after floods into new channel configurations. Estuaries support highly sensitive habitat types, species of special concern, and play an important nursery function for estuarine and marine fish.

Key potential impacts of gas pipeline development to estuaries include:

- Estuarine habitat destruction caused by access roads and vegetation clearing;
- Altered estuarine physical and sediment dynamics caused by pipeline construction; e.g. infilling, altered channel migration, increased mouth closure;
- Deterioration of water quality associated with the disturbance of sediment;

Loss of connectivity and habitat fragmentation between system’s upper catchments and/or marine environments with associated ecological impacts (e.g. loss of fish recruitment).

2 INTRODUCTION

Energy demands in South Africa are rising faster than electricity suppliers can meet them. An over-reliance on coal as an energy source poses a risk to future national development and has environmental consequences in generating large volumes of greenhouse gasses. South Africa is therefore investigating alternative means of power-generation. At present, South Africa does not have significant oil and gas reserves and produces oil and gas from imported crude oil and coal. The historic relative under-utilisation of gas as an energy source is as a result of the once abundant coal resources that allowed for the cheap production of petroleum and its by-products as well as electricity from coal. However, diminishing coal reserves and the relative cost of coal-produced electricity and petroleum, both financially and environmentally, has forced South Africa to diversify its energy mix, a process that is already under way. This involves the expansion of natural gas and oil production, and with it there is a need to plan and develop transmission pipelines between the points of origin, processing plants and the consumption districts.

As transportation systems involving fixed infrastructure that crosses large distances pipelines have inevitable environmental impacts. These include impacts to a variety of aquatic habitats, including estuaries (Chen and Gao, 2006; Yu et al., 2010). Indeed, pipeline crossings of aquatic ecosystems have been shown to have potential for substantial negative impacts (Reid and Anderson, 1998; Lévesque and Dubé, 2007; Castro et al., 2015). The construction of pipelines primarily affects physical and chemical characteristics of sensitive aquatic ecosystems, with detrimental knock-on effects on the associated biota such as invertebrates, fish and birds (Reid and Anderson, 1999; Chen and Gao, 2006; Lévesque and Dubé, 2007; Yu et al., 2010; Castro et al., 2015).

Estuaries are amongst the most productive ecosystems on earth, often far more so than their inflowing riverine and adjacent marine ecosystems (Costanza et al., 1997; Simenstad et al., 2000; Robins et al., 2005). These systems are critical migration links between marine spawning grounds and freshwater habitats for several species such as eels and prawns. They support diverse fauna and flora, but importantly also provide critical nursery habitat for estuarine and marine fish and invertebrates. Estuaries therefore provide ecological services that affect ecosystems at broader regional, national and global coastal scales.

The socio-economic importance of estuaries to humans is now widely recognised. In South Africa many people are directly or indirectly reliant on these resources. However, coastal development, water abstraction and catchment degradation has already resulted in marked impacts on the limited estuarine resources in South Africa. With a decline in the health and functionality of these systems due to various human interferences, increasing need and pressure is placed on relevant authorities to manage these resources wisely. Any proposed development that could affect estuarine resources must be adequately assessed for potential impacts.

This specialist study seeks to identify potential impacts, and assess risks of such impacts on estuaries that are associated with the construction and operation of gas pipelines within a selection of the Gas Pipeline corridors that are proposed along the coast of South Africa (i.e. Phases 5, 1, 2, 7 and 4 are selected for study). The remaining corridors, such as Phases 3, 6, 8 and inland, are not assessed as they fall in inland areas or are set back from the coastline.

Note that this Specialist Assessment Report was peer reviewed prior to release to stakeholders for review. The report was updated, as required, following the peer review findings. A copy of the peer review report and responses from the Specialist Team is included in Appendix B of this report.

3 SCOPE OF THIS STRATEGIC ISSUE

3.1 Understanding of development

3.1.1 Construction phase

Oil and gas pipeline crossings can be implemented using various techniques, including below- and above-ground methods (Lévesque and Dubé, 2007). Both methods incur a spatial “footprint” which includes a nominal Right of Way (ROW) of 30 to 50 m wide and temporary work space (which is the area needed during construction for work and travel lanes as well as a pile area where pipes, equipment and soil can be stockpiled during excavation) during the construction phase. The area used for temporary work space will be rehabilitated after construction.

The most common methods involved in pipeline construction spanning water bodies are below-ground methods and can be either trenched (wet open-cut and dry open-cut techniques) or trenchless techniques (information from Aquashare 2011, PennEast Pipeline 2016, NEB 2017):

1. **Wet open-cut techniques**, where construction does not involve diversion of stream flow and trenching and installation of the pipe is done within a waterbody (typically during the dry or low flow season). Once the pipe is installed the trenched area is backfilled with sediment.
2. **Dry open-cut techniques**, otherwise known as isolation techniques, separate the construction activities from stream flow of the waterbody by using high volume pumps, dams, culverts, or other methods to divert stream flow around the trench excavation and pipe installation. Pumped diversions are used to divert water around the (isolated) trench area to maintain natural downstream flows and prevent upstream ponding or damming effects. Before construction and installation, the area is de-watered.
3. **Trenchless techniques,** whereby a tunnel is drilled beneath the stream or water body. These techniques are typically used in areas that are environmentally sensitive, difficult to access or where surface activities cannot be disrupted. They require limited or no in-stream construction and so cause little to no disturbance to the watercourse bed and banks. However, they are not without potential environmental impacts. For installation they require excavation of pits intermittently along the pipeline route and the assistance of drilling fluids or bentonite based “muds”, and in the long term can affect groundwater flows. The most common type of trenchless crossing is **Horizontal Directional Drilling (HDD)**. HDD installation starts with a pilot hole being drilled along the predetermined drill path. The drill string is pulled back through the bore hole to enlarge the diameter of the drill hole. Pipe is welded into a string that is slightly longer than the length of the drill and is coated with abrasion resistant covering. Once the borehole has been widened to the appropriate diameter, the pipe string is pulled through. **Pipe jacking** is another trenchless technique. It relies on hydraulic jacks to push pipes through the ground behind an excavating

shield. Trenchless techniques are typically longer and slower processes than traditional open-cut methods (time frames can be many months rather than days).

3.1.2 Operations phase

In addition to pipe infrastructure, Pipeline Intelligence Gauge Stations (PIGS), also referred to as "pigging stations", will be situated above ground at selected locations approximately every 130 km, but possibly as far apart as 250-500 km. The pigging stations will be approximately 30x80 m in size. There will also be block valves every 30 km, which will have a concrete slab (similar to a manhole cover) on the surface, leading to an inspection chamber. There will not be a permanent service road parallel to the pipeline, as usually required for power lines. The access roads to site camps used during construction and right of way will be rehabilitated.

A 10 m wide permanent servitude will be established and kept clear of all deep-rooted vegetation along the full length of the pipeline for access and maintenance. Shallow-rooted vegetation will be allowed to re-establish along this servitude.

During the operational phase, there is also the potential for accidents, leaks, and explosions**, which could result in impacts on estuaries**.

3.2 Key links with other topics

This specialist assessment exclusively focused on the direct impact of the gas pipeline development and infrastructure on estuarine abiotic processes and related biotic responses as encapsulated by the estuarine functional zone (EFZ[1]). However, given that estuaries are highly dependent on the condition of the rivers flowing into them and/or wetlands adjacent to estuaries, cross reference was also made to the Freshwater Specialist Assessment included in Appendix C.1.7 of the Gas Pipeline SEA Report (De Winnaar & Ross-Gillespie, 2018) to ensure that downstream estuarine functionality is not impacted on by pipeline and associated infrastructure development. **In this report inflowing coastal rivers just above an estuary and/or coastal wetlands and seeps adjacent to estuaries are collectively referred to as supporting coastal freshwater ecosystems.**

This report does not focus on estuarine birds as these are being dealt elsewhere within the Avifauna specialist study (refer to Froneman & van Rooyen, 2018 (Appendix C.1.8 of the Gas Pipeline SEA Report)).

3.3 Data sources

For this specialist study information on relevant estuaries in the selected gas pipeline corridors was obtained from available data sources. No additional field studies were undertaken. The information and data sources included:

- Van Niekerk L and Turpie JK (eds). 2012. **National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component.** CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch. Available at: http://bgis.sanbi.org/nba/project.asp.
- Van Niekerk, L, Adams JB, Bate GC, Forbes N, Forbes A, Huizinga P, Lamberth SJ, MacKay F, Petersen C, Taljaard S, Weerts S, Whitfield AK and Wooldridge TH. 2013. **Country-wide assessment of estuary health: An approach for integrating pressures and ecosystem response in a data limited environment.** Estuarine, Coastal and Shelf Science 130: 239-251.

[1] In South Africa the EFZ is generally defined by the +5 m topographical contour (as indicative of 5 m above mean sea level) and includes all the estuarine open water area; estuarine habitats (sand and mudflats, rock and plant communities) and adjacent floodplain area whether developed or undeveloped. It therefore encompasses not only the estuary water-body but also all the habitats that support physical and biological processes that characterise an estuarine system.

- Van Niekerk L, Taljaard S, Ramjukadh C-L Adams JB, Lamberth SJ, Weerts SP, Petersen C, Audouin M, Maherry A. 2017. **A multi-sector Resource Planning Platform for South Africa's estuaries.** Water Research Commission Report No K5/2464. South Africa.
- Van Niekerk, L., Taljaard, S., Adams, J. B., Fundidi, D., Huizinga, P., Lamberth, S. J., Mallory, S., Snow, G. C., Turpie, J. K., Whitfield, A. K. and Wooldridge, T. H. 2015. **Desktop Provisional Ecoclassification of the Temperate Estuaries of South Africa.** WRC Report No K5/2187.
- Turpie, J.K., Wilson, G. and van Niekerk, L. 2012. **National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa.** Anchor Environmental Consulting Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.

- The 2018 National Biodiversity Assessment is currently a work in progress, but where appropriate, interim findings from this study were considered here.

Key environmental attributes that were used in this study included the demarcated EFZs, ecological health condition, ecological importance and pressure status of estuaries (e.g. extent to which human disturbance already affected an estuary). Information on potential impacts and possible mitigation measures associated with the different construction methods and pipeline operations were sourced from international literature, as well as expert judgement.

3.4 Assumptions and limitations

The following assumptions and limitations apply to this estuarine assessment:

- This assessment assumes that only below-ground construction methods will be considered for estuary crossings by gas pipelines. Three below-ground methods will be investigated, namely wet open-cut construction, isolated (dry-open cut) construction and HDD.
- Given elevated water tables, corrosion associated with salt water and scouring potential associated with estuaries, above ground construction methods for the proposed gas pipeline (i.e. diverting over the river bed in the form of pipe-bridges or suspension below existing bridge infrastructure) were also assessed for completeness.
- At the broad, overview scale of this strategic assessment, operational phases involving pipeline maintenance is assumed largely to be similar for all options.
- Due to the strategic nature of the assessment and the expansive area under investigation, a generic approach was applied; selecting a suite of key estuarine attributes considered appropriate, to assess impact and associated risks for various construction methods, and during operation.
- This assessment provides a broad scale sensitivity rating for estuaries in the various corridors. As all estuaries are sensitive to altered sediment and hydrodynamic processes, more detailed spatially scaled sensitivity demarcation within the study areas will need to be refined during the detailed planning and construction phases.
- Consequence ratings applied in this assessment are associated with narrative qualitative statements, rather than detailed quantitative ratings (such as % loss of biota/habitat, or with regard to temporal or spatial extents). This was necessary given the scope and scale of this strategic environmental assessment.
- This assessment makes use of information available and in a useable format. No fieldwork was done and no additional raw data were collected and/or processed.
- All estuaries are important bird areas. Potential impacts to estuarine avifauna were assessed as part of the Avifauna specialist study (refer to Froneman & van Rooyen (2018) for further details (Appendix C.1.8 of the Gas Pipeline SEA Report).
- Marine-estuarine-freshwater connectivity, critical to some species of crustaceans and fish, is reliant on free flowing rivers and impacted by activities in rivers. Potential impacts to these fauna (e.g. *Anguillid* eels) in catchments above estuaries (i.e. rivers) were not dealt with in this assessment, but were assumed to have been addressed in the Freshwater specialist assessment (refer to De Winnaar & Ross-Gillespie (2018) for further details (Appendix C.1.7 of the Gas Pipeline SEA Report)).

4 KEY ATTRIBUTES AND SENSITIVITIES OF STUDY AREAS

4.1 Overview of South African estuaries

An estuary is defined as ‘‘a partially enclosed permanent water body, either continuously or periodically open to the sea on decadal time scales, extending as far as the upper limit of tidal action, back-flooding or salinity penetration. During floods an estuary can become a river mouth with no seawater entering the formerly estuarine area, and when there is little or no fluvial input, an estuary can be isolated from the sea by a sandbar and become a lagoon or lake which may become fresh or hypersaline” (van Niekerk and Turpie, 2012:29).

South African estuaries differ considerably in terms of their physicochemical and biotic characteristics (Colloty et al., 2002; Vorwerk et al., 2008). Despite their differences, proactive planning and effective management of estuaries require an understanding of changing estuarine patterns, processes and responses to global change pressures (i.e. those that arise directly from anthropogenic activities as well as climate change). As human population pressures escalate, the need for strategic management becomes increasingly evident (Boehm et al., 2017; Borja et al., 2017). Reactive planning of resource allocation in these systems on an estuary-by-estuary basis is costly, time consuming and not feasible. Proactive planning requires a strategic assessment of change at a range of scales to ensure optimum resource use.

Estuaries and adjacent ecosystems form an interrelated network of life-support systems that includes neighbouring terrestrial and marine habitats. Many estuarine species are dependent on different habitats in order to complete their life cycles (Whitfield, 1998). Estuarine ecosystems are, therefore, not independent and isolated from other ecosystems. Rather, estuaries form part of regional, national and global ecosystems, directly through connections via water flows (e.g. the transport of nutrients and detritus) and indirectly via the movement of estuarine fauna (e.g. Gillanders, 2005; Ray, 2005). Linkages between individual estuaries and other ecosystems span scales ranging from a few hundred metres to thousands of kilometres. Therefore, impacts to a specific estuarine ecosystem may affect ecosystems seemingly remote from that estuary, and have ramifications for ecosystem goods and services that people rely on from areas distant over large spatial scales. The closure of Lake St Lucia for example, resulted in declines and eventual closure of a prawn fishery on the Thukela Banks over 100 km to the south.

South Africa has nearly 300 relatively small estuaries, the majority (>70%) of which are <50 ha in size. These estuaries fall into three biogeographical regions which characterise the South African coast; namely the Cool Temperate west coast, the Warm Temperate southern and south-east coast, and the Subtropical east coast (Emanuel et al., 1992; Harrison, 2002; Turpie et al., 2002) (Figure 1). In addition to obvious sea temperature differences, rainfall patterns in these regions vary significantly (Davies and Day, 1998; Lynch, 2004; Schulze and Lynch, 2007; Schulze and Maharaj, 2007). Annual runoff of South African rivers is highly variable and unpredictable in comparison with larger Northern Hemisphere systems, fluctuating between floods and extremely low (to zero) flows (Poff and Ward, 1989; Dettinger and Diaz, 2000; Jones et al., 2014) (Figure 2). Estuary catchment sizes range from very small (<1 km^2) to very large (>10 000 km^2), with those in the Cool Temperate region tending to be larger than those in the Warm Temperate and Subtropical regions (Jezewski et al., 1984; Reddering and Rust, 1990).

Strong wave action and high sediment availability results in more than 90% of South African estuaries having restricted inlets (or mouths). More than 75% of estuaries close for varying periods of time due to sand bar formation across the mouth (Whitfield, 1992; Cooper, 2001; Taljaard et al., 2009; Whitfield and Elliott, 2011). Most estuaries are highly dynamic with an average water depth of 1-5 m. The tidal range around the whole coast is microtidal (<2 m) but high wave energy, makes it a wave-dominated coast (Cooper, 2001).

Estuaries exhibit a high spatial heterogeneity, with each system characterised by its own unique geomorphology and physicochemical processes. Individual systems can be highly variable temporally and the full spatial extent (i.e. tidal limit or back-flooding mark) of many systems remains unknown. This makes it difficult to delineate the dynamic spatial area where estuarine processes occur within each system, the so-called EFZ. In South Africa the EFZ is generally defined by the +5 m topographical contour (as indicative of 5 m above mean sea level) and includes all the estuarine open water area; estuarine habitats (sand and mudflats, rock and plant communities) and adjacent floodplain area whether developed or undeveloped. It therefore encompasses not only the estuary water-body but also all the habitats that support physical and biological processes that characterise an estuarine system.

For the purposes of this study, and as is typical in estuarine assessment in a South African context, all permanent coastal water bodies (i.e. not ephemeral water bodies) sporadically or permanently linked to the sea were regarded as estuarine systems. Using existing estuarine vegetation and fish data sets, published and unpublished literature, as well as anecdotal information, all systems were evaluated by an expert panel and their health evaluated (Van Niekerk and Turpie, 2012).

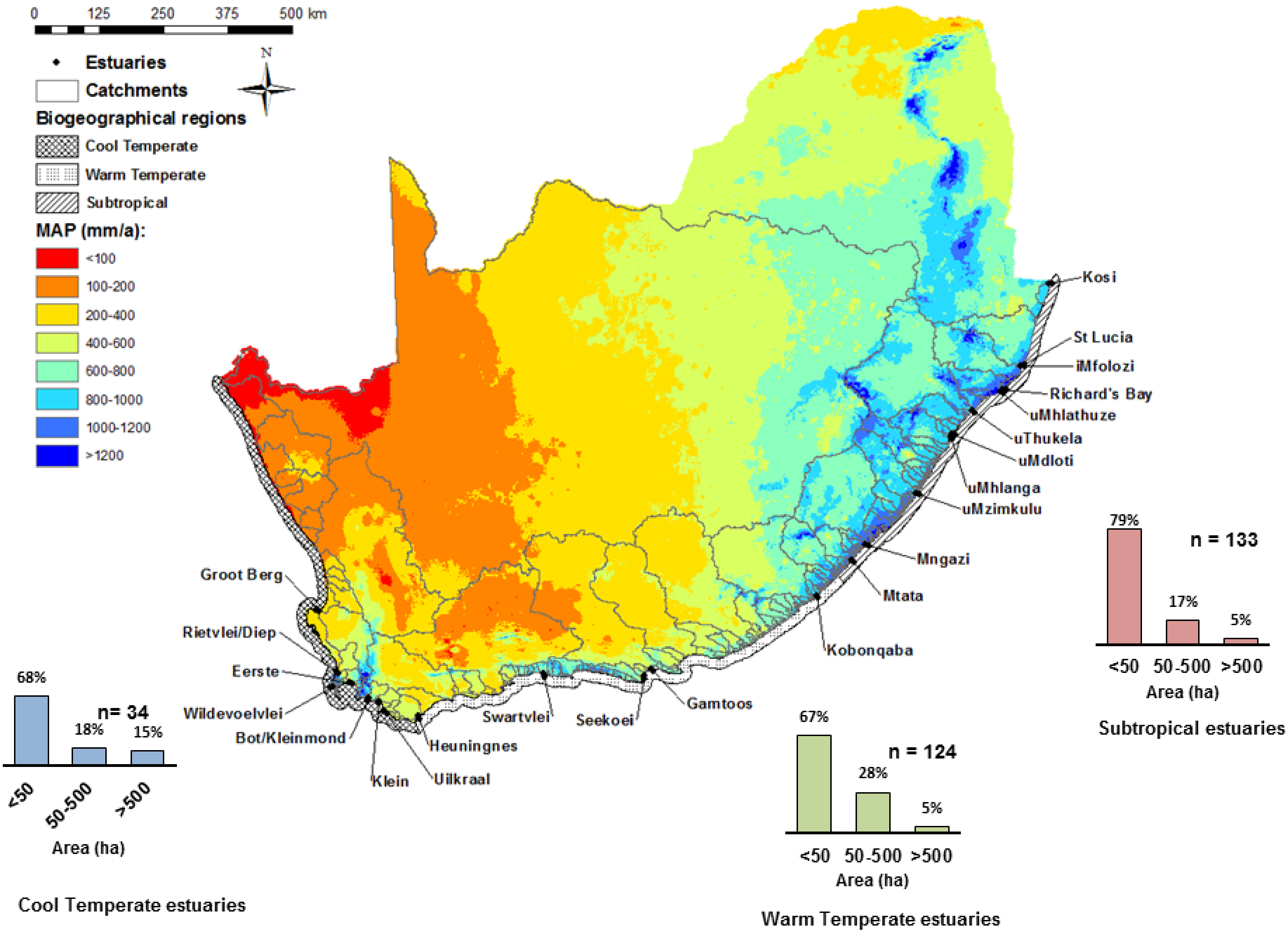

Figure 1: Map showing the three biogeographical regions, relative catchment size, mean annual precipitation (MAP) (in mm/a) and estuary size distribution (in ha) for South Africa (van Niekerk et al. 2013).

4.2 Estuarine sedimentary processes of importance

Estuaries are complex water bodies and differ considerably from fluvial systems. In estuaries the flow reverses due to tidal inflows being stronger than freshwater outflows. Water quality charges in an estuary are also complex due to both upstream and downstream sources.

Estuaries also have two sources of sediment; that from the river (delivered primarily during floods) and a supply of marine sediment from the ocean delivered by littoral drift and transported by tidal currents into the estuary. Within estuaries, tidal sediment transport is a result of the interaction of both currents and waves. This is especially dynamic in the mouth region of estuaries and further up the system wave action is rapidly reduced. Wave-current interaction considerably complicates sediment transport predictions. During neap tides, maximum water velocities in the estuary are low with little sediment transport, while both velocities and transport increase towards spring tides. Significantly, in some estuaries over this neap to spring period, there is a net upstream sediment transport, e.g. in the Goukou (Beck et al., 2004). If there is a long-term net ingress of marine sediment (which is often the case), then the only plausible way for a long-term equilibrium to be established is for occasional large river floods to flush out this accumulated sediment.

Floods therefore, are the most important natural processes which erode and transport sediments out of estuaries. Large volumes of sediments can be removed in a very short time during major floods with a return period of 1 in 50 years and more. Smaller floods with return periods of 1-2 years can sometimes also have a significant influence. Floods of various scales therefore play a major role in the equilibrium between sedimentation and erosion in estuaries (Beck et al., 2004).

This is an important consideration because sedimentation of South African estuaries has created several environmental and social problems. Sediment transport imbalances are caused by changes in the river inflow (especially floods), increased catchment sediment yields and hard structures in estuaries that change flow velocities. Reduced sediment transport capacities within estuaries and decreased flushing efficiencies cause increased sedimentation and in the long-term this may lead to the complete closure of estuaries.

Estuary channel formation is also highly dynamic on decadal time scales. During low flow periods shallow tidal flows can meander several sand banks in the EFZ. During floods rapid changes in estuarine morphology occur over very short time frames. The system can be completely reset and channels can be scoured by meters, only to be filled in over time again by catchment and marine sediment. These types of changes can be illustrated using the Thukela Estuary as an example (Figure 2). Scouring during flooding can be significant with numerical modelling studies indicating possible scour depths on larger river systems of between 20 and 30 m (Basson et al., 2017, as indicated in Figure 3 and Figure 4).

These dynamic processes are an integral part of the natural functioning of South African estuaries and need to be accounted for in proposals to develop within EFZs. In the context of the present work, proposed crossings of estuaries by pipelines need to be assessed with the knowledge that estuary channel formation can occur anywhere in the EFZ and that scouring during floods (with a return period of 1:10 years) is significantly deeper than the observed estuary bed levels under typical (non-flood) conditions.

Figure 2: Thukela Estuary under low flow conditions with a stable channel meandering between sand banks (left) and the Thukela Estuary under resetting flood conditions with high volumes of sediment being eroded from the system (right).

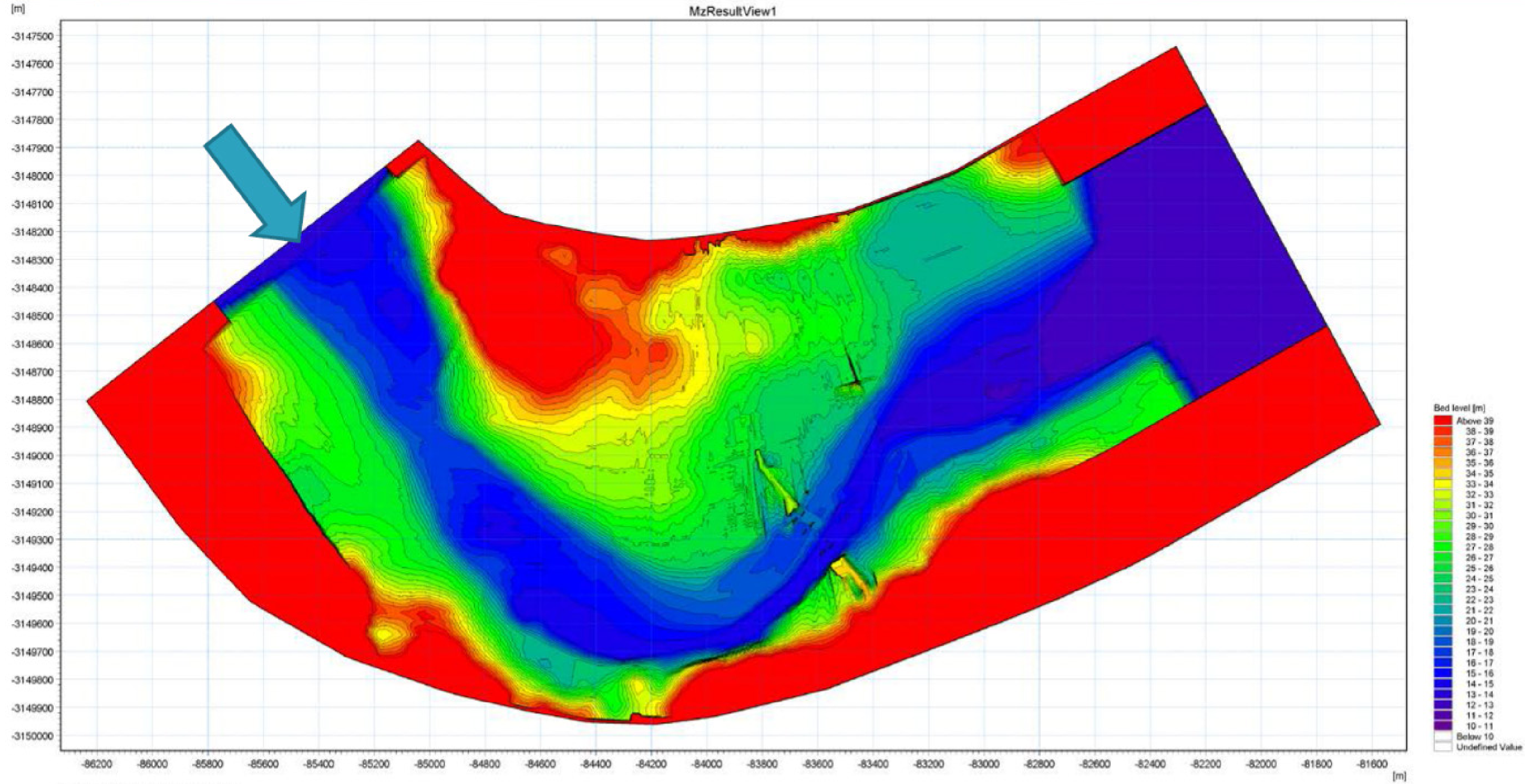

Figure 3: Predicted scouring in the uMfolozi River before floods (Basson et al., 2017). Arrow indicates flow direction.

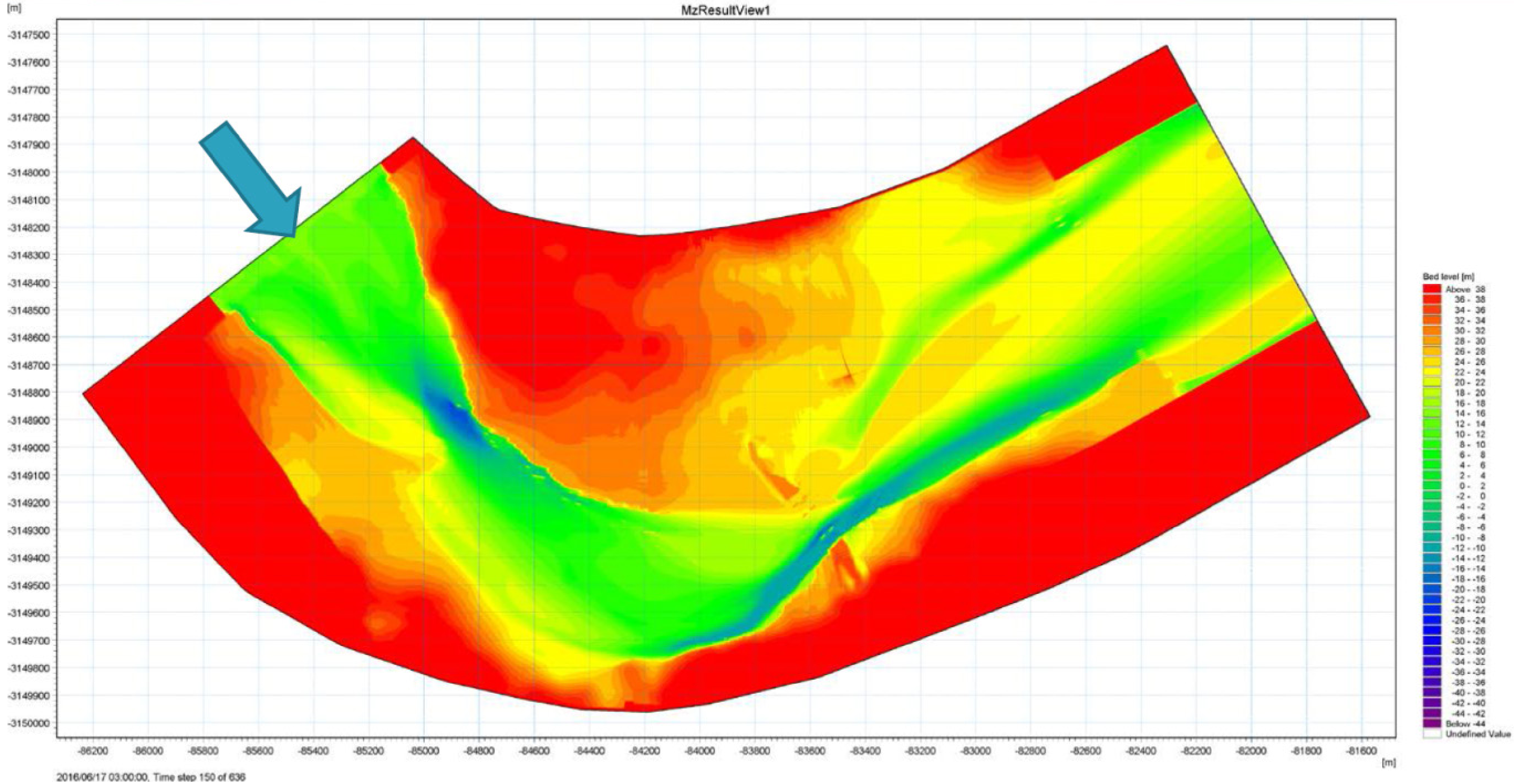

Figure 4: Predicted scouring in the uMfolozi River during floods (Basson et al., 2017). Arrow indicates flow direction.

4.3 Estuarine habitat of importance

Estuaries are generally made up of a high diversity of habitat types, which include open water areas, un-vegetated sand-, mudflats and rock areas, and vegetated areas (plant communities). Plant community types can be subdivided into submerged macrophytes, salt marsh, mangroves, reeds and sedges (Adams et al., 2018).

- **Open water area:** Un-vegetated basin and channel waters which are measured as the water surface area. The primary producers are the phytoplankton consisting of flagellates, dinoflagellates, diatoms and blue-green algae which occur in a wide range of salinity ranging from freshwater to marine conditions.
- **Sand / mudflats / rock:** Soft (mobile) substrates (sand and mud) and hard (non-mobile) substrates (rocks) and shorelines areas. Habitat mapping from aerial photographs cannot distinguish between sand and mud habitats and therefore in databases used for the purposes of this study are presented as a single area. The dominant primary producers of these habitats are the benthic microalgae.
- **Macroalgae:** Macroalgae may be intertidal (intermittently exposed) or subtidal (submerged at all times), and attached or free floating. Filamentous macroalgae often form algal mats and increase in response to nutrient enrichment or calm sheltered conditions when the mouth of an estuary is closed. Typical genera include *Enteromorpha* and *Cladophora*. Many marine species can get washed into an estuary and providing that the salinity is high enough, can proliferate. These include *Codium*, *Caulerpa*, *Gracilaria* and *Polysiphonia*.
- **Submerged macrophytes:** Submerged macrophytes are plants that are rooted in the substrate with their leaves and stems completely submersed (e.g. *Stukenia pectinata* and *Ruppia cirrhosa*) or exposed on each low tide (e.g. the seagrass *Zostera capensis*). *Zostera capensis* occupies the intertidal zone of most permanently open Cape estuaries whereas *Ruppia cirrhosa* is common in temporarily open/closed estuaries. *Stukenia pectinata* occurs in closed systems or in the upper reaches of open estuaries where the salinity is less than 10 ppt.
- **Salt marsh:** Salt marsh plants show distinct zonation patterns along tidal inundation and salinity gradients. Zonation is well developed in estuaries with a large tidal range e.g. Berg, Knysna and Swartkops estuaries. Common genera are *Sarcocornia*, *Salicornia*, *Triglochin*, *Limonium* and *Juncus*. Halophytic grasses such as *Sporobolus virginicus* and *Paspalum* spp. are also present. Intertidal salt marsh occurs below mean high water spring and supratidal salt marsh above this. *Sarcocornia pillansii* is common in the supratidal zone and large stands can occur in estuaries such as the Olifants.
- **Reeds and sedges:** Reeds, sedges and rushes are important in the freshwater and brackish zones of estuaries. Because they are often associated with freshwater input they can be used to identify freshwater seepage sites along estuaries. The dominant species are the common reed *Phragmites australis*, *Schoenoplectus scirpoides* and *Bolboschoenus maritimus* (sea club-rush).
- **Mangroves:** Mangroves are trees that establish in the intertidal zone in permanently open estuaries along the east coast of South Africa, north of East London where water temperature is usually above 20°C. The white mangrove *Avicennia marina* is the most widespread, followed by *Bruguiera gymnorrhiza* and then *Rhizophora mucronata*. *Lumnitzera racemosa*, *Ceriops tagal* and *Xylocarpus granatum* only occur in the Kosi Estuary.
- **Swamp forest:** Swamp forests, unlike mangroves are freshwater habitats associated with estuaries in KwaZulu-Natal. Common species include *Syzygium cordatum*, *Barringtonia racemosa* and *Ficus trichopoda*. It is often difficult to distinguish this habitat from coastal forest in aerial photographs.

4.4 Species of special concern

4.4.1 Plants

Plant species listed in the estuarine botanical database were cross referenced against the South African Red List (http://redlist.sanbi.org) to produce a list of estuarine plant species of conservation significance (Table 1). Categorisation was made on the basis of the IUCN Red List categories and Criteria version 3.1 (IUCN, 2012):

Some macrophyte species (mangroves and eelgrass) have only recently been reassessed in the Red Data List and freshwater mangrove *Barringtonia racemosa* was only added in 2016. If categorised as a species of special concern the data provided for each assessment was tabulated. Further research on these species was also captured. If categorised as 'Least Concern' details pertaining to the state of the population was not captured unless noted in a particular study. While the spatial location of all species of special concern is not known for South Africa's estuaries, what becomes clear from Table 1 is that all estuaries support estuarine habitat of concern and should be deemed as highly sensitive.

Interference (harvesting, clearing, removal) of mangrove and swamp forest is regulated under the National Forests Act No. 84 of 1998 (RSA 1998) and destruction or harvesting of indigenous trees requires a licence. All mangrove trees and swamp forests are protected under this act. The taxonomy of some salt marsh species is under currently under review; which makes it difficult to determine their population sizes, report on their threat status or set targets for protection. However according to the National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008, as amended), all coastal wetlands, which include salt marshes and mangroves, form part of the coastal protection zone. The purpose of establishing this zone is to restrict and regulate activities in order to achieve the aims as set out in the Act. Other laws pertaining to species in these areas: National Environmental Management Act 1998, Marine and Living Resources Act 1998, The National Environmental Management: Biodiversity Act 2004, and National Forestry Act 1998.

4.4.2 Fish

The IUCN Red List of Threatened Species includes many fish that occur in estuaries in South Africa (ICUN, 2018). Table 2 lists those known to occur commonly in South African systems (i.e. excluding species that only occur sporadically in South African estuaries, species at the margins of their biogeographical ranges and which are more common in estuaries further north) (Whitfield, 1998, pers.obs). By far the majority of these fish are categorised as species of Least Concern. The IUCN Red List categories and criteria (IUCN 2012) are designed to be applied to the entire (global) range of a species and fish listed in the Least Concern category here range from those which are actually quite common and (still) abundant in South African systems (e.g. *Rhabdosargus sarba*) to species which are uncommon, rare and in a national sense could be considered as endangered (e.g. *Microphis brachyurus*). Included in Table 2 as a species of special concern, in the process of being IUCN red listed, is *Argyrosomus japonicus* (Dusky Kob), a species with South African populations at critically low levels (Griffiths, 1997, Mirimil et al., 2016). Predominant threats faced by the listed species include development (urban, commercial, recreational and industrial), agriculture, mining, resource use (fishing and harvesting of aquatic resources), modification of natural systems (flow modification and other), pollution, and climate change (ICUN 2018). **All estuaries in the corridors function as nurseries for Critically Endangered or Endangered fish species of high recreational or conservation importance.**

4.4.3 Mammals, Reptiles and Amphibians

Mammals, reptiles and amphibians are not traditionally assessed as part of estuarine studies. Given the overlap in sensitivity buffers between the study areas of the Estuary Specialist Assessment (i.e. this report) and the Freshwater Specialist Assessment included in Appendix C.1.7 of the Gas Pipeline SEA Report (De Winnaar & Ross-Gillespie, 2018), the detailed features maps and four-tier sensitivity maps developed for Mammals, reptiles and amphibians in the later study can be regarded as applicable for estuaries.

Table 1: Macrophyte updates to the Red List of South Africa (Adams et al. 2018) (LC = Least Concern, EN = Endangered, NA = Not assessed, IUCN 2012).

Species	Common name	Category	Distribution	Habitat	Threats	Reference
Avicennia marina	White mangrove	LC	Widespread across the east coast from Chalumna to Kosi Bay and occurs in a large number of estuaries	Common and often dominant constituent of mangrove swamps (usually the inland fringes of mangrove associations) and is also a pioneer of new mud banks.	Continuous habitat loss due to urban, industrial development and infrastructure development	Adams et al., 2016a
Bruguiera gymnorrhiza	Black mangrove	LC	Widespread along the east coast of South Africa from the Nahoon to Kosi Bay.	Evergreen woodlands and thickets along the intertidal mud-flats of sheltered shores, estuaries and inlets, mainly towards the seaward side of mangrove formation.	Coastal development, over-harvesting	Adams et al., 2016b
Ceriops tagal	Indian mangrove	LC	Very limited distribution on the coast of South Africa	Evergreen woodlands and thickets along the intertidal mud-flats of sheltered shores, estuaries and inlets. The most inland of the rhizophoraceous mangroves.	No major threats	Adams et al., 2016c
Lumnitzera racemosa	Tonga mangrove	EN	Kosi Bay	Mangrove swamps, usually on the landward side.	Harvesting for firewood	Rajkaran et al., 2017
Rhizophora mucronata	Red mangrove	LC	Nahoon to Kosi Bay	Evergreen woodlands and thickets along the intertidal mud-flats of sheltered shores, estuaries and inlets, mainly in the seaward side of the mangrove formation.	Coastal development	Rajkaran et al., 2016
Xylocarpus granatum	Mangrove mahogany	NA	Single individual in Kosi Bay	Tidal mud of mangrove swamps, especially towards their upper limits.	Harvesting	SANBI, 2017
Barringtonia racemosa	Powder puff tree	LC	Coastal areas between the Eastern Cape and KwaZulu-Natal	Streamsides, freshwater swamps and less saline areas of coastal mangrove swamps.	Sensitive to salinity changes and tidal intrusion caused by infrastructure development and water abstraction as well as sea level rise associated to climate change. Fungal disease and chemical pollution is also problematic.	Von Staden, 2016
Zostera capensis	Eelgrass	LC	Olifants River Mouth on the Cape West Coast to Kosi Bay, northern KwaZulu-Natal.	Intertidal zone of permanently open estuaries. It occasionally persists in temporarily closed estuaries when conditions are saline.	Development, freshwater abstraction, catchment disturbance, eutrophication resulting in shading and outcompeting.	Adams & van der Colff, 2016

Table 2: Threatened South African estuarine fish species (CR = Critically Endangered, EN = Endangered, LC = Least Concern, DD = Data Deficient, IUCN 2012, * = Lower Risk/near threatened IUCN 1994 Categories & Criteria version 2.3, ** = Not IUCN listed, but critically low stocks in SA). The numbers indicated in the column entitled "Distribution within the relevant proposed Gas Pipeline Corridor" indicates the distribution of these estuarine fish species within the applicable corridors that are being studied as part of this assessment i.e. Phases 1, 2, 4, 5 and 7).

Scientific name	Common name	Red List status	Distribution within the relevant proposed Gas Pipeline corridor
Syngnathus watermeyeri	Estuarine Pipefish	CR	7
Clinus spatulatus	Bot River Klipfish	EN	1
Lithognathus lithognathus	White Steenbras	EN	1, 2, 5, 7
Hippocampus capensis	Knysna Seahorse	EN	2
Argyrosomus japonicus	Dusky Kob	EN**	1, 2, 4, 7
Anguilla bicolor	Shortfin Eel	NT	4, 7
Oreochromis mossambicus	Mozambique Tilapia	NT	1, 2, 4, 5, 7
Epinephelus malabaricus	Malabar Rockcod	NT	4, 7
Pomatomus saltatrix	Elf	VU	1, 2, 4, 5, 7
Acanthopagrus vagus	Estuarine Bream	VU	2, 4, 7
Rhabdosargus globiceps	White Stumpnose	VU	1, 2, 5, 7
Taenioides jacksoni	Bearded Goby	*LR/nt	4, 7
Albula oligolepis	Smallscale Bonefish	DD	4, 7
Hypseleotris cyprinoides	Golden Sleeper	DD	4, 7
Oligolepis acutipennis	Sharptail Goby	DD	4, 7
Megalops cyprinoides	Indo-Pacific Tarpon	DD	4, 7
Liza dumerili	Groovy Mullet	DD	1, 2, 4, 7
Microphis fluviatilis	Freshwater Pipefish	DD	4, 7
Ambassis natalensis	Slender Glassy	LC	4, 7
Anguilla marmorata	Marbled Eel	LC	1, 2, 4, 7
Anguilla mossambica	African Longfin Eel	LC	1, 2, 4, 7
Ablennes hians	Flat Needlefish	LC	4, 7
Caranx ignobilis	Giant Trevally	LC	4, 7
Caranx papuensis	Brassy Trevally	LC	4, 7
Lichia amia	Garrick	LC	1, 2 ,4, 5, 7
Scomberoides commersonnianus	Talang Queenfish	LC	2, 4, 7
Scomberoides lysan	Doublespotted Queenfish	LC	4, 7
Chanos chanos	Milkfish	LC	2, 4, 7
Eleotris fusca	Dusky Sleeper	LC	4, 7
Eleotris mauritiana	Widehead Sleeper	LC	4, 7
Eleotris melanosoma	Broadhead Sleeper	LC	4, 7
Elops machnata	Springer	LC	2, 4, 7
Stolephorus holodon	Natal Anchovy	LC	4, 7
Stolephorus indicus	Indian Anchovy	LC	4, 7
Thryssa setirostris	Longjaw Thryssa	LC	4, 7
Gerres filamentosus	Threadfin Pursemouth	LC	4, 7
Gerres longirostris	Smallscale Pursemouth	LC	4, 7
Gerres oyena	Longtail Pursemouth	LC	4, 7
Awaous aeneofuscus	Freshwater Goby	LC	4, 7
Croilia mossambica	Burrowing Goby	LC	4, 7
Favonigobius reichei	Tropical Sand Goby	LC	4, 7
Glossogobius callidus	River Goby	LC	2, 4, 7
Glossogobius giuris	Tank Goby	LC	4, 7
Oxyurichthys keiensis	Kei Goby	LC	4, 7
Paratrypauchen microcephalus	Blind Goby	LC	4, 7
Psammogobius biocellatus	Sleepy Goby	LC	4, 7
Redigobius bikolanus	Bigmouth Goby	LC	4, 7

Scientific name	Common name	Red List status	Distribution within the relevant proposed Gas Pipeline corridor
Redigobius dewaali	Checked Goby	LC	2, 4, 7
Stenogobius kenyae	Kenyan River Goby	LC	4, 7
Yongeichthys nebulosus	Shadow Goby	LC	4, 7
Lobotes surinamensis	Tripletail	LC	7
Lutjanus argentimaculatus	River Snapper	LC	4, 7
Monodactylus argenteus	Natal Moony	LC	1, 2, 4, 7
Monodactylus falciformis	Cape Moony	LC	1, 2, 4, 7
Chelon melinopterus	Giantscale Mullet	LC	4, 7
Crenimugil crenilabis	Fringerlip Mullet	LC	4, 7
Mugil cephalus	Flathead Mullet	LC	1, 2, 4, 7
Myxus capensis	Freshwater Mullet	LC	1, 2, 4, 7
Planiliza alata	Diamondscale Mullet	LC	4, 7
Planiliza macrolepis	Largescale Mullet	LC	2, 4, 7
Valamugil buchanani	Bluetail Mullet	LC	1, 2, 4, 7
Valamugil robustus	Robust Mullet	LC	4, 7
Ophisurus serpens	Sand Snake-eel	LC	4, 7
Sillago sihama	Silver Sillago	LC	4, 7
Acanthopagrus berda	Black Bream	LC	2, 4, 7
Crenidens crenidens	Karenteen Seabream	LC	4, 7
Diplodus capensis	Blacktail	LC	1, 2, 4, 5, 7
Rhabdosargus holubi	Cape Stumpnose	LC	1, 2, 4, 5, 7
Rhabdosargus sarba	Natal Stumpnose	LC	2, 4, 7
Rhabdosargus thorpei	Bigeye Stumpnose	LC	4, 7
Hippichthys cyanospilos	Bluespeckled Pipefish	LC	4, 7
Hippichthys heptagonus	Reticulated Pipefish	LC	4, 7
Hippichthys spicifer	Bellybarred Pipefish	LC	4, 7
Microphis brachyurus	Opossum Pipefish	LC	4, 7
Amblyrhynchotes honckenii	Evileye Pufferfish	LC	1, 2, 4, 7
Arothron immaculatus	Immaculate Pufferfish	LC	4, 7
Chelonodon laticeps	Bluespotted Pufferfish	LC	4, 7

4.5 Consideration of estuary condition and sensitivity to current and future impacts

Assessing the status and/or future impacts on estuarine ecosystems involves assessing anthropogenic pressures against a background of inherent variability and natural change (Gray and Elliott, 2009; Elliott, 2011). It requires an understanding of estuarine health, connectivity and coastal interaction on a regional scale, as well as consideration of resilience to natural and anthropogenic resetting events and recruitment processes. This requires an understanding of how pressures (including cumulative pressures) result in changes in the natural systems and the implications for resource use (Korpinen and Andersen, 2016).

Estuaries are by nature resilient systems, because their fauna and flora are adapted to living in ever changing conditions. However, development in and around estuaries can cause changes to the structural habitat of an estuary, resulting in local extinctions. Infrastructure development also prevents lateral movement of habitats such as salt marsh. Impacts caused by construction of hard structures in estuary floodplains are not easily reversible and can be mitigated at best. Even recovery from temporary disturbances can take decades to restore to natural conditions. For example, the crossing of the Nhlabane Estuary in KwaZulu-Natal by a mining dredger in 1993 involved construction of temporary sand berms across the estuary mid-way along the system (Jerling, 2005). Due to continuous freshwater inputs from groundwater seepage, the then closed estuary soon became fresh leading to change in the zooplankton community, including the appearance of freshwater taxa such as rotifers, Cyclopoids (*Mesocyclops* sp. *and Thermocyclops* sp.), freshwater *Cladocerans* and insect larvae. Estuarine species became less abundant or

were lost from the system completely, including the copepod *Acartia natalensis*, the mysid *Mesopodopsis africana*, and larval stages of polychaetes, decapods and fish. Not all taxa recovered after the mouth reopened (Jerling, 2005). In addition, fine sediment intruded into the estuary from the berm wall area and caused a rapid decline in the density of benthic organisms and number of taxa. Recovery of the affected area was slow and characterized by initial proliferation of opportunistic colonizers (Vivier and Cyrus, 1999).
Coastal development along most of South Africa's coast has resulted in a continuous escalation of pressures on estuaries. While many of these estuaries are small, they act as a network, and incremental losses collectively add up to be significant and impact a large area of an estuarine system. Ribbon development along the coast is particularly problematic in this regard, well demonstrated by the KwaZulu-Natal south coast where urbanisation and development has led to significant habitat modification in all estuaries. Road and rail infrastructure negatively affects nearly every estuary along this coast. Bridge foundations and abutments, and road and rail berms have led to infilling of systems and consequential habitat destruction. They have resulted in changes to the natural flow and scouring dynamics in estuaries. Development across floodplains and channel stabilisation has affected natural flow patterns resulting in localised scour and deposition. Sugar cane farming along the banks of a large number of systems has led to infilling of floodplains, general constriction of tidal flows and large-scale loss of marginal vegetation and natural vegetation buffers around the estuaries. This has caused ever increasing "gaps" between functional estuaries along the coastline and large numbers of poor condition systems adjacent to each other is a concern. Little research has been done on the direct consequences of declining estuary condition and this type of loss of connectivity in an estuarine network, especially with respect to the ability of individual and collective systems to absorb and recover from events. It is nevertheless increasingly recognised that in the case of estuaries, the health of neighbouring systems matters as it ensures overall resilience of a regional network of estuaries. Future telemetry and genetic studies will assist in understanding this aspect of estuarine connectivity better, and inform the development of guidelines for regional resource allocation.

In particular it is important to preserve coastal connectivity to ensure recruitment from healthy neighbouring systems in the event of natural and anthropogenic disasters. In order to accommodate flood events, sea storms and climate change estuary floodplains and supporting habitats must be protected from infrastructure development to ensure resilience to extreme flooding (and allow for lateral channel movement), negate the need for premature artificial breaching of systems, and prevent coastal squeeze of estuarine habitats.

4.6 Description of estuaries in corridors/feature maps

Available information was used to describe important environmental attributes of estuaries within each of the applicable corridors. This includes a brief overview of present health conditions, biodiversity importance and important uses of estuaries in the selected study areas (corridors). Important ecological and socio-economic attributes of estuaries within each of the applicable corridors are summarised in Appendix A, Table A.1.

Figure 5 illustrates the proposed Gas Pipeline corridors. Note that Phases 3 and 8, as well as portions of the inland corridor (via the Karoo) are inland, and Phase 6 is set back from the coast. As such, estuaries are not directly affected by these corridors. As noted above, this assessment therefore focuses on Phases 5, 1, 2, 7, and 4 (from west to east) which are routed along the coast.

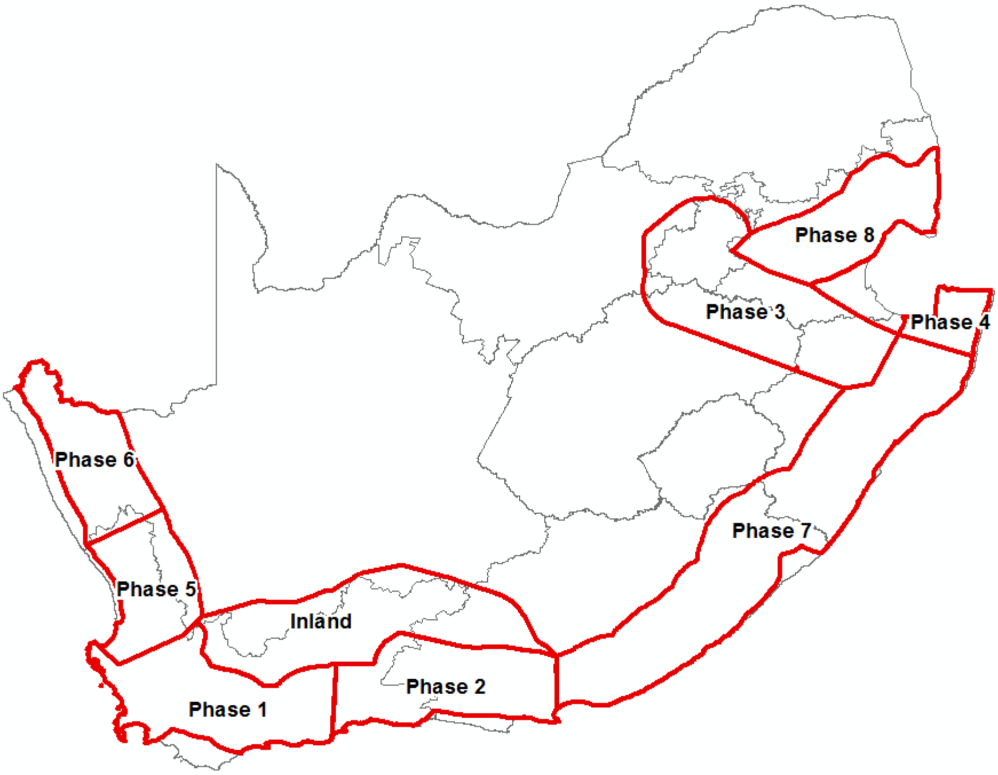

Figure 5: Image indicating the proposed Gas Pipeline corridors. Only the Phases 5, 1, 2, 7, and 4 corridors are considered in this study.

4.6.1 Phase 5 corridor

Three estuaries are situated within the Phase 5 corridor; the Olifants, Verlorenvlei and the Groot Berg. They have a combined estuarine habitat area of 8 600 ha (Figure 6) and are amongst the longest of South Africa's estuaries with the Groot Berg Estuary nearly 70 km and the Olifants Estuary about 40 km long. The Groot Berg roughly extends about 40 km into the Phase 5 corridor. Their health statuses vary between C and D Categories on the Department of Water and Sanitation (DWS) scale ("A" being near natural and "F" being extremely degraded) (Van Niekerk et al., 2018, in progress).

All three estuaries are national conservation priorities as identified in the national estuaries biodiversity plan (Turpie et al., 2012). The Olifants and Groot Berg are of very high biodiversity Importance, ranking in the top five estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). These systems are also important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). From a habitat diversity and abundance perspective the Olifants and Groot Berg are also considered highly important as they support large areas of sensitive estuarine habitats such as intertidal and supratidal saltmarsh.

4.6.2 Phase 1 corridor

In total 25 estuaries are situated within the Phase 1 corridor, with a combined estuarine habitat area of 3 100 ha (Figure 7). Most are not particularly long and extend less than 10 km into the proposed Gas Pipeline corridor. Exceptions are the Breede (<30 km), Gourits (<25 km), Duiwenhoks (<15 km), Goukou (<15 km), Sand (<10 km), Sout (Wes) (<10 km) and Rietvlei/Diep (<10 km).

The Langebaan, Wildevoëlvlei, Breë, Duiwenhoks and Goukou estuaries are of very high biodiversity importance, ranking in the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). In addition the Rietvlei/Diep, Sand, Palmiet, Gourits estuaries are also rated as important from a biodiversity perspective.

Only eight estuaries in this corridor are in excellent or good conditions (Categories A to B); Langebaan, Schuster, Krom, Buffels Wes, Steenbras, Rooiels, Buffels (Oos), and Klipdrifsfontein. These systems have a high sensitivity to change as they will degrade from their near pristine state relatively easily.

Eleven estuaries in the corridor are identified as national conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012). These include Langebaan, Rietvlei/Diep, Krom, Sand, Eerste, Lourens, Palmiet, Klipdrifsfontein, Breë, Goukou and Gourits estuaries. Seven estuaries are identified as important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). These include Langebaan, Rietvlei/Diep, Sand, Breë, Duiwenhoks, Goukou and Gourits estuaries. From a habitat diversity and abundance perspective the Langebaan, Rietvlei/Diep, Wildevoëlvlei, Sand, Palmiet, Breë, Duiwenhoks, Goukou and Gourits estuaries are also considered important as they support sensitive estuarine habitats such as intertidal and supratidal saltmarsh.

4.6.3 Phase 2 corridor

In total 26 estuaries (Figure 8) are situated within the Phase 2 corridor, with a combined estuarine habitat area of 7 000 ha (note that the Sundays Estuary overlaps with both the Phase 2 and Phase 7 corridor boundaries and is therefore included in both assessments). Most of the estuaries in the region are not particularly long and extend less than 10 km into the corridor, with the exception of the Sundays (<25 km), Swartkops (<15 km), Klein Brak (<10 km), Swartvlei (<10 km), Goukamma (<10 km), Knysna (<10 km), Keurbbooms (<10 km), Gamtoos (<10 km) and Coega (<10 km).

Only seven estuaries in this corridor are in an excellent or good condition (Categories A to B); Maalgate, Kaaimans, Goukamma, Noetsie, Keurbooms, Matjies and Van Stadens. These systems are highly sensitive to change as they will degrade from their near pristine state relatively easily.

The Wilderness/Touws, Swartvlei, Knysna, Keurbooms, Gamtoos, and Swartkops estuaries are of very high biodiversity importance, ranking among the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). The Hartenbos, Groot Brak, Goukamma, Piesang, Kabeljous and Sundays estuaries are also rated as important from a biodiversity perspective.

Thirteen estuaries in the corridor are identified as national conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012). These include Kaaimans, Wilderness, Swartvlei, Goukamma, Knysna, Noetsie, Piesang, Keurbooms, Gamtoos, Van Stadens, Maitland, Swartkops and Sundays estuaries. In addition, 13 estuaries are identified as important fish nurseries that play a critical role in the maintenance and recovery of South Africa's recreational and commercial fish stock (Lamberth and Turpie, 2003; Van Niekerk et al., 2017). These include the Hartenbos, Klein Brak, Groot Brak, Wilderness, Swartvlei, Goukamma, Knysna, Piesang, Keurbooms, Kabeljous, Gamtoos, Swartkops and Sundays estuaries. From a habitat diversity and abundance perspective the Hartenbos, Klein Brak, Groot Brak, Wilderness, Swartvlei, Goukamma, Knysna, Piesang, Keurbooms, Kabeljous, Gamtoos, Swartkops, Coega and Sundays estuaries are also considered important as they support sensitive estuarine habitats such as intertidal and supratidal saltmarsh.

4.6.4 Phase 7 corridor

In total 155 estuaries are situated within the Phase 7 corridor, with a combined estuarine habitat area of about 55 100 ha (Figure 9 and Figure 10). Most of the estuaries in the region are not particularly long and extend less than 10 km into the corridor, with the exception of St Lucia (< 30km), Sundays (<25 km), Bushmans (<20 km), Keiskamma (<20 km), Kowie (<15 km), Great Fish (<15 km), Tyolomnqa (<15 km),